

ITHACA FIRE STATION

**BID SET
VOLUME 2**

August 17, 2023

Ithaca Fire Station
403 Elmwood Avenue
Ithaca, New York 14850



Wendel Project No. 618601

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PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 099123 - Interior Painting: Preparation and painting of interior fire protection piping systems.
- C. Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- D. Section 210553 - Identification for Fire Suppression Piping and Equipment: Piping identification.
- E. Section 211300 - Fire-Suppression Sprinkler Systems: Sprinkler systems design.

1.03 REFERENCE STANDARDS

- A. ASME A112.18.1 - Plumbing Supply Fittings.
- B. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- D. ASME B16.3 - Malleable Iron Threaded Fittings: Classes 150 and 300.
- E. ASME B16.4 - Gray Iron Threaded Fittings: Classes 125 and 250.
- F. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.
- G. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.

- H. ASTM A234/A234M - Standard Specification for Piping Fittings of Wrought Carbon Steel and Alloy Steel for Moderate and High Temperature Service.
- I. ASTM A536 - Standard Specification for Ductile Iron Castings.
- J. ASTM A795/A795M - Standard Specification for Black and Hot-Dipped Zinc-Coated (Galvanized) Welded and Seamless Steel Pipe for Fire Protection Use.
- K. ASTM C592 - Standard Specification for Mineral Fiber Blanket Insulation and Blanket-Type Pipe Insulation (Metal-Mesh Covered) (Industrial Type).
- L. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- M. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.
- N. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- O. AWWA C606 - Grooved and Shouldered Joints.
- P. FM (AG) - FM Approval Guide.
- Q. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- R. UL (DIR) - Online Certifications Directory.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's catalog information. Indicate valve data and ratings.
- C. Shop Drawings: Indicate pipe materials used, jointing methods, supports, and floor and wall penetration seals. Indicate installation, layout, weights, mounting and support details, and piping connections.
- D. Manufacturer's qualification statement.
- E. Installer's qualification statement.
- F. Project Record Documents: Record actual locations of components and tag numbering.
- G. Operation and Maintenance Data: Include installation instructions and spare parts lists.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Extra Valve Stem Packings: Two for each type and size of valve.

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 in this section.
- C. Comply with FM (AG) and UL (DIR) requirements.

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

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

2.02 BURIED PIPING

- A. Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Fittings: AWWA C110/A21.10, standard thickness.
 - 2. Joints: AWWA C111/A21.11, styrene-butadiene rubber (SBR) or vulcanized SBR gasket.
 - 3. Mechanical Couplings: Shaped composition sealing gasket, steel bolts, nuts, and washers.
- B. Refer to Pipe Schedule section at the end of Part 3 below for where and when to use various pipe types.

2.03 ABOVE GROUND PIPING

- A. Steel Pipe: ASTM A795 Schedule 10 or ASTM A795 Schedule 40, Black or Galvanized.
 - 1. Steel Fittings: ASTM A234/A234M wrought carbon steel or alloy steel or ASME B16.5 steel flanges and fittings.
 - 2. Cast Iron Fittings: ASME B16.1, flanges and flanged fittings and ASME B16.4, threaded fittings.
 - 3. Malleable Iron Fittings: ASME B16.3, threaded fittings and ASTM A47/A47M.
 - 4. Mechanical Grooved Couplings: Malleable iron housing clamps to engage and lock, "C" shaped elastomeric sealing gasket, steel bolts, nuts, and washers; galvanized for galvanized pipe.

- B. Refer to Pipe Schedule section at the end of Part 3 below for where and when to use various pipe types.

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. Pipe Passing Through Below Grade Exterior Walls:
 - 1. Cast-iron pipe.
 - 2. Provide watertight space with link rubber or modular seal between sleeve and pipe on both pipe ends.
- C. Not required for wall hydrants for fire department connections or in drywall construction.
- D. Clearances:
 - 1. Wall, Floor, Partitions, and Beam Flanges: 1 inch greater than external; pipe diameter.
 - 2. Rated Openings: Caulked tight with firestopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

2.05 PIPE SLEEVE-SEAL SYSTEMS

- A. Manufacturers:
 - 1. Advance Products & Systems, Inc.
 - 2. CALPICO, Inc.
 - 3. GPT, a company of Enpro Industries, Inc.
 - 4. The Metraflex Company
- B. Modular Mechanical Seals:
 - 1. Elastomer-based interlocking links to continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
 - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
 - 3. Size and select seal component materials in accordance with service requirements.
 - 4. Service Requirements:
 - a. Underground, buried, and wet conditions.
 - 5. Glass-reinforced plastic pressure end plates.
- C. Wall Sleeve: PVC material with waterstop collar, and nailer end caps.
- D. Sleeve-Forming Disk: Nonconductive plastic-based material, 3 inch thick.
- E. Pipeline-Casing Seals:
 - 1. End Seals: 1/8 inch, pull-on type, rubber or synthetic rubber based.

2.06 ESCUTCHEONS

- A. Material:

1. Chrome-plated.
 2. Metals and Finish: Comply with ASME A112.18.1.
- B. Construction:
1. Split-pattern type for new sprinkler piping.
 2. Split-pattern type with concealed hinge.
 3. Internal spring tension devices or setscrews to maintain a fixed position against a surface.

2.07 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. Vertical Support: Steel riser clamp.
- D. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
- E. Seismic Hangers and Couplings:
1. Provide coupling with a factory set disengagement rating of 140 percent to 160 percent of the static weight.
 2. Provide resettable and reusable, break away couplings.
 3. Provide tether cables to avoid excessive seismic joint movement.
 4. Coupling to be manufactured from non-corrosive materials.

2.08 MECHANICAL COUPLINGS

- A. Manufacturers:
1. Anvil International
 2. Tyco Fire Protection Products
 3. Victaulic Compan
- B. 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 -30°F to 230°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. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- C. Install piping to conserve building space, to not interfere with use of space and other work.
- D. Group piping whenever practical at common elevations.
- E. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- F. 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 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.
- G. Slope piping and arrange systems to drain at low points.
- H. Prepare pipe, fittings, supports, and accessories for finish painting. Where pipe support members are welded to structural building framing, scrape, brush clean, and apply one coat of zinc-rich primer to welding.
 - 1. Painting of interior fire suppression systems is specified in Section 099123.
- I. Structural Considerations:
 - 1. Do not penetrate building structural members unless indicated.
- J. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including annular space around 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 firestopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.
 - 4. Caulk exterior wall sleeves watertight with lead and oakum or mechanically expandable chloroprene inserts with mastic-sealed components.
- K. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.

4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
5. Tighten bolting for a watertight seal.
6. Install in accordance with manufacturer's recommendations.

L. 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.

- M. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, unions, and couplings for servicing are consistently provided.

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.

3.04 PIPE SCHEDULE

- A. Piping between Fire-Department Connection and Check Valve:
 1. Schedule 40, Galvanized steel pipe with grooved fittings, couplings, and joints.
- B. Wet-Pipe Sprinkler System Piping - Standard Pressure 175 psi
 1. 1 inch to 2 inch: Schedule 40, Black or Galvanized steel pipe with threaded fittings, couplings, and joints.
 2. 2-1/2 inch to 4 inch: Schedule 40 , Black or Galvanized steel pipe with grooved fittings, couplings, and joints.
 3. 5 inch and larger: Schedule 10 or Schedule 40 , Black or Galvanized steel pipe with grooved fittings, couplings, and joints.
- C. Dry-Pipe and Double Interlock Pre-Action Sprinkler System Piping - Standard Pressure 175 psi
 1. 1 inch to 2 inch: Schedule 40, Galvanized steel pipe with threaded fittings, couplings, and joints.
- D. Underground fire-suppression water service piping:
 1. 8 inch and smaller: Ductile Iron pipe, Mechanical joint with standard fittings.
- E. Underslab fire-suppression water service piping:
 1. 8 inch and smaller: Ductile Iron pipe, Mechanical joint with restrained fittings.
- F. Drain piping, 2 inch and smaller:
 1. Schedule 40, Galvanized steel pipe with threaded fittings, couplings, and joints.

END OF SECTION 210500

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

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 210553 - Identification for Fire Suppression Piping and Equipment.
- B. Section 211300 - Fire-Suppression Sprinkler Systems.

1.03 REFERENCE STANDARDS

- A. ASME B1.20.1 - Pipe Threads, General Purpose, Inch.
- B. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- C. ASME B31.9 - Building Services Piping.
- D. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- E. AWWA C509 - Resilient-Seated Gate Valves for Water Supply Service.
- F. AWWA C606 - Grooved and Shouldered Joints.
- G. FM (AG) - FM Approval Guide.
- H. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- I. UL (DIR) - Online Certifications Directory.
- J. UL 262 - Gate Valves for Fire-Protection Service.
- K. UL 312 - Check Valves for Fire-Protection Service.
- L. UL 1091 - Standard for Butterfly Valves for Fire-Protection Service.

1.04 SUBMITTALS

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

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
 - 1. Obtain valves for each valve type from single manufacturer.
- B. Where listed products are specified, provide products listed, classified, and labeled by FM (AG) or UL (DIR) as suitable for the purpose indicated.
- C. Welding Materials and Procedures: Comply with ASME BPVC-IX.
- D. Installer Qualifications:
 - 1. Complies with manufacturer's certification requirements.

1.06 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:
 - 1. Main Level: HAMV - Fire Main Equipment.
 - a. Level 1: HLOT - Valves.
 - b. Level 3: HLUG - Ball Valves, System Control.
 - c. Level 3: HMER - Check Valves.
 - d. Level 3: HMRZ - Gate Valves.

2. Main Level: VDGT - Sprinkler System & Water Spray System Devices.
 - a. Level 1: VQGU - Valves, Trim, and Drain.
 - B. 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.
 - C. Comply with AWWA C606 for grooved-end connections.
 - D. Comply with NFPA 13 for valves.
 - E. Valve Pressure Ratings: Not less than minimum pressure rating indicated or higher as required.
 - F. Valve Sizes: Same as upstream piping unless otherwise indicated.
 - G. Valve Actuator Types:
 1. Worm-gear actuator with handwheel for quarter-turn valves, except trim and drain valves.
 2. Handwheel: For other than quarter-turn trim and drain valves.
 3. Hand-lever: For quarter-turn trim and drain valves 2 NPS and smaller.
- 2.02 TWO-PIECE BALL VALVES WITH INDICATORS
- A. Manufacturers:
 1. Globe Fire Sprinkler Company
 2. NIBCO Inc.
 3. Victaulic Company
 - B. UL 1091, except with ball instead of disc and FM (AG) standard listing for indicating valves (butterfly or ball type), Class Number 1112.
 - C. Description:
 1. Minimum Pressure Rating: 175 psig.
 2. Body Design: Two piece.
 3. Body Material: Forged brass.
 4. Port Size: Full.
 5. Seat: PTFE.
 6. Stem: Bronze or Stainless Steel.
 7. Ball: Chrome-plated brass.
 8. Actuator: Weatherproof housing with worm gear or traveling nut.
 9. Supervisory Switch: Internal or external.
 10. End connections of valves to match pipe type connections at respective sizes.
- 2.03 CHECK VALVES
- A. Manufacturers:
 1. Anvil International, Inc.
 2. Globe Fire Sprinkler Company
 3. NIBCO Inc.
 4. Reliable Automatic Sprinkler Co., Inc.
 5. Tyco Fire & Building Products LP.

- 6. Victaulic Company
- 7. Viking Corporation
- 8. Watts Water Technologies, Inc.

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

2.04 BRONZE OS&Y GATE VALVES

- A. Manufacturers:
 - 1. Milwaukee Valve Company
 - 2. NIBCO Inc.
 - 3. United Brass Works, Inc.
- B. UL 262 and FM (AG) standard listing for fire-service water control valves (OS&Y and NRS-type gate valves).
- C. Minimum Pressure Rating: 175 psig.
- D. Body and Bonnet Material: Bronze or brass.
- E. Wedge: One-piece bronze or brass.
- F. Wedge Seat: Bronze.
- G. Stem: Bronze or brass.
- H. Packing: Non-asbestos PTFE.
- I. Supervisory Switch: External.
- J. End Connections: Threaded.

2.05 IRON OS&Y GATE VALVES

- A. Manufacturers:
 - 1. Globe Fire Sprinkler Company
 - 2. Kennedy Valve
 - 3. Mueller Co.
 - 4. NIBCO Inc.
 - 5. Victaulic Company
 - 6. Watts Water Technologies, Inc.
- B. Listed and Body Marked: AWWA C509, FM (AG), and UL 262.

- C. Maximum Working Pressure: 175 psi.
- D. Body and Bonnet Material: Cast or ductile iron.
- E. Wedge: Cast or ductile iron, or bronze with elastomeric coating.
- F. Stem: Brass, bronze, or stainless steel.
- G. Packing: Non-asbestos PTFE.
- H. Supervisory Switch: External.

2.06 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.
- B. Angle Valves:
 - 1. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Material: Brass or bronze.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc: Bronze.
 - f. Packing: Asbestos free.
 - g. Handwheel: Malleable iron, bronze, or aluminum.
- C. Globe Valves:
 - 1. Description:
 - a. Pressure Rating: 175 psig.
 - b. Body Material: Bronze with integral seat and screw-in bonnet.
 - c. Ends: Threaded.
 - d. Stem: Bronze.
 - e. Disc Holder and Nut: Bronze.
 - f. Disc Seat: Nitrile.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron, bronze, or aluminum.

PART 3 EXECUTION

3.01 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.

3.02 INSTALLATION

- A. Comply with specific valve installation requirements and application in the following Sections:
 - 1. Section 211300 for application of valves in wet and dry pipe, fire-suppression sprinkler systems.
- B. Install listed fire protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections.
 - 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 210553 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 210523

SECTION 210548 - VIBRATION AND SEISMIC CONTROLS FOR FIRE SUPPRESSION PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Seismic control requirements.
 - 1. Includes requirements for seismic qualification of equipment not specified in this section.
- B. External seismic snubber assemblies.
- C. Seismic restraint systems

1.02 RELATED REQUIREMENTS

- A. Section 014533 - Code-Required Special Inspections and Procedures.

1.03 DEFINITIONS

- A. Fire Suppression Component: Where referenced in this section in regards to seismic controls, applies to any portion of the fire suppression system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., piping).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

1.04 REFERENCE STANDARDS

- A. ASCE 19 - Structural Applications of Steel Cables for Buildings.
- B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.
- C. FEMA 412 - Installing Seismic Restraints for Mechanical Equipment.
- D. FEMA 413 - Installing Seismic Restraints for Electrical Equipment.
- E. FEMA 414 - Installing Seismic Restraints for Duct and Pipe.
- F. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage.
- G. FM 1950 - Seismic Sway Braces for Pipe, Tubing and Conduit.
- H. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components.
- I. MFMA-4 - Metal Framing Standards Publication.
- J. NFPA 13 - Standard for the Installation of Sprinkler Systems.
- K. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems.

- L. UL 203A - Standard for Sway Brace Devices for Sprinkler System Piping.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Seismic Controls: Include seismic load capacities.
- D. Shop Drawings - Seismic Controls:
 - 1. Include dimensioned plan views and sections indicating proposed fire suppression component locations and distributed system routing, with locations and details of gravity supports and seismic restraints and associated attachments.
 - 2. Identify mounting conditions required for equipment seismic qualification.
 - 3. Identify anchor manufacturer, type, minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
 - 4. Indicate proposed arrangement of distributed system trapeze support groupings.
 - 5. Indicate proposed locations for distributed system flexible fittings and/or connections.
 - 6. Indicate locations of seismic separations where applicable.
 - 7. Include point load drawings indicating design loads transmitted to structure at each attachment location.
- E. Seismic Design Data:
 - 1. Compile information on project-specific characteristics of actual installed fire suppression components necessary for determining seismic design forces required to design appropriate seismic controls.
 - 2. Include structural calculations, stamped or sealed by seismic controls designer, demonstrating suitability of seismic controls for seismic design forces.
- F. Certification for seismically qualified equipment; identify basis for certification.
- G. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- H. Manufacturer's detailed field testing and inspection procedures.
- I. Field quality control test reports.

1.06 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Seismic Controls Designer Qualifications: Registered professional engineer licensed in the State in which the Project is located.
- C. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SEISMIC CONTROL REQUIREMENTS

- A. Design and provide fire suppression component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor fire suppression components.
- B. Seismic Design Criteria: As indicated on the structural drawings.
- C. Component Importance Factor (Ip): Fire suppression components to be assigned a component importance factor (Ip) of 1.5 unless otherwise indicated.
- D. Seismic Qualification of Equipment:
 - 1. Provide special certification for fire suppression equipment furnished under other sections and assigned a component importance factor (Ip) of 1.5, certifying that equipment will remain operable following a design level earthquake.
 - 2. Seismic qualification to be by shake table testing in accordance with recognized testing standard procedure, such as ICC-ES AC156, acceptable to authorities having jurisdiction.
 - 3. Notify Engineer of Record and obtain direction where mounting restrictions required by conditions of seismic certification conflict with specified requirements.
 - 4. Seismically qualified equipment to be furnished with factory-installed labels referencing certificate of compliance and associated mounting restrictions.
- E. Seismic Restraints:
 - 1. Provide seismic restraints for fire suppression components except where exempt according to applicable codes and specified seismic design criteria, as approved by authorities having jurisdiction.
 - 2. Seismic Restraint Exemptions, All Seismic Design Categories:
 - a. Fire Suppression Piping Exemptions, All Seismic Design Categories:
 - 1) Lateral sway bracing for piping individually supported within 6 inches of the structure measured between the top of pipe and the point of attachment to the structure, where all conditions for exception specified in NFPA 13 are met.
 - 2) Lateral sway bracing for branch lines smaller than 2-1/2 inches in diameter, where branch line restraint is provided in accordance with NFPA 13.
 - 3. Comply with applicable general recommendations of the following, where not in conflict with applicable codes, seismic design criteria, or other specified requirements:
 - a. ASHRAE (HVACA).
 - b. FEMA 412.
 - c. FEMA 413.
 - d. FEMA 414.
 - e. FEMA E-74.
 - f. SMACNA (SRM).

4. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
5. External Seismic Snubber Assemblies:
 - a. Provide quantity and arrangement of external seismic snubber assemblies as required to restrain equipment in all directions (both lateral and vertical).
 - b. Do not use external seismic snubber assemblies that restrain equipment only in one or more lateral directions (but not vertical) except where uplift forces are zero or are addressed by other restraints.
6. Seismic Restraint Systems:
 - a. Arrange restraint elements to avoid obstruction of sprinklers in accordance with NFPA 13.
 - b. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
 - c. Use only cable restraints to restrain vibration-isolated fire suppression components.
 - d. Use only one restraint system type for a given fire suppression component or distributed system (e.g., piping) run; mixing of cable and rigid restraints on a given component/run is not permitted.
 - e. Size restraint elements, including anchorage, to resist seismic loads as necessary to restrain fire suppression component in all lateral directions; consider bracket geometry in anchor load calculations.
 - f. Use rod stiffener clips to attach bracing to hanger rods as required to prevent rod buckling from vertical (upward) compressive load introduced by cable or rigid restraints loaded in tension, in excess of downward tensile load due to supported fire suppression component weight.
 - g. Select hanger rods and associated anchorage as required to accommodate vertical (downward) tensile load introduced by rigid restraints loaded in compression, in addition to downward tensile load due to supported fire suppression component weight.
 - h. Clevis hangers may only be used for attachment of transverse restraints; do not use for attachment of longitudinal restraints.
 - i. Where seismic restraints are attached to clevis hangers, provide clevis bolt reinforcement accessory to prevent clevis hanger deformation.
 - j. Do not introduce lateral loads on open bar joist chords or the weak axis of beams, or loads in any direction at other than panel points unless approved by project Structural Engineer of Record.

F. Seismic Attachments:

1. Comply with support and attachment requirements of NFPA 13.
2. Attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
3. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) or qualified evaluation service acceptable to authorities having jurisdiction for compliance with applicable building code, and qualified for seismic applications; concrete anchors to be qualified for installation in both cracked and uncracked concrete.
4. Do not use power-actuated fasteners.
5. Do not use friction clips (devices that rely on mechanically applied friction to resist loads). Beam clamps may be used for supporting sustained loads where provided with restraining straps, but not for sway bracing attachments as prohibited by NFPA 13.

6. Comply with anchor minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
7. Concrete Housekeeping Pads:
 - a. Increase size of pad as required to comply with anchor requirements.
 - b. Provide pad reinforcement and doweling to ensure integrity of pad and connection and to provide adequate load path from pad to supporting structure.

G. Seismic Interactions:

1. Include provisions to prevent seismic impact between fire suppression components and other structural or nonstructural components.
2. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.
3. Comply with minimum clearance requirements between other equipment, distribution systems, and associated supports and fire protection sprinkler system drops and sprigs.

H. Seismic Relative Displacement Provisions:

1. Use suitable fittings or flexible connections, in accordance with NFPA 13, to accommodate:
 - a. Relative displacements at connections between components, including distributed systems (e.g., piping); do not exceed load limits for equipment utility connections.
 - b. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.
 - c. Design displacements at seismic separations.
 - d. Anticipated drifts between floors.
2. Provide clearance around fire suppression system piping extending through walls, floors, platforms, and foundations in accordance with NFPA 13.
3. Include provisions to prevent interruption of utility service due to seismic displacements.

2.02 EXTERNAL SEISMIC SNUBBER ASSEMBLIES

- A. Description: Steel snubbing assemblies designed for external attachment to both equipment and supporting structure that, as part of a complete system, restrain equipment motion in all directions during a seismic event while maintaining vibration isolation during normal operation.
- B. Seismic Snubbing Elements:
 1. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 2. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

2.03 SEISMIC RESTRAINT SYSTEMS

- A. Description: System components and accessories specifically designed for field assembly and attachment of seismic restraints.
- B. Where required by NFPA 13, provide products listed as complying with UL 203A or FM 1950.
- C. Cable Restraints:
 1. Comply with ASCE 19.
 2. Cables: Pre-stretched, galvanized steel wire rope with certified break strength.
 3. Cable Connections: Use only swaged end fittings. Cable clips and wedge type end fittings are not permitted in accordance with ASCE 19.
 4. Use protective thimbles for cable loops where potential for cable damage exists.

- D. Rigid Restraints: Use MFMA-4 steel channel (strut), steel angle, or steel pipe for structural element; suitable for both compressive and tensile design loads.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 CODE-REQUIRED SPECIAL INSPECTIONS

- A. Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner in accordance with Section 014533 and statement of special inspections as required by applicable building code.
- B. Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 - 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 - 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C. Seismic special inspections include, but are not limited to:
 - 1. Seismically Qualified Equipment: Verification that label, anchorage, and mounting comply with certificate of compliance.
 - 2. Verification of required clearances between other equipment, distribution systems, and associated supports and fire protection sprinkler system drops and sprigs for Seismic Design Categories C, D, E, and F; periodic inspection.
- D. Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- E. Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.03 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. Seismic Controls:
1. Provide specified snubbing element air gap; remove any factory-installed spacers, debris, or other obstructions.
 2. Use only specified components, anchorage, and hardware evaluated by seismic design. Comply with conditions of seismic certification where applicable.
 3. Where mounting hole diameter exceeds bolt diameter by more than 0.125 inch, use epoxy grout, elastomeric grommet, or welded washer to reduce clearance to 0.125 inch or less.
 4. Equipment with Sheet Metal Housings:
 - a. Use Belleville washers to distribute stress over a larger surface area of the sheet metal connection interface as approved by manufacturer.
 - b. Attach additional steel as approved by manufacturer where required to transfer loads to structure.
 - c. Where mounting surface is irregular, do not shim housing; reinforce housing with additional steel as approved by manufacturer.
 5. Concrete Housekeeping Pads:
 - a. Size in accordance with seismic design to meet anchor requirements.
 - b. Install pad reinforcement and doweling in accordance with seismic design to ensure integrity of pad and associated connection to slab.
 6. Seismic Restraint Systems:
 - a. Do not attach seismic restraints and gravity supports to dissimilar parts of structure that may move differently during an earthquake.
 - b. Install restraints within permissible angles in accordance with seismic design.
 - c. Install cable restraints straight between component/run and structural attachment; do not bend around other nonstructural components or structural elements.
 - d. Install cable restraints for vibration-isolated components slightly slack to prevent short-circuiting of isolation.
 - e. Install hanger rod stiffeners where indicated using only specified clamps; do not weld stiffeners to hanger rod.

END OF SECTION 210548

SECTION 210553 - 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.
- B. ASTM D709 - Standard Specification for Laminated Thermosetting Materials.

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. Instrumentation: Tags.
- B. Major Control Components: Nameplates.
- C. Equipment: Nameplates.
- D. Piping: Pipe markers.
- E. Valves: Tags and ceiling tacks where above lay-in ceilings.

2.02 NAMEPLATES

- A. Description: Stainless steel with stamped letters and predrilled holes for attachment hardware.
 - 1. Letter Color: Black.
 - 2. Letter Height: 1/4 inch.
 - 3. Background Color: Stainless steel.
 - 4. Thickness: 0.025 inch.
 - 5. Minimum label size: 2-1/2 inch x 3/4 inch.
 - 6. Fasteners: Stainless steel rivits or self tapping screws.
 - 7. Adhesive: Contact-type permanant adhesive, compatible with label and with substrate.
 - 8. Label Content: Include equipment's drawing designation or unique equipment number, capacity and characteristic information including electrical requirements.

2.03 TAGS

- A. Metal Tags: Brass with stamped letters and predrilled holes for attachment hardware.
 - 1. Letter Color: White.
 - 2. Leter Height: 1/4 inch.
 - 3. Background Color: Red.
 - 4. Thickness: 0.032 inch
 - 5. Minimum tag size: 1-1/2 inch diameter.
 - 6. Fasteners: Brass wire-link chain or S-hook.

2.04 PIPE MARKERS

- A. 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 system type.

2.05 CEILING TACKS

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

PART 3 EXECUTION

3.01 PREPARATION

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

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. Locate where accessible and visibe when equipment is installed.
- B. Install tags on valves and control devices in piping systems. List tagged valves in a valve-tag schedule.
- C. Install plastic pipe markers or plastic tape pipe markers in accordance with manufacturer's instructions.
- D. Identify piping 3/4 inch diameter and larger.

1. Install in clear view and align with axis of piping.
2. 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.

END OF SECTION 210553

SECTION 211100 - FACILITY FIRE-SUPPRESSION WATER-SERVICE PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Water pipe.
- B. Bedding and cover materials.
- C. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 312316 - Excavation.
- C. Section 312316.13 - Trenching.
- D. Section 312323 - Fill.

1.03 REFERENCE STANDARDS

- A. ASTM A536 - Standard Specification for Ductile Iron Castings.
- B. ASTM C94/C94M - Standard Specification for Ready-Mixed Concrete.
- C. AWWA C105/A21.5 - Polyethylene Encasement for Ductile-Iron Pipe Systems.
- D. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.
- E. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- F. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.
- G. AWWA C600 - Installation of Ductile-Iron Mains and Their Appurtenances.
- H. NFPA 13 - Standard for the Installation of Sprinkler Systems.

1.04 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.
- B. Sequencing: Ensure that utility connections are achieved in an orderly and expeditious manner.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data:

1. Include data on pipe materials, pipe fittings, valves, and accessories.
 2. Provide manufacturer's catalog information.
- C. Project Record Documents:
1. Record actual locations of piping mains, connections, thrust restraints, and invert elevations.
 2. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.
- D. Maintenance Data: Include installation instructions, spare parts lists, and exploded assembly views.

1.06 QUALITY ASSURANCE

- A. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- B. Perform Work in accordance with local authorities having jurisdiction, municipality, and water utility requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

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

1.08 FIELD CONDITIONS

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

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 WATER PIPE

- A. Ductile Iron Pipe: Listed, AWWA C151/A21.51.
 1. Joints: Mechanical-joint bell and plain spigot end.
 2. Fittings: AWWA C110/A21.10, ductile iron, standard thickness.
 3. Gaskets: AWWA C111/A21.11, styrene-butadiene rubber (SBR) or vulcanized SBR rubber gasket with 3/4 inch diameter rods.

2.02 BEDDING AND COVER MATERIALS

- A. Bedding: As specified in Section 312316.13.
- B. Cover: As specified in Section 312316.13.

2.03 ACCESSORIES

- A. Concrete for Thrust Restraints: Concrete type specified in Section 033000.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that building service connection and municipal utility water main size, location, and invert are as indicated.

3.02 PREPARATION

- A. Cut pipe ends square, ream pipe and tube ends to full pipe diameter, remove burrs.
- B. Remove scale and dirt on inside and outside before assembly.
- C. Prepare pipe connections to equipment with flanges or unions.

3.03 TRENCHING

- A. Earthwork: Perform earthwork operations in accordance with Sections 312316, 312316.13, and 312323.
- B. Hand trim excavation for accurate placement of pipe to elevations indicated.
- C. Form and place concrete for pipe thrust restraints at each change of pipe direction. Place concrete to permit full access to pipe and pipe accessories.
- D. Backfill around sides and to top of pipe with cover fill, tamp in place and compact, then complete backfilling.

3.04 INSTALLATION

- A. General Requirements:
 - 1. Location of Water Lines:
 - a. Terminate the work covered by this Section at a point approximately 5 feet from the building unless indicated otherwise.
 - b. Do not install water line closer horizontally than 10 feet from any sewer line unless indicated otherwise.
 - c. Do not install water lines in the same trench with gas lines, fuel lines, or electric wiring.
 - 2. Sleeving:
 - a. Sleeve water piping where piping is required to be installed within 3 feet of existing structures, passes through, or under foundation walls
 - b. Provide Schedule 40 steel sleeves two pipe diameters larger than carrier pipe.
 - c. Fill annular space between pipe and sleeves with mastic.
 - d. Install water pipe and sleeve without damaging structures or causing settlement or movement of foundations or footings.
 - 3. Pipe Laying and Jointing:

- a. Remove fins and burrs from pipe and fittings.
 - b. Prior to placing in position, clean pipe, fittings, valves, and accessories, and maintain in clean condition.
 - c. Provide proper facilities for lowering pipe sections into trenches.
 - d. Dropping or dumping of piping, fittings, valves, or any other water line material into trenches is not permitted.
 - e. Cut pipe in a neat, workmanlike manner accurately to length established at the site and work into place without forcing or springing.
 - f. Replace by one of the proper length any pipe or fitting that does not allow sufficient space for proper installation of jointing material.
 - g. Wedging or blocking between bells and spigots will not be permitted.
 - h. Install bell-and-spigot pipe with the bell end pointing in the direction of laying.
 - i. Grade the pipeline in straight lines avoiding the formation of dips and low points.
 - j. Support piping at proper elevation and grade.
 - k. Secure firm, uniform support.
 - l. Wood support blocking will not be permitted.
 - m. Install pipe so that the full length of each pipe section and each fitting will rest solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings.
 - n. Provide anchors and supports where indicated and necessary for fastening work into place.
 - o. Provide proper provisions for expansion and contraction of pipelines.
 - p. Keep trenches free of water until joints have been properly made.
 - q. Close open ends of piping temporarily with wood blocks or bulkheads at the end of each workday.
 - r. Do not install pipe during unacceptable trench conditions or inclement weather.
 - s. Minimum Depth of Pipe Cover: Top of pipe shall be at least 4 inches below local frost line, but never less than 2-1/2 feet of cover.
4. Connections to Existing Water Lines:
- a. Ensure minimal interruption of service on the existing line.
 - b. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped.
5. Flanged Pipe: Install only above grade or with the flanges in valve pits.

B. Special Requirements:

- 1. Ductile Iron Piping:
 - a. Unless otherwise specified, install pipe and fittings in accordance with paragraph "General Requirements".
 - b. Jointing:
 - 1) Make push-on joints with the gaskets and lubricant specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly.
 - 2) Make mechanical joints with the gaskets, glands, bolts, and nuts specified for this type joint; assemble in accordance with the applicable requirements of AWWA C600 for joint assembly and the recommendations of Appendix A to AWWA C111/A21.11.
 - c. Allowable Deflection:
 - 1) Maximum Allowable Deflection: As stated in AWWA C600.
 - 2) If the alignment requires deflection in excess of the above limitations, furnish special blends or a sufficient number of shorter pipe lengths to provide angular deflections within the limit set forth.

- d. Pipe Anchorage:
 - 1) Provide concrete thrust blocks (reaction backing), for pipe anchorage except where metal harness is indicated.
 - 2) Thrust blocks to comply with the requirements of AWWA C600 for thrust restraint, except that size and positioning of thrust blocks to be as indicated.
 - 3) Use concrete, ASTM C94/C94M, having a minimum compressive strength of 4,000 psi at 28 days; or use concrete of a mix not leaner than one part cement, 2-1/2 parts sand, and 5 parts gravel, having the same minimum compressive strength.
 - 4) Provide metal harness in accordance with the requirements of AWWA C600 for thrust restraint, using tie rods and clamps as indicated in NFPA 13, except as otherwise indicated.
- e. Exterior Protection: Completely encase buried ductile iron pipelines with polyethylene tube or sheet, using Class A polyethylene film, in accordance with AWWA C105/A21.5.

3.05 SERVICE CONNECTIONS

- A. Provide fire water service from where civil documents end 5 feet outside of the building, to location indicated inside building. Terminate piping in water room indicated with a flange located 6 inches above finished floor.

3.06 FIELD QUALITY CONTROL

- A. Field Tests and Inspections:
 - 1. See Section 014000 - Quality Requirements for additional requirements.
 - 2. Provide all labor, equipment, and incidentals required for field testing, except that water and electric power needed for field tests will be furnished as set forth in Section 015100 - Temporary Utilities.
 - 3. Conduct piping tests before joints are covered and after concrete thrust blocks have hardened sufficiently and at least 5 days after placing of concrete.
 - 4. Fill pipeline 24 hours before testing and apply test pressure to stabilize system, using only potable water.
 - 5. Pressure test piping to requirements in NFPA 24.
 - 6. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.
 - 7. Prepare reports of testing activities.

END OF SECTION 211100

SECTION 211300 - FIRE-SUPPRESSION SPRINKLER SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 210500 - Common Work Results for Fire Suppression: Pipe and fittings.
- B. Section 210523 - General-Duty Valves for Water-Based Fire-Suppression Piping.
- C. Section 210553 - Identification for Fire Suppression Piping and Equipment.

1.03 REFERENCE STANDARDS

- A. FM (AG) - FM Approval Guide.
- B. NFPA 1963 - Standard for Fire Hose Connections.
- C. UL (DIR) - Online Certifications Directory.
- D. UL 405 - Standard for Safety Fire Department Connection Devices.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on sprinklers, valves, and specialties, including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Shop Drawings:
 - 1. Submit preliminary layout of finished ceiling areas indicating only sprinkler locations coordinated with ceiling installation.
 - 2. Indicate hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components, and accessories. Indicate system controls.
- D. Delegated Design Submittal: For sprinkler systems indicated to comply with performance requirements and design criteria, include analysis data, hydraulic calculations, detailed pipe layout, hangers and supports, sprinklers, components, and accessories stamped and signed by the qualified professional engineer responsible for their preparation.

- E. Fire hydrant flow test must be performed within 12 months of permit plan submission. Perform fire-hydrant flow test, record, and submit the following information:
 - 1. Date
 - 2. Time
 - 3. Performed by
 - 4. Location of Residual Fire Hydrant, "R"
 - 5. Location of Flow Fire Hydrant, "F"
 - 6. Static Pressure at Residual Fire Hydrant R (psig)
 - 7. Measured Flow at Flow Fire Hydrant F (gpm)
 - 8. Residual Pressure at Residual Fire Hydrant R (psig)
- F. Installer's qualification statement.
- G. 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.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.
 - 2. Extra Sprinklers: Type and size matching those installed in quantity required by referenced NFPA design and installation standard.
 - 3. Sprinkler Wrenches: For each sprinkler type.
- I. Project Record Documents: Record actual locations of sprinklers and deviations of piping from drawings. Indicate drain and test locations.

1.05 QUALITY ASSURANCE

- A. Comply with FM (AG) requirements.
- B. Designer Qualifications: Design system under direct supervision of a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- C. Installer Qualifications: Company specializing in performing the work of this section with documented experience and approved by manufacturer.
- D. Equipment and Components: Provide products that bear FM (AG) label or marking.
- E. Products Requiring Electrical Connection: Listed and classified by UL (DIR) as suitable for the purpose specified and indicated.

1.06 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. Globe Fire Sprinkler Corporation
2. Reliable Automatic Sprinkler Co., Inc.
3. Tyco Fire Protection Products
4. Victaulic Company
5. Viking Corporation

2.02 SPRINKLER SYSTEM

- A. Sprinkler System: Provide coverage for entire building.
- B. Delegated Design: Engage a qualified professional engineer to design sprinkler system(s), including comprehensive engineering analysis using performance requirements and design criteria indicated.
- C. System Pressure: All sprinklers, valves, and equipment shall be rated for operating pressures up to 175 psi.
- D. Margin of Safety: A 10 percent margin of safety shall be included in all hydraulic calculations, including losses through piping, valves and backflow preventers.
- E. Occupancy: As indicated below, and per NFPA 13.
 1. Electrical Equipment Rooms: Ordinary Hazard, Group 1
 2. General Storage Areas: Ordinary Hazard, Group 1
 3. Indoor Vehicle Parking: Ordinary Hazard, Group 1
 4. Kitchen Areas: Ordinary Hazard, Group 1
 5. Mechanical Equipment Rooms: Ordinary Hazard, Group 1
 6. Office, Corridors, and Public Areas: Light Hazard
 7. Special Occupancy Hazards: As determined by NFPA 13 and authorities having jurisdiction.
- F. Water Supply: Determine volume and pressure from water flow test data obtained.
- G. Provide fire department connections where indicated.
- H. Storage Cabinet for Spare Sprinklers and Tools: Steel, locate near water service and sprinkler zone risers..

2.03 SPRINKLERS

- A. Sprinklers for light and ordinary hazard classification areas to be quick response type with ordinary temperature, red glass bulb type, having a minimum temperature rating of 155°F, unless specifically indicated otherwise or prohibited by NFPA 13.
- B. Sprinklers for extra hazard classification areas, generator rooms, and trash rooms to be standard response type with high temperature, blue glass bulb type, having a minimum temperature rating of 280°F, unless specifically indicated otherwise or prohibited by NFPA 13.
- C. Characteristics: Nominal 1/2 inch orifice with discharge coefficient of 5.6K and as follows for specific applications:
 1. Apparatus Bays - 8.0K
- D. Suspended Ceiling Type: Semi-recessed and Concealed pendant type with matching push on escutcheon or cover plate, as indicated in Sprinkler Schedule at the end of Part 3 below or on drawings.

1. Coverage Type: Standard and Extended.
 2. Standard Finish: Bronze, Brass, or Polyester white.
 3. Corrosion-Resistant Finish: Electroless Nickel.
 4. Escutcheon and Cover Plate Finish: Polyester white.
- E. Exposed Area Type: Upright type, as indicated in Sprinkler Schedule at the end of Part 3 below or on drawings.
1. Coverage Type: Standard and Extended.
 2. Standard Finish: Bronze, Brass, or Polyester white.
 3. Corrosion-Resistant Finish: Electroless Nickel, Electroless Nickel PTFE Plated, or Nickel/Teflon coating.
- F. Sidewall Type: Semi-recessed and Standard horizontal sidewall type with matching push on escutcheon or cover plate, as indicated in Sprinkler Schedule at the end of Part 3 below or on drawings.
1. Coverage Type: Standard and Extended.
 2. Standard Finish: Bronze or Polyester white.
 3. Corrosion-Resistant Finish: Electroless Nickel, Electroless Nickel PTFE Plated, or Nickel/Teflon coating.
 4. Escutcheon Plate Finish: Polyester white.
- G. Dry Sprinklers: Semi-recessed side wall type with matching push on escutcheon or cover plate, as indicated in Sprinkler Schedule at the end of Part 3 below or on drawings.
1. Coverage Type: Standard.
 2. Standard Finish: Polyester white.
 3. Corrosion-Resistant Finish: Electroless Nickel, Electroless Nickel PTFE Plated, or Nickel/Teflon coating.
 4. Escutcheon Plate Finish: Polyester white.
- H. Guards: Wire cage with fastening device for attaching to sprinkler. Finish to match sprinkler finish.
- I. Flexible Drop System: Stainless steel, multiple use, open gate type.
1. Application: Permitted for wet systems in suspended ACT ceiling applications only. System shall be UL listed and FM Approved for sprinkler services to 175 psi.
 2. Include all supports, bracing and brackets required for installation and to attach to ACT ceiling grid. Bracket attached to ceiling grid shall allow installation before the ceiling tile is in place.
 3. Provide 304 stainless steel, braided type flexible tube as required for the application. Flexible tube shall have a UL approved minimum bend radius of 3 inches.
 4. Maximum tube length shall be 6 feet.
 5. Flexible tube connection to branch piping shall only be permitted to be on the top half of the branch pipe.

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.

4. Include taps for inlet and outlet pressure gauges.
- B. Floor Control - Zone Assembly
1. Description: Universal Manifold Check Valve
 2. Where universal manifold check valves are installed for use in wet-pipe sprinkler systems, as floor control manifolds they shall be specifically listed for such use.
 3. Universal manifold check valves shall be ductile iron construction, incorporating a control valve, check valve, flow switch, test & drain assembly, adjustable relief valve, and system gauges in one compact body/footprint, and shall be manufactured for “right” and “left”-hand orientations.
 4. The test & drain assemble shall contain an adjustable relief valve, with a range of 175 to 310 psi, and a universal test orifice of K5.6; to provide testing capabilities of systems with k-factors ranging from K5.6 and larger.
 5. Universal manifold check valve shall be rated for use at the maximum service pressure of 300 psi
 6. Standard: UL listed and FM approved
- C. Dry Pipe Sprinkler Alarm Valve: Check type valve with divided seat ring, rubber faced clapper to automatically actuate water motor alarm, accelerator, and with the following additional capabilities and features:
1. Activate electric alarm.
 2. Test and drain valve.
 3. Externally resettable.
 4. Replaceable internal components without removing valve from installed position.
 5. Provide with full trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
 6. Pressure Maintenance Device: Automatic device to maintain minimum air pressure in piping. Including shut-off valves for servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig outlet pressure.
 7. Anti-flooding device.
 8. Manufacturers:
 - a. Globe Fire Sprinkler Corporation
 - b. Reliable Automatic Sprinkler Co., Inc.
 - c. Tyco Fire & Building Products LP.
 - d. Victaulic Company: www.victaulic.com/#sle.
 - e. Viking Corporation.
- D. Backflow Preventer: Double check detector assembly backflow preventer.
1. Standards: ASSE 1048 and UL (Dir) or FM (AG).
 2. Operation: Continuous pressure applications.
 3. Size: As indicated on drawings.
 4. Body Material: Cast Bronze.
 5. End Connections: Grooved.
 6. Configuration: Designed for horizontal, straight through flow.
 7. Valves:
 - a. Standard: UL 262 and FM (AG).
 - b. Type: OS&Y gate valve.
 - c. Location: Inlet and outlet of backflow preventer.
 8. Manufacturers:
 - a. Flowmatic Corporation

- b. Watts; a Watts Water Technologies Company
 - c. Wilkins; Zurn Industries.
- E. Test Connections:
 - 1. Inspector's Test Connection for Dry and Preaction Systems:
 - a. Body Material: Bronze, Cast- or ductile-iron housing with integral sight glass.
 - b. Valve Type: Multi-position valve with positions for closed, test, and drain.
 - 1) Test position shall be equivalent to a 1/2 inch sprinkler orifice discharge.
 - c. Size: 1 inch inlet and outlet.
 - d. Inlet and Outlet: Threaded or Grooved ends.
 - e. Provide test connection located at the most hydraulically remote part of each system zone.
- F. Electric Alarm: Electrically operated red enameled alarm bell.
 - 1. Standard: UL 464
 - 2. Voltage: 24V.
 - 3. Type: Vibrating, metal alarm bell.
 - 4. Size: 6 inch minimum diameter.
 - 5. Manufacturers:
 - a. Fire-Lite Alarms, Inc; a Honeywell company
 - b. Notifier; a Honeywell company.
 - c. Potter Electric Signal Company.
 - d. System Sensor.
- G. Water Flow Switch:.
 - 1. Standard: UL 346
 - 2. Water Flow Detector: Electrically supervised.
 - 3. 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
 - 4. Type: Paddle operated
 - 5. Pressure rating: 250 psig.
 - 6. Manufacturers:
 - a. ADT Security Services, Inc.
 - b. Potter Electric Signal Company
 - c. System Sensor
 - d. Viking Corporation
- H. Fire Department Connections:
 - 1. Type: Flush, wall mount made of corrosion resistant metal complying with UL 405.
 - a. Inlets: Two way, threaded brass, 2-1/2 inch diameter. Thread size and inlets according to NFPA 1963 or Authority Having Jurisdiction. Brass caps with gaskets, chains, and lugs.
 - b. Configuration: Horizontal.
 - c. Outlet: With pipe threads, 4 NPS.
 - 1) Location: Back.
 - d. Rated Working Pressure: 175 psi.
 - e. Finish: Rough bronze.
 - f. Signage: Raised or engraved lettering 1 inch minimum indicating system type.
 - g. Manufacturers:
 - 1) American Fire Hose and Cabinet
 - 2) Elkhart Brass Manufacturing Company, Inc

- 3) Fire End & Croker Corporation
- 4) Guardian Fire Equipment, Inc.
- 5) Potter Roemer

- I. Valve Supervisory Switches:
 1. All isolating valves in a fire protection system shall be supervised.
 2. Standard: UL 346
 3. Type: Electrically supervised.
 4. Components: Single-pole, double-throw switch with normally closed contacts.
 5. Design: Signals that controlled valve is in other than fully open position.
 6. Manufacturers:
 - a. ADT Security Services, Inc.
 - b. Potter Electric Signal Company
 - c. System Sensor
 - d. Viking Corporation

2.05 AIR COMPRESSOR

- A. Manufacturers:
 1. Gast Manufacturing Inc.
 2. General Air Products, Inc.
 3. Victaulic Company
 4. Viking Corporation
- B. Air compressor must be capable of restoring normal air pressure within the largest zone within 30 minutes.
- C. Compressor: Single-unit, electric motor driven, motor, motor starter, safety valves, check valves, air maintenance device incorporating electric pressure switch and unloader valve.
- D. Riser Mounted
- E. Accessories
 1. Pressure Maintenance Device: Automatic device to maintain minimum air pressure in piping. Including shut-off valves for servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig outlet pressure.

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. Locate outside alarm gong on building wall as indicated.
- D. Place pipe runs to minimize obstruction to other work.
- E. Place piping in concealed spaces above finished ceilings.

- F. 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.
- G. Flush entire piping system of foreign matter.
- H. Install guards on sprinklers installed at a height of 78 inches or lower..
- I. Hydrostatically test entire system.
- J. Require test be witnessed by Fire Marshal.

3.02 SCHEDULES

- A. Sprinklers:
 - 1. Spaces with Ceilings: Semi-Recessed Pendant sprinkler, with polyester white finish.
 - 2. Wall Mounting: Semi-Recessed horizontal sidewall sprinkler, with polyester white finish.
 - 3. Below Overhead Doors: Horizontal sidewall sprinkler, with corrosion resistant finish.
 - 4. Finished Spaces without Ceilings: Upright sprinkler, with chrome finish.
 - 5. Unfinished Spaces without Ceilings: Upright sprinkler, with bronze finish.
 - 6. Through Exterior or IT Room Wall: Dry-type horizontal sidewall sprinkler, with corrosion resistant finish.
 - 7. Special Applications: Extended-coverage, flow-control and ESFR sprinklers where indicated with finish to match other heads in space or in accordance with finish above.
 - 8. Corrosive Environments: Corrosion resistant finish shall be factory applied to all heads exposed to acids, chemical, moisture or other corrosive fumes.

END OF SECTION 211300

SECTION 220517 - SLEEVES AND SLEEVE SEALS FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 220719 - Plumbing 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).
- B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
- C. FM (AG) - FM Approval Guide.
- D. UL (DIR) - Online Certifications Directory.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.

1.05 QUALITY ASSURANCE

- A. 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.

PART 2 PRODUCTS

2.01 PIPE SLEEVES

- A. Manufacturers:
 - 1. Flexicraft Industries; Pipe Wall Sleeve: www.flexicraft.com/#sle.
- B. 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.
- C. Plastic or Sheet Metal: Pipe passing through interior walls, partitions, and floors, unless steel or brass sleeves are specified below.
- D. 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.
- E. Clearances:
 - 1. Provide allowance for insulated piping.
 - 2. Wall, Floor, and Partitions: 1 inch greater than external pipe diameter.
 - 3. All Rated Openings: Caulked tight with fire stopping material complying with ASTM E814 in accordance with Section 078400 to prevent the spread of fire, smoke, and gases.

2.02 PIPE-SLEEVE SEALS

- A. Manufacturers:
 - 1. Advance Products & Systems, LLC; Innerlynx: www.apsonline.com/#sle.
 - 2. American Polywater Corporation; PGKD Modular Seals: www.polywater-haufftechnik.com/#sle.
 - 3. Flexicraft Industries; PipeSeal: www.flexicraft.com/#sle.
- B. Modular Mechanical Sleeve-Seal:
 - 1. Elastomer-based interlocking links continuously fill annular space between pipe and wall-sleeve, wall or casing opening.
 - 2. Watertight seal between pipe and wall-sleeve, wall or casing opening.
 - 3. Size and select seal component materials in accordance with service requirements.
 - 4. Service Requirements:
 - a. Corrosion resistant.
 - b. Oil, fuel, gas, and solvent resistant.
 - c. Underground, buried, and wet conditions.
 - d. Fire Resistant: 1 hour, UL (DIR) approved.
 - 5. Glass-reinforced plastic pressure end plates.
- C. Sealing Compounds:
 - 1. Provide packing and sealing compound to fill pipe to sleeve thickness.
 - 2. Combined packing and sealing compounding to match partition fire-resistance hourly rating.
- D. Pipe Sleeve Material:
 - 1. Bearing Walls: Steel.

- 2. Masonry Structures: Sheet metal or fiber.
- E. Wall Sleeve: PVC material with waterstop collar, and nailer end-caps.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Route piping in orderly manner, plumb and parallel to building structure. Maintain gradient.
- B. Install piping to conserve building space, to not interfere with use of space and other work.
- C. Install piping and pipe sleeves to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- D. Inserts:
 - 1. Provide inserts for placement in concrete formwork.
 - 2. Provide inserts for suspending hangers from reinforced concrete slabs and sides of reinforced concrete beams.
 - 3. Provide hooked rod to concrete reinforcement section for inserts carrying pipe over 4 inches.
 - 4. Where concrete slabs form finished ceiling, locate inserts flush with slab surface.
 - 5. Where inserts are omitted, drill through concrete slab from below and provide through-bolt with recessed square steel plate and nut above slab.
- E. Structural Considerations: Do not penetrate building structural members unless indicated.
- F. Provide sleeves when penetrating footings, floors, walls, and partitions. Seal pipe including sleeve penetrations to achieve fire resistance equivalent to fire separation required.
 - 1. 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 Section 078400 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.
- G. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.

4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 5. Tighten bolting for a water-tight seal.
 6. Install in accordance with manufacturer's recommendations.
- H. When installing more than one piping system material, ensure system components are compatible and joined to ensure the integrity of the system. Provide necessary joining fittings. Ensure flanges, union, and couplings for servicing are consistently provided.

3.03 CLEANING

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

END OF SECTION 220517

SECTION 220519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pressure Gauges:
 - 1. Bourdon tube for liquids and gases.
- B. Thermometers.

1.02 REFERENCE STANDARDS

- A. ASME B40.100 - Pressure Gauges and Gauge Attachments.
- B. ASTM E1 - Standard Specification for ASTM Liquid-in-Glass Thermometers.
- C. ASTM E77 - Standard Test Method for Inspection and Verification of Thermometers.
- D. NSF 61 - Drinking Water System Components - Health Effects.
- E. NSF 372 - Drinking Water System Components - Lead Content.
- F. UL 393 - Indicating Pressure Gauges for Fire-Protection Service.
- G. UL 404 - Gauges, Indicating Pressure, for Compressed Gas Service.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide red-marked product data sheets for each furnished item with associated components and accessories.

PART 2 PRODUCTS

2.01 PRESSURE GAUGES

- A. Manufacturers:
 - 1. Ashcroft, Inc; _____: www.ashcroft.com/#sle.
 - 2. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/#sle.
 - 3. Moeller Instrument Company, Inc; _____: www.moellerinstrument.com/#sle.
 - 4. Omega Engineering a subsidiary of Spectris, Plc; [_____]: www.omega.com/#sle.
 - 5. Weksler Glass Thermometer Corp; _____: www.wekslerglass.com/#sle.
- B. Bourdon Tube for Liquids and Gases:
 - 1. Dial Size and Cover: 4-1/2 inch diameter scale with polycarbonate window.
 - 2. Dial Text and Markings: Black color on white background with scaled kPa and psi units.
 - 3. Accuracy: ASME B40.100, adjustable commercial grade (D) with 5 percent of span.
 - 4. Process Connection: Lower-back, 1/4 inch NPT male except where noted.

5. Gauge Wetted Materials: Painted steel case and brass socket rated to match process pressure and temperature range.
6. Comply with UL 393 when used for fire protection service or UL 404 when used for compressed gas service.

C. Accessories:

1. Air or Gas Sensor: Static pressure with compression fittings for bulkhead mounting and 1/4 inch diameter tubing.
2. Gauge Cock: Carbon steel with tee or lever handle for maximum 150 psi.
3. Needle Valve: Carbon steel, 1/4 inch NPT female for noncorrosive service.
4. Pressure Snubber (Pulsation Damper): Brass, 1/4 inch NPT male.

2.02 THERMOMETERS

A. Manufacturers:

1. Dwyer Instruments, Inc; _____: www.dwyer-inst.com/
2. Trerice; _____: www.trerice.com/
3. Watts Water Technologies, Inc; _____: www.watts.com/
4. Weiss Instruments, LLC; _____: www.weissinstruments.com/
5. Winters; _____: www.winters.com/

B. General:

1. Product Compliance: ASTM E1.
2. Lens: Clear glass, except where stated.
3. Accuracy: One percent, when tested in accordance with ASTM E77, except where stated.
4. Scale: Black markings depicting single scale in degrees F where expected process value falls half-span of standard temperature range.

C. Thermometers - Adjustable Angle: 7 inch v-shape aluminum case with clear glass window scale, 6 inch NPT stem, red or blue organic non-toxic liquid filled glass tube, and adjustable joint with positive locking device allowing 360 degrees in horizontal plane or 180 degrees in vertical plane adjustments.

D. Thermometers - Dial Type:

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verification of Conditions: Verify Utility Service Provider piping readiness to receive meter.
- B. Do not install instrumentation when areas are under construction, except for required rough-in, taps, supports, and test plugs.

3.02 INSTALLATION

A. Install pressure gauges as follows:

1. At Pumps: Place single gauge before strainer, suction side and discharge side.
2. Include gauge cock to isolate each gauge and extend nipples for insulation clearance.
3. Adjust gauges to selected viewing angle, clean thoroughly, and calibrate to zero.

- B. Install thermometers as follows:
 - 1. Hot Water Heaters: Place upstream and downstream of heater. Add one on the inlet end when using steam as the water heating medium.

3.03 SCHEDULES

- A. Pressure Gauges, Location and Scale Range:
 - 1. Pumps, 0 to 100 psi.
 - 2. Expansion tanks, 0 to 120 psi.
 - 3. Pressure reducing valves, 0 to 100 psi.
 - 4. Backflow preventers, 0 to 100 psi.
- B. Pressure Gauge Tappings, Location:
 - 1. Upstream and downstream of backflow preventers

END OF SECTION 220519

SECTION 220523 - GENERAL-DUTY VALVES FOR PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Ball valves.
- B. Check valves.
- C. Gate valves.
- D. Globe valves.

1.02 REFERENCE STANDARDS

- A. API STD 594 - Check Valves: Flanged, Lug, Wafer, and Butt-Welding.
- B. ASME B1.20.1 - Pipe Threads, General Purpose, Inch.
- C. ASME B16.1 - Gray Iron Pipe Flanges and Flanged Fittings: Classes 25, 125, and 250.
- D. ASME B16.5 - Pipe Flanges and Flanged Fittings NPS 1/2 Through NPS 24 Metric/Inch Standard.
- E. ASME B16.10 - Face-to-Face and End-to-End Dimensions of Valves.
- F. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- G. ASME B16.34 - Valves — Flanged, Threaded, and Welding End.
- H. ASME B31.9 - Building Services Piping.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- J. ASTM A48/A48M - Standard Specification for Gray Iron Castings.
- K. ASTM A126 - Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings.
- L. ASTM A216/A216M - Standard Specification for Steel Castings, Carbon, Suitable for Fusion Welding, for High-Temperature Service.
- M. ASTM A536 - Standard Specification for Ductile Iron Castings.
- N. ASTM B61 - Standard Specification for Steam or Valve Bronze Castings.
- O. ASTM B62 - Standard Specification for Composition Bronze or Ounce Metal Castings.
- P. MSS SP-45 - Drain and Bypass Connections.
- Q. MSS SP-70 - Gray Iron Gate Valves, Flanged and Threaded Ends.

- R. MSS SP-71 - Gray Iron Swing Check Valves, Flanged and Threaded Ends.
- S. MSS SP-72 - Ball Valves with Flanged or Butt-Welding Ends for General Service.
- T. MSS SP-78 - Gray Iron Plug Valves, Flanged and Threaded Ends.
- U. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves.
- V. MSS SP-85 - Gray Iron Globe and Angle Valves, Flanged and Threaded Ends.
- W. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- X. NSF 61 - Drinking Water System Components - Health Effects.
- Y. NSF 372 - Drinking Water System Components - Lead Content.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on valves including manufacturers catalog information. Submit performance ratings, rough-in details, weights, support requirements, and piping connections.
- C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, maintenance and repair data, and parts listings.

1.04 QUALITY ASSURANCE

- A. Manufacturer:
 - 1. Obtain valves for each valve type from single manufacturer.
- B. Welding Materials and Procedures: Comply with ASME BPVC-IX.

1.05 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.
- 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.

1.06 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. See drawings for specific valve locations.
- B. Listed pipe sizes shown using nominal pipe sizes (NPS) and nominal diameter (DN).
- C. Provide the following valves for the applications if not indicated on drawings:
 - 1. Shutoff: Ball and gate.
 - 2. Throttling: Provide globe.
 - 3. Swing Check (Pump Outlet):
 - a. 2 inch and Smaller: Bronze swing check valves with bronze or nonmetallic disc.
 - b. 2-1/2 inch and Larger for Domestic Water: Iron swing check valves with closure control, metal or resilient seat check valves.
- D. Substitutions of valves with higher CWP classes or WSP ratings for same valve types are permitted when specified CWP ratings or WSP classes are not available.
- E. Low Pressure, Compressed Air Valves 150 psi or Less:
 - 1. 2 inch and Smaller:
 - a. Bronze: Provide with solder-joint or threaded ends.
 - b. Ball: One piece, full port, brass with brass trim.
 - c. Bronze Lift Check: Class 125, bronze disc.
 - d. Bronze Swing Check: Class 125, bronze disc.
- F. Domestic, Hot and Cold Water Valves:
 - 1. 2 inch and Smaller:
 - a. Ball: Two piece, full port, brass with brass trim.
 - b. Bronze Swing Check: Class 125, bronze disc.
 - c. Bronze Gate: Class 125, NRS.
 - d. Bronze Globe: Class 125, bronze disc.
 - 2. 2-1/2 inch and Larger:
 - a. Iron, 2-1/2 inch to 4 inch: Provide with flanged ends.
 - b. Iron Ball: Class 150.
 - 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. Valve Actuator Types:
 - 1. Gear Actuator: Quarter-turn valves 8 inch and larger.
 - 2. Handwheel: Valves other than quarter-turn types.
 - 3. Hand Lever: Quarter-turn valves 6 inch and smaller except plug valves.
- D. Insulated Piping Valves: With 2 inch stem extensions 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.
- E. Valve-End Connections:
 1. Threaded End Valves: ASME B1.20.1.
 2. Flanges on Iron Valves: ASME B16.1 for flanges on iron valves.
 3. Pipe Flanges and Flanged Fittings 1/2 inch through 24 inch: ASME B16.5.
 4. Solder Joint Connections: ASME B16.18.
- F. 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.
- G. Potable Water Use:
 1. Certified: Approved for use in compliance with NSF 61 and NSF 372.
 2. Lead-Free Certified: Wetted surface material includes less than 0.25 percent lead content.
- H. Valve Bypass and Drain Connections: MSS SP-45.
- I. Source Limitations: Obtain each valve type from a single manufacturer.

2.03 BRASS, BALL VALVES

- A. Two Piece, Full Port with Brass Trim and Female Thread, Male thread, or Solder Connections:
 1. Comply with MSS SP-110.
 2. WSP Rating: 150 psi.
 3. WOG Rating: 600 psi.
 4. Vacuum Rating: 28.9 in-Hg.
 5. Body: Forged brass.
 6. Seats: PTFE.
 7. Stem: Brass.
 8. Ball: Chrome-plated brass.
 9. Cap: Include cap-gasket and chain for 3/4 inch hose connection.
 10. Operator: Lockable handle and memory stop.
 11. Manufacturers:
 - a. Apollo Valves; _____: www.apollovalves.com/#sle.
 - b. FNW; 410A: www.fnw.com/#sle.
 - c. Jomar Valves, a division of Jomar Group; _____: www.jomarvalve.com/#sle.
 - d. Nibco: www.nibco.com

2.04 BRONZE, BALL VALVES

- A. General:
 1. Fabricate from dezincification resistant material.
 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. One Piece, Reduced Port with Bronze Trim:
 1. Comply with MSS SP-110.
 2. WSP Rating: 400 psi.

3. CWP Rating: 600 psi.
4. Body: Bronze.
5. End Connections: Pipe press.
6. Seats: PTFE.

C. Two Piece, Full Port with Bronze Trim:

1. Comply with MSS SP-110.
2. WSP Rating: 150 psi.
3. WOG Rating: 600 psi.
4. Body: Forged bronze or dezincified-brass alloy.
5. Ends Connections: Pipe thread or solder.
6. Seats: PTFE.
7. Stem: Bronze, blowout proof.
8. Ball: Chrome plated brass.
9. Operator: Provide stem extension.
10. Manufacturers:
 - a. Apollo Valves: www.apollovalves.com/#sle.
 - b. FNW; X450: www.fnw.com/#sle.
 - c. Jomar Valves, a division of Jomar Group: www.jomarvalve.com/#sle.
 - d. Viega LLC: www.viega.us/#sle.
 - e. Nibco: www.nibco.com

2.05 IRON, BALL VALVES

A. Class 125, Full Port, Stainless Steel Trim:

1. Comply with MSS SP-72.
2. CWP Rating: 200 psi.
3. Body: ASTM A536 Grade 65-45-12, ductile iron.
4. End Connections: Flanged.
5. Seats: PTFE.
6. Operator: Lever with locking handle.

2.06 BRONZE, LIFT CHECK VALVES

A. General:

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

B. Class 125:

1. Comply with MSS SP-80, Type 1, Metal Disc to Metal Seat and Type 2, Nonmetallic Disc to Metal Seat.
2. CWP Rating: 200 psi.
3. Design: Vertical flow.
4. Body: Comply with ASTM B61 or ASTM B62, bronze.
5. End Connections: Threaded.
6. Disc (Type 1): Bronze.

2.07 BRONZE, SWING CHECK VALVES

A. General:

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

B. Class 125:

1. Pressure and Temperature Rating: MSS SP-80, Type 3.
2. Design: Y-pattern, horizontal or vertical flow.
3. WOG Rating: 200 psi.
4. Body: Bronze, ASTM B62.
5. End Connections: Threaded.
6. Disc: Bronze.
7. Manufacturers:
 - a. Apollo Valves: www.apollovalves.com/#sle.
 - b. Jomar Valves, a division of Jomar Group: www.jomarvalve.com/#sle.
 - c. Nibco: www.nibco.com

2.08 IRON, HORIZONTAL SWING CHECK VALVES

2.09 IRON, SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125 with Lever and Spring-Closure Control.

1. Comply with MSS SP-71, Type I.
2. Description:
 - a. CWP Rating: 200 psi.
 - b. Design: Clear or full waterway.
 - c. Body: ASTM A126, gray iron with bolted bonnet.
 - d. Ends: Flanged as indicated.
 - e. Trim: Bronze.
 - f. Gasket: Asbestos free.
 - g. Closer Control: Factory installed, exterior lever, and weight.

2.10 BRONZE, GATE VALVES

A. General:

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

2.11 IRON, GATE VALVES

A. Bolted Bonnet: OS&Y; Rising Stem:

1. Pressure and Temperature Rating: MSS SP-70, Type I.
2. Class 125: WOG Rating; 200 psi.
3. Body: ASTM A126, gray iron with bolted bonnet.
4. End Connections: Flanged.
5. Trim: Bronze.
6. Disc: Solid wedge.
7. Packing and Gasket: Asbestos free.
8. Manufacturers:
 - a. Apollo Valves: www.apollovalves.com/#sle.
 - b. FNW; 651B: www.fnw.com/#sle.
 - c. Jomar Valves, a division of Jomar Group: www.jomarvalve.com/#sle.

- d. Nibco: www.nibco.com

2.12 BRONZE, GLOBE VALVES

- A. General:
 - 1. Fabricate from dezincification resistant material.
 - 2. Copper alloys containing more than 15 percent zinc are not permitted.
- B. Class 125 and Class 250:
 - 1. Class 125:
 - a. WOG Rating: 200 psi.
 - b. WSP Rating: 125 psi, saturated.
 - 2. Class 250: WOG Rating; 300 psi.
 - 3. Comply with MSS SP-80, Type 1.
 - 4. Body: ASTM B62, bronze with integral seat and screw-in bonnet.
 - 5. End Connections: Threaded or solder.
 - 6. Bonnet: NRS; Non-rising Stem.
 - 7. Non-Rising Stem: Bronze.
 - 8. Disc: PTFE.
 - 9. Packing: Asbestos free.
 - 10. Handwheel Operator: Malleable iron.
 - 11. Manufacturers:
 - a. Apollo Valves: www.apollovalves.com/#sle.
 - b. FNW; 1231, Federal: www.fnw.com/#sle.
 - c. Nibco: www.nibco.com

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. If 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.

END OF SECTION 220523

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Strut systems for pipe or equipment support.
- B. Beam clamps.
- C. Pipe hangers.
- D. Pipe supports, guides, shields, and saddles.
- E. Seismic bracing hardware.
- F. Nonpenetrating rooftop supports for low-slope roofs.
- G. Anchors and fasteners.

1.02 RELATED REQUIREMENTS

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

1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.
- F. ASTM A283/A283M - Standard Specification for Low and Intermediate Tensile Strength Carbon Steel Plates.
- G. ASTM A395/A395M - Standard Specification for Ferritic Ductile Iron Pressure-Retaining Castings for Use at Elevated Temperatures.
- H. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- I. ASTM A1011/A1011M - Standard Specification for Steel, Sheet and Strip, Hot-Rolled, Carbon, Structural, High-Strength Low-Alloy, High-Strength Low-Alloy with Improved Formability, and Ultra-High Strength.

- J. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- K. ASTM D635 - Standard Test Method for Rate of Burning and/or Extent and Time of Burning of Plastics in a Horizontal Position.
- L. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- M. ASTM E96/E96M - Standard Test Methods for Water Vapor Transmission of Materials.
- N. FM (AG) - FM Approval Guide.
- O. MFMA-4 - Metal Framing Standards Publication.
- P. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- Q. NFPA 101 - Life Safety Code.
- R. UL (DIR) - Online Certifications Directory.
- S. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 ADMINISTRATIVE REQUIREMENTS

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

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for metal channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- C. Shop Drawings: Include details for fabricated hangers and supports where materials or methods other than those indicated are proposed for substitution.
 - 1. Application of protective inserts, saddles, and shields at pipe hangers for each type of insulation and hanger.

- D. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

- A. Comply with applicable building code.
- B. Installer Qualifications for Powder-Actuated Fasteners (when specified): Certified by fastener system manufacturer with current operator's license.
- C. Installer Qualifications for Field-Welding: As specified in Section 055000.
- D. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

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

2.02 STRUT SYSTEMS FOR PIPE OR EQUIPMENT SUPPORT

- A. Strut Channels:
 - 1. Manufacturers:
 - a. ABB Installation Products; _____: electrification.us.abb.com/#sle.
 - b. Gripple, Inc; Universal Bracket: www.gripple.com/#sle.
 - c. Unistrut, a brand of Atkore International Inc; _____: www.unistrut.com/#sle.
 - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. ASTM A653/A653M galvanized steel bracket with clamps for surface mounting of piping or plumbing equipment support.
 - 3. Channel or Bracket Kits: Include rods, brackets, end-fixed fittings, covers, clips, and other related hardware required to complete sectional trapeze section for piping or other

support.

- B. Hanger Rods:
 - 1. Threaded zinc-plated steel unless otherwise indicated.
 - 2. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Piping up to 1 inch: 1/4 inch diameter.
 - c. Trapeze Support for Multiple Pipes: 3/8 inch in length.
- C. Channel Nuts:
 - 1. Provide carbon steel channel nut with epoxy copper or zinc finish and long, regular, or short spring.

2.03 BEAM CLAMPS

- A. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
- B. C-Clamp: MSS SP-58 type 23, malleable iron and steel with plain, stainless steel, and zinc finish.
- C. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish. For inverted usage provide manufacturer listed size(s).
- D. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish.
- E. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with plain finish.
- F. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plain finish.
- G. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
- H. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.

2.04 PIPE HANGERS

- A. Clevis Hangers, Adjustable:
 - 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation:
 - b. FNW; 7005:
 - c. Carpenter & Patterson
 - d. Anvil International
 - e. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. Copper Tube: MSS SP-58 type 1, epoxy-plated copper.

2.05 PIPE CLAMPS

- A. Riser Clamps:
 - 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation; ____: www.eaton.com/#sle.
 - b. FNW; 7020: www.fnw.com/#sle.

- c. nVent Caddy, a brand of nVent; ____: www.erico.com/#sle.
 - d. Carpenter & Patterson
 - e. Anvil International
 - f. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
 - 3. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 - 4. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.
- B. Extension Split Pipe Clamp:
- 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation; ____: www.eaton.com/#sle.
 - b. FNW; 7001: www.fnw.com/#sle.
 - c. nVent Caddy, a brand of nVent; ____: www.erico.com/#sle.
 - d. Carpenter & Patterson
 - e. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. MSS SP-58 type 12, hinged split ring and yoke roller hanger with epoxy copper or plain finish.
 - 3. Material: ASTM A47/A47M malleable iron or ASTM A36/A36M carbon steel.
 - 4. Provide hanger rod and nuts of the same type and material for a given pipe run.
 - 5. Provide coated or plated hangers to isolate steel hangers from dissimilar metal tube or pipe.
- C. Offset Pipe Clamps: Double-leg design two-piece pipe clamp.
- D. Strut Clamps:
- 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation: www.eaton.com/#sle.
 - b. FNW; 7815: www.fnw.com/#sle.
 - c. Unistrut, a brand of Atkore International, Inc: www.unistrut.com/#sle.
 - d. Carpenter & Patterson
 - e. Anvil International
 - f. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
 - 3. Cushioned Pipe or Tubing Strut Clamp: Provide strut clamp with thermoplastic elastomer cushion having dielectric strength of 670 V/mil.
 - 4. Service Temperature Range: Minus 65 to 275 degrees F.
- E. Insulation Coupling:
- 1. Manufacturers:
 - a. FNW; 7897: www.fnw.com/#sle.
 - b. nVent Caddy, a brand of nVent: www.erico.com/#sle.
 - c. Unistrut, a brand of Atkore International, Inc: www.unistrut.com/#sle.
 - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 - 2. Two bolt-type clamps designed for installation under insulation.
 - 3. Material: Carbon steel with epoxy copper or zinc finish.

2.06 PIPE SUPPORTS, GUIDES, SHIELDS, AND SADDLES

- A. Dielectric Barriers: Provide between metallic supports and metallic piping and associated items of dissimilar type; acceptable dielectric barriers include rubber or plastic sheets or coatings attached securely to pipe or item.
- B. Stanchions:
 - 1. Manufacturers:
 - a. Anvil International: www.anvilintl.com/#sle.
 - b. B-Line, a brand of Eaton Corporation: www.eaton.com/#sle.
 - c. nVent Caddy, a brand of nVent: www.erico.com/#sle.
 - 2. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 - 3. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
- C. U-Bolts:
 - 1. MSS SP-58 type 24, carbon steel u-bolt for pipe support or anchoring.
- D. Pipe Shields for Insulated Piping:
 - 1. MSS SP-58 type 40, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
 - 2. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Service Temperature: Minus 40 to 178 degrees F.
 - e. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- E. Pipe Supports:
 - 1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
 - 2. Liquid Temperatures Up to 140 degrees F:
 - a. Overhead Support: MSS SP-58 types 1, 3 through 12 clamps.
 - b. Support From Below: MSS SP-58 types 35 through 38.
 - 3. Operating Temperatures from 122 to 446 degrees F:
 - a. Overhead Support: MSS SP-58 type 1 or 3 through 12 clamps with appropriate saddle of MSS SP-58 type 40 for insulated pipe.
 - b. Roller Chair: MSS SP-58 types 41 or 43 through 46 roller chair support with appropriate saddle of MSS SP-58 type 39 for insulated pipe.
 - c. Sliding Support: MSS SP-58 types 35 through 38.
- F. Pipe Supports, Thermal Insulated:
 - 1. General Requirements:
 - a. Insulated pipe supports to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
 - b. Surface Burning Characteristics: Flame spread index/smoke developed index of 5/30, maximum, when tested in accordance with ASTM E84 or UL 723.
 - c. Provide pipe supports for 1/2 to 30 inch iron pipes.
 - d. Insulation inserts to consist of rigid phenolic foam insulation surrounded by 360 degree, PVC jacketing.

2. PVC Jacket:
 - a. Pipe insulation protection shields to be provided with ball bearing hinge and locking seam.
 - b. Moisture Vapor Transmission: 0.0071 perm inch, when tested in accordance with ASTM E96/E96M.
 - c. Minimum Thickness: 60 mil, 0.06 inch.

2.07 SEISMIC BRACING HARDWARE

A. Cable Suspension Systems:

1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation: www.eaton.com/#sle.
 - b. nVent Caddy, a brand of nVent: www.erico.com/#sle.
 - c. Gripple, Inc; UniGrip Standard: www.gripple.com/#sle.
2. Strut channel or bracket-fitted fitting with locking mechanism for pipe or equipment suspension using cable wires extended to surface-mounted end-fixing fittings.
3. Provide cable wire and end-fixing as required to hold minimum weight of 120 lb.

B. Cable Sway Bracing Systems:

1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation: www.eaton.com/#sle.
 - b. nVent Caddy, a brand of nVent: www.erico.com/#sle.
 - c. Gripple, Inc; Standard Hanger: www.gripple.com/#sle.
2. Cable wire hanger with fix and release spring mechanism enclosed using zinc housing with 302 stainless steel components for pipe or equipment suspension to surface-mounted end-fixing fittings.
3. Provide cable wire and end-fixing as required to hold minimum weight of 25 lb.

2.08 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
3. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for the load to be supported with a minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.
4. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
5. Steel Components: Use corrosion resistant materials suitable for the environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

B. Metal Channel (Strut) Framing Systems:

1. Manufacturers:
 - a. Cooper B-Line, a division of Eaton Corporation; ____: www.cooperindustries.com/#sle.
 - b. Thomas & Betts Corporation; ____: www.tnb.com/#sle.
 - c. Unistrut, a brand of Atkore International, Inc; ____: www.unistrut.com/#sle.
 - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
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 gauge, 0.1046 inch.
6. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.

C. Hanger Rods:

1. Threaded zinc-plated steel unless otherwise indicated.
2. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2 inch diameter.
 - b. Piping up to 1 inch: 1/4 inch diameter.
 - c. Piping larger than 1 inch: 3/8 inch diameter.
 - d. Trapeze Support for Multiple Pipes: 3/8 inch in diameter.

D. Pipe Supports:

1. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
2. Liquid Temperatures Up To 122 degrees F:
 - a. Overhead Support: MSS SP-58 Types 1, 3 through 12 clamps.
 - b. Support From Below: MSS SP-58 Types 35 through 38.
3. Operating Temperatures from 122 to 446 degrees F:
 - a. Overhead Support: MSS SP-58 Type 1 or 3 through 12 clamps with appropriate saddle of MSS SP-58 Type 40 for insulated pipe.
 - b. Roller Chair: MSS SP-58 Types 41 or 43 through 46 roller chair support with appropriate saddle of MSS SP-58 Type 39 for insulated pipe.

E. Pipe Stanchions:

1. Manufacturers:
 - a. Anvil International: www.anvilintl.com/#sle.
 - b. Carpenter & Patterson: www.pipehangers.com
 - c. ASC Engineered Solutions: www.asc-es.com
 - d. Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
2. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
3. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
4. For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.

- F. Beam Clamps:
1. MSS SP-58 types 19 through 23, 25 or 27 through 30 based on required load.
 2. Beam C-Clamp: MSS SP-58 type 23, malleable iron and steel with plain, stainless steel, and zinc finish.
 3. Small or Junior Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish. For inverted usage provide manufacturer listed size(s).
 4. Wide Mouth Beam Clamp: MSS SP-58 type 19, malleable iron with plain finish.
 5. Centerload Beam Clamp with Extension Piece: MSS SP-58 type 30, malleable iron with plain finish.
 6. FM (AG) and UL (DIR) Approved Beam Clamp: MSS SP-58 type 19, plain finish.
 7. Provide clamps with hardened steel cup-point set screws and lock-nuts for anchoring in place.
 8. Material: ASTM A395/A395M ductile iron, ASTM A36/A36M carbon steel, ASTM A47/A47M malleable iron, ASTM A181/A181M forged steel, or ASTM A283/A283M steel.
- G. Riser Clamps:
1. For insulated pipe runs, provide two bolt-type clamps designed for installation under insulation.
 2. MSS SP-58 type 1 or 8, carbon steel or steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 3. Medium Split Horizontal Pipe Clamp: MSS SP-58 type 4, carbon steel or stainless steel with epoxy plated, plain, stainless steel, or zinc plated finish.
 4. Copper Tube Pipe Clamp: MSS SP-58 type 8, epoxy plated copper.
 5. UL (DIR) listed: Pipe sizes 1/2 to 8 inch.
- H. U-Bolts:
1. MSS SP-58 Type 24, carbon steel u-bolt for pipe support or anchoring.
- I. Strut Clamps:
1. Pipe Clamp: Two-piece rigid, universal, or outer diameter type, carbon steel with epoxy copper or zinc finish.
 2. Cushioned Pipe or Tubing Strut Clamp: Provide strut clamp with thermoplastic elastomer cushion having dielectric strength of 670 V/mil.
 3. Service Temperature Range: Minus 65 to 275 degrees F.
- J. Pipe Hangers:
1. Hangers:
 - a. Manufacturers:
 - 1) FNW; 7001: www.fnw.com/#sle.
 - 2) Carpenter & Patterson: www.pipehangers.com
 - 3) ASC Engineered Solutions: www.asc-es.com
 - 4) Anvil International: www.anvilintl.com
 - 5) Source Limitations: Furnish hardware, fittings, and accessories from single manufacturer.
 2. Clevis Hangers, Adjustable:
 - a. Manufacturers:
 - b. Copper Tube: MSS SP-58 Type 1, epoxy-plated copper.
 - c. Light-Duty: MSS SP-58 Type 1, zinc-colored, epoxy plated.
 - d. Standard-Duty: MSS SP-58 Type 1, zinc-colored, epoxy plated.
 - e. UL (DIR) listed: Pipe sizes 2-1/2 to 8 inch

f. FM (AG) listed: Pipe sizes 2-1/2 to 8 inch

K. Pipe Shields for Insulated Piping:

1. MSS SP-58 Type 40, ASTM A1011/A1011M steel or ASTM A653/A653M carbon steel.
2. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Minimum Service Temperature: Minus 40 degrees F.
 - e. Maximum Service Temperature: 178 degrees F.
 - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.

L. Anchors and Fasteners:

1. Manufacturers - Mechanical Anchors:
 - a. FNW; 7502: www.fnw.com/#sle.
 - b. Hilti, Inc: www.us.hilti.com/#sle.
 - c. ITW Red Head, a division of Illinois Tool Works, Inc: www.itwredhead.com/#sle.
 - d. Powers Fasteners, Inc: www.powers.com/#sle.
 - e. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.
2. Manufacturers - Powder-Actuated Fastening Systems:
 - a. Hilti, Inc: www.us.hilti.com/#sle.
 - b. ITW Ramset, a division of Illinois Tool Works, Inc: www.ramset.com/#sle.
 - c. Powers Fasteners, Inc: www.powers.com/#sle.
 - d. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.
3. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.
4. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
5. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
6. Hollow Masonry: Use toggle bolts.
7. Hollow Stud Walls: Use toggle bolts.
8. Steel: Use beam ceiling clamps, beam clamps, machine bolts, or welded threaded studs.
9. Plastic and lead anchors are not permitted.
10. Hammer-driven anchors and fasteners are not permitted.
11. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.

2.09 ANCHORS AND FASTENERS

A. Manufacturers - Mechanical Anchors:

1. FNW; 7502: www.fnw.com/#sle.
2. Hilti, Inc: www.us.hilti.com/#sle.
3. ITW Red Head, a division of Illinois Tool Works, Inc: www.itwredhead.com/#sle.
4. Powers Fasteners, Inc: www.powers.com/#sle.
5. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.

B. Unless otherwise indicated and where not otherwise restricted, use the anchor and fastener types indicated for the specified applications.

C. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.

D. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.

- E. Preset Concrete Inserts: Continuous metal strut channel and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - 1. Channel Material: Use galvanized steel.
 - 2. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch minimum base metal thickness.
 - 3. Manufacturer: Same as manufacturer of metal strut channel framing system.
- F. Concrete Inserts:
 - 1. Manufacturers:
 - a. B-Line, a brand of Eaton Corporation: www.eaton.com/#sle.
 - b. HoldRite, a brand of Reliance Worldwide Corporation: www.holdrite.com/#sle.
 - c. nVent Caddy, a brand of nVent: www.erico.com/#sle.
 - d. _____.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D. Do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Engineer of Record, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Provide thermal insulated pipe supports complete with hangers and accessories. Install thermal insulated pipe supports during the installation of the piping system.
- H. Equipment Support and Attachment:
 - 1. Use supports assembled from metal channel (strut) to support equipment as required.
 - 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 4 inch high concrete pad constructed in accordance with Section 033000.

5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.

- I. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.
- J. Secure fasteners according to manufacturer's recommended torque settings.
- K. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

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

END OF SECTION 220529

SECTION 220548 - VIBRATION AND SEISMIC CONTROLS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Seismic control requirements.
 - 1. Includes requirements for seismic qualification of equipment not specified in this section.
- C. Vibration-isolated equipment support bases.
- D. Vibration isolators.
- E. External seismic snubber assemblies.
- F. Seismic restraint systems.

1.02 RELATED REQUIREMENTS

- A. Section 014533 - Code-Required Special Inspections and Procedures.
- B. Section 033000 - Cast-in-Place Concrete.
- C. Section 055000 - Metal Fabrications: Materials and requirements for fabricated metal supports.
- D. Section 210548 - Vibration and Seismic Controls for Fire Suppression Piping and Equipment.
- E. Section 220529 - Hangers and Supports for Plumbing Piping and Equipment.
- F. Section 230548 - Vibration and Seismic Controls for HVAC.

1.03 DEFINITIONS

- A. Plumbing Component: Where referenced in this section in regards to seismic controls, applies to any portion of the plumbing system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., piping).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

1.04 REFERENCE STANDARDS

- A. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- B. ASCE 19 - Structural Applications of Steel Cables for Buildings.
- C. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.

- D. FEMA 412 - Installing Seismic Restraints for Mechanical Equipment.
- E. FEMA 413 - Installing Seismic Restraints for Electrical Equipment.
- F. FEMA 414 - Installing Seismic Restraints for Duct and Pipe.
- G. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage.
- H. ICC (IBC) - International Building Code.
- I. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components.
- J. MFMA-4 - Metal Framing Standards Publication.
- K. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems.

1.05 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. Seismic Controls:
 - a. Coordinate the arrangement of seismic restraints with piping, conduit, equipment, and other potential conflicts installed under other sections or by others.
 - b. Coordinate the work with other trades to accommodate relative positioning of essential and nonessential components in consideration of seismic interaction.
 - 5. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.06 SUBMITTALS

- A. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- 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 methods for spring element load capacities.
 - 2. Seismic Controls: Include seismic load capacities.
- C. Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.

2. Vibration-Isolated Equipment Support Bases: Include base weights, including concrete fill where applicable; indicate equipment mounting provisions.
- D. Shop Drawings - Seismic Controls:
1. Include dimensioned plan views and sections indicating proposed plumbing component locations and distributed system routing, with locations and details of gravity supports and seismic restraints and associated attachments.
 2. Identify mounting conditions required for equipment seismic qualification.
 3. Identify anchor manufacturer, type, minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
 4. Indicate proposed arrangement of distributed system trapeze support groupings.
 5. Indicate proposed locations for distributed system flexible fittings and/or connections.
 6. Indicate locations of seismic separations where applicable.
 7. Include point load drawings indicating design loads transmitted to structure at each attachment location.
- E. Seismic Design Data:
1. Compile information on project-specific characteristics of actual installed plumbing components necessary for determining seismic design forces required to design appropriate seismic controls, including but not limited to the following.
 - a. Component operating weight and center of gravity.
 - b. Component elevation in the building in relation to the roof elevation (z/h).
 - c. Component importance factor (I_p).
 - d. For distributed systems, component materials and connection methods.
 - e. Component amplification factor (a_p) and component response modification factor (R_p), determined in accordance with ASCE 7 tables.
 - f. Applicability of overstrength factor (for certain anchorage in concrete and masonry).
 2. Include structural calculations, stamped or sealed by seismic controls designer, demonstrating suitability of seismic controls for seismic design forces.
- F. Certification for seismically qualified equipment; identify basis for certification.
- G. Evaluation Reports: For products specified as requiring evaluation and recognition by a qualified evaluation service, provide current evaluation reports.
- H. 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.
- I. Evidence of qualifications for seismic controls designer.
- J. Evidence of qualifications for manufacturer.
- K. Manufacturer's detailed field testing and inspection procedures.
- L. Field quality control test reports.
- 1.07 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. Seismic Controls Designer Qualifications: Registered professional engineer licensed in the State of New York and with minimum five years experience designing seismic restraints for nonstructural components.
 - 1. Designer may be employed by the manufacturer of the seismic restraint products.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

1.08 DELIVERY, STORAGE, AND HANDLING

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

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 plumbing equipment and/or plumbing 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.
 - 3. Select seismic type vibration isolators to comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
 - 4. Select vibration isolators for outdoor equipment to comply with wind design requirements.
 - 5. Select vibration-isolated equipment support bases and associated vibration isolators to provide minimum 2-inch operating clearance beneath base unless otherwise indicated.
- D. Piping Isolation:
 - 1. Provide vibration isolators for piping supports:
 - 2. 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 SEISMIC CONTROL REQUIREMENTS

- A. Design and provide plumbing component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor plumbing components.
- B. Seismic Design Criteria: As indicated on structural drawings..
- C. Component Importance Factor (Ip): Plumbing components to be assigned a component importance factor (Ip) of 1.5 unless otherwise indicated.

- D. Component Importance Factor (Ip): Plumbing components essential to life safety to be assigned a component importance factor (Ip) of 1.5 as indicated or as required. This includes but is not limited to:
1. Plumbing components required to function for life safety purposes after an earthquake.
 2. Plumbing components that support or otherwise contain hazardous substances.
- E. Seismic Qualification of Equipment:
1. Provide special certification for plumbing equipment furnished under other sections and assigned a component importance factor (Ip) of 1.5, certifying that equipment will remain operable following a design level earthquake.
 2. Seismic qualification to be by shake table testing in accordance with recognized testing standard procedure, such as ICC-ES AC156, acceptable to authorities having jurisdiction.
 3. Notify Engineer of Record and obtain direction where mounting restrictions required by conditions of seismic certification conflict with specified requirements.
 4. Seismically qualified equipment to be furnished with factory-installed labels referencing certificate of compliance and associated mounting restrictions.
- F. Seismic Restraints:
1. Provide seismic restraints for plumbing components except where exempt according to applicable codes and specified seismic design criteria, as approved by authorities having jurisdiction.
 2. Seismic Restraint Exemptions:
 - a. Exemptions for Seismic Design Category C:
 - 1) Plumbing components where either of the following apply:
 - a) The component importance factor (Ip) is 1.0 and the component is positively attached to the structure.
 - b) The component weighs 20 pounds or less or, in the case of a distributed system, 5 pounds per foot or less.
 - 2) Plumbing piping with component importance factor (Ip) of 1.5 and nominal pipe size of 2 inch or less, where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, and where piping is positively attached to the structure; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron, glass, nonductile plastics).
 - b. Exemptions for Seismic Design Category D, E, and F:
 - 1) Discrete plumbing components that are positively attached to the structure where either of the following apply:
 - a) The component weighs 400 pounds or less, has a center of mass located 4 feet or less above the adjacent floor level, flexible connections are provided between the component and associated ductwork, piping, and conduit, and the component importance factor (Ip) is 1.0.
 - b) The component weighs 20 pounds or less or, in the case of a distributed system, 5 pounds per foot or less.
 - 2) Plumbing piping with component importance factor (Ip) of 1.0 and nominal pipe size of 3 inch or less, or with component importance factor (Ip) of 1.5 and nominal pipe size of 1 inch or less, where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, and where piping is positively attached to the structure; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron, glass, nonductile plastics).

- c. Plumbing Piping Exemptions, All Seismic Design Categories:
 - 1) Plumbing piping where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, where piping is positively attached to the structure, and where one of the following apply:
 - a) Trapeze supported piping weighing less than 10 pounds per foot, where all pipes supported meet size requirements for exemption as single pipes described under specific seismic design category exemptions above.
 - b) Trapeze supported piping with trapeze assemblies using 3/8 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (I_p) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 100 pounds or less.
 - c) Trapeze supported piping with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (I_p) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 200 pounds or less.
 - d) Trapeze supported piping with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 24 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (I_p) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 100 pounds or less.
 - e) Hanger supported piping with individual rod hangers 3/8 inch or 1/2 inch in diameter not exceeding 12 inches in length from support point connection to the supporting structure, where pipe has a component importance factor (I_p) of 1.0 and meets size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single rod is 50 pounds or less.
- 3. Seismic Restraint Exemptions:
 - a. Exemptions for Seismic Design Category C:
 - 1) Plumbing components with component importance factor (I_p) of 1.0.
 - 2) Plumbing piping with component importance factor (I_p) of 1.5 and nominal pipe size of 2 inch or less; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron, glass, nonductile plastics).
 - b. Exemptions for Seismic Design Category D, E, and F:
 - 1) Plumbing components with component importance factor (I_p) of 1.0 where all of the following apply:
 - a) The component is positively attached to the structure.
 - b) Flexible connections are provided between the component and associated ductwork, piping, and conduit.
 - c) Either:
 - 1 The component weighs 400 pounds or less and has a center of mass located 4 feet or less above the adjacent floor level.

- 2 The component weighs 20 pounds or less or, in the case of a distributed system, 5 pounds per foot or less.
 - 2) Plumbing piping with component importance factor (I_p) of 1.0 and nominal pipe size of 3 inch or less, or with component importance factor (I_p) of 1.5 and nominal pipe size of 1 inch or less; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron, glass, nonductile plastics).
 - c. Plumbing Piping Exemptions, All Seismic Design Categories:
 - 1) Trapeze supported piping weighing less than 10 pounds per foot, where all pipes supported meet requirements for exemption as single pipes described under specific seismic design category exemptions above.
 - 2) Hanger supported piping where each hanger in the piping run is 12 inches or less in length from the pipe support to the supporting structure; rod hangers, where used, to be equipped with swivels.
4. Comply with applicable general recommendations of the following, where not in conflict with applicable codes, seismic design criteria, or other specified requirements:
 - a. ASHRAE (HVACA).
 - b. FEMA 412.
 - c. FEMA 413.
 - d. FEMA 414.
 - e. FEMA E-74.
 - f. SMACNA (SRM).
5. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
6. Seismic Type Vibration Isolators:
 - a. Comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
7. External Seismic Snubber Assemblies:
 - a. Provide quantity and arrangement of external seismic snubber assemblies as required to restrain equipment in all directions (both lateral and vertical).
 - b. Do not use external seismic snubber assemblies that restrain equipment only in one or more lateral directions (but not vertical) except where uplift forces are zero or are addressed by other restraints.
8. Seismic Restraint Systems:
 - a. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
 - b. Use only cable restraints to restrain vibration-isolated plumbing components, including distributed systems.
 - c. Use only one restraint system type for a given plumbing component or distributed system (e.g., piping) run; mixing of cable and rigid restraints on a given component/run is not permitted.
 - d. Size restraint elements, including anchorage, to resist seismic loads as necessary to restrain plumbing component in all lateral directions; consider bracket geometry in anchor load calculations.
 - e. Use rod stiffener clips to attach bracing to hanger rods as required to prevent rod buckling from vertical (upward) compressive load introduced by cable or rigid restraints loaded in tension, in excess of downward tensile load due to supported plumbing component weight.
 - f. Select hanger rods and associated anchorage as required to accommodate vertical (downward) tensile load introduced by rigid restraints loaded in compression, in

- g. addition to downward tensile load due to supported plumbing component weight. Clevis hangers may only be used for attachment of transverse restraints; do not use for attachment of longitudinal restraints.
- h. Where seismic restraints are attached to clevis hangers, provide clevis bolt reinforcement accessory to prevent clevis hanger deformation.
- i. Do not introduce lateral loads on open bar joist chords or the weak axis of beams, or loads in any direction at other than panel points unless approved by project Structural Engineer of Record.
- j. Manufacturer's certified seismic restraint design may be submitted as an alternative to project-specific design and documentation, subject to approval of authorities having jurisdiction.

G. Seismic Attachments:

1. Attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
2. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) or qualified evaluation service acceptable to authorities having jurisdiction for compliance with applicable building code, and qualified for seismic applications; concrete anchors to be qualified for installation in both cracked and uncracked concrete.
3. Do not use power-actuated fasteners.
4. Do not use friction clips (devices that rely on mechanically applied friction to resist loads). Beam clamps may be used for supporting sustained loads where provided with restraining straps.
5. Comply with anchor minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
6. Concrete Housekeeping Pads:
 - a. Increase size of pad as required to comply with anchor requirements.
 - b. Provide pad reinforcement and doweling to ensure integrity of pad and connection and to provide adequate load path from pad to supporting structure.

H. Seismic Interactions:

1. Include provisions to prevent seismic impact between plumbing components and other structural or nonstructural components.
2. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.
3. Comply with minimum clearance requirements between plumbing equipment, distribution systems, and associated supports and fire protection sprinkler system drops and sprigs.

I. Seismic Relative Displacement Provisions:

1. Use suitable fittings or flexible connections to accommodate:
 - a. Relative displacements at connections between components, including distributed systems (e.g., piping); do not exceed load limits for equipment utility connections.
 - b. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.
 - c. Design displacements at seismic separations.
 - d. Anticipated drifts between floors.
2. Include provisions to prevent interruption of utility service due to seismic displacements.

2.03 VIBRATION-ISOLATED EQUIPMENT SUPPORT BASES

- A. Manufacturers:
 - 1. Vibration-Isolated Equipment Support Bases:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 - 2. Source Limitations: Furnish vibration-isolated equipment support bases and associated components and accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.

2.04 VIBRATION ISOLATORS

- A. Manufacturers:
 - 1. Vibration Isolators:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 - 2. Source Limitations: Furnish vibration-isolators and associated accessories produced by a single manufacturer and obtained from a single supplier.
- 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.
 - 3. Seismic Snubbing Elements for Seismic Isolators:
 - a. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - b. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.
- C. Vibration Isolators for Nonseismic 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, Nonseismic:
 - 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. Bottom Load Plate: Nonskid, molded, elastomeric isolator material or steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - c. 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, nonadjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - d. Furnished with integral leveling device for positioning and securing supported equipment.
 5. Restrained Spring Isolators, Nonseismic:
 - 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.
 - b. Bottom Load Plate: Steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - c. Furnished with integral leveling device for positioning and securing supported equipment.
 - d. Provides constant free and operating height.
 6. Resilient Material Isolator Hangers, Nonseismic:
 - 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, Nonseismic:
 - 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, Nonseismic:
 - 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.
- D. Vibration Isolators for Seismic Applications:
1. Resilient Material Isolator Mounts, Seismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) isolator material; specifically designed and rated for seismic applications with integral snubbing in all directions.
 2. Restrained Spring Isolators, Seismic:

- a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) in series with elastomeric (e.g., neoprene, rubber) isolator material within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop; specifically designed and rated for seismic applications with integral snubbing in all directions.
- b. Bottom Load Plate: Steel with provisions for bolting to supporting structure as required.
- c. Furnished with integral leveling device for positioning and securing supported equipment.
- d. Provides constant free and operating height.
3. Resilient Material Isolator Hangers, Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g., neoprene, rubber) isolator material for the lower hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
4. Spring Isolator Hangers, 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; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
5. Combination Resilient Material/Spring Isolator Hangers, 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) isolator material for the upper hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

2.05 EXTERNAL SEISMIC SNUBBER ASSEMBLIES

- A. Manufacturers:
 1. External Seismic Snubber Assemblies:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 2. Source Limitations: Furnish external seismic snubber assemblies and associated accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.
- B. Description: Steel snubbing assemblies designed for external attachment to both equipment and supporting structure that, as part of a complete system, restrain equipment motion in all directions during a seismic event while maintaining vibration isolation during normal operation.
- C. Seismic Snubbing Elements:
 1. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 2. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

2.06 SEISMIC RESTRAINT SYSTEMS

- A. Manufacturers:
 - 1. Seismic Restraint Systems:
 - a. AFCON, a brand of Anvil International; _____: www.anvilintl.com/#sle.
 - b. Eaton Corporation; _____: www.eaton.com/#sle.
 - c. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - d. Mason Industries; _____: www.mason-ind.com/#sle.
 - 2. Source Limitations: Furnish seismic restraint system components and accessories produced by a single manufacturer and obtained from a single supplier.
- B. Description: System components and accessories specifically designed for field assembly and attachment of seismic restraints.
- C. Cable Restraints:
 - 1. Comply with ASCE 19.
 - 2. Cables: Pre-stretched, galvanized steel wire rope with certified break strength.
 - 3. Cable Connections: Use only swaged end fittings. Cable clips and wedge type end fittings are not permitted in accordance with ASCE 19.
 - 4. Use protective thimbles for cable loops where potential for cable damage exists.
- D. Rigid Restraints: Use MFMA-4 steel channel (strut), steel angle, or steel pipe for structural element; suitable for both compressive and tensile design loads.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 CODE-REQUIRED SPECIAL INSPECTIONS

- A. Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner or Engineer of Record in accordance with Section 014533 and statement of special inspections as required by applicable building code.
- B. Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 - 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 - 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C. Seismic special inspections include, but are not limited to:

1. Seismically Qualified Equipment: Verification that label, anchorage, and mounting comply with the certificate of compliance.
 2. Installation and anchorage of piping systems designed to carry hazardous materials and their associated mechanical units for Seismic Design Categories C, D, E, and F; periodic inspection.
 3. Installation and anchorage of vibration isolation systems for Seismic Design Categories C, D, E, and F where the approved Contract Documents require a nominal clearance of 1/4 inch or less between equipment support frame and seismic restraint; periodic inspection.
 4. Verification of required clearances between plumbing equipment, distribution systems, and associated supports and fire protection sprinkler system drops and sprigs for Seismic Design Categories C, D, E, and F; periodic inspection.
- D. Seismic special inspections include, but are not limited to:
1. Seismically Qualified Equipment: Verification that label, anchorage, and mounting comply with the certificate of compliance.
 2. Installation and anchorage of piping systems designed to carry hazardous materials and their associated mechanical units for Seismic Design Categories C, D, E, and F; periodic inspection.
 3. Installation and anchorage of vibration isolation systems for Seismic Design Categories C, D, E, and F where the approved Contract Documents require a nominal clearance of 1/4 inch or less between equipment support frame and seismic restraint; periodic inspection.
- E. Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- F. Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.03 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.
- F. Seismic Controls:
- 1. Provide specified snubbing element air gap; remove any factory-installed spacers, debris, or other obstructions.
 - 2. Use only specified components, anchorage, and hardware evaluated by seismic design. Comply with conditions of seismic certification where applicable.
 - 3. Where mounting hole diameter exceeds bolt diameter by more than 0.125 inch, use epoxy grout, elastomeric grommet, or welded washer to reduce clearance to 0.125 inch or less.
 - 4. Equipment with Sheet Metal Housings:
 - a. Use Belleville washers to distribute stress over a larger surface area of the sheet metal connection interface as approved by manufacturer.
 - b. Attach additional steel as approved by manufacturer where required to transfer loads to structure.
 - c. Where mounting surface is irregular, do not shim housing; reinforce housing with additional steel as approved by manufacturer.
 - 5. Concrete Housekeeping Pads:
 - a. Size in accordance with seismic design to meet anchor requirements.
 - b. Install pad reinforcement and doweling in accordance with seismic design to ensure integrity of pad and associated connection to slab.
 - 6. Seismic Restraint Systems:
 - a. Do not attach seismic restraints and gravity supports to dissimilar parts of structure that may move differently during an earthquake.
 - b. Install restraints within permissible angles in accordance with seismic design.
 - c. Install cable restraints straight between component/run and structural attachment; do not bend around other nonstructural components or structural elements.
 - d. Install cable restraints for vibration-isolated components slightly slack to prevent short-circuiting of isolation.
 - e. Install hanger rod stiffeners where indicated using only specified clamps; do not weld stiffeners to hanger rod.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Provide manufacturer representative or authorized technician services to assist with inspection and testing of vibration isolation systems and seismic controls. Submit a detailed copy of manufacturer recommended inspection, testing, and field report procedures.
- D. Vibration Isolation Systems:

1. Verify isolator static deflections.
2. Verify required clearance beneath vibration-isolated equipment support bases.
3. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.

E. Seismic Controls:

1. Verify snubbing element air gaps.

F. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.

G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.05 ATTACHMENTS

A. Statement of special inspections.

END OF SECTION 220548

SECTION 220553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

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

1.03 REFERENCE STANDARDS

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

1.04 SUBMITTALS

- A. Chart and Schedule: Submit valve chart and schedule, including valve tag number, location, function, and valve manufacturer's name and model number.
- B. Product Data: Provide manufacturers catalog literature for each product required.

PART 2 PRODUCTS

2.01 IDENTIFICATION APPLICATIONS

- A. Piping: Tags.
- B. Pumps: Nameplates.
- C. Equipment: Tags.
- D. Tanks: Nameplates.
- E. Valves: Tags and ceiling tacks where located above lay-in ceiling.

2.02 NAMEPLATES

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

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

2.03 TAGS

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

2.04 PIPE MARKERS

- A. Manufacturers:
 - 1. Brady Corporation; _____: www.bradycorp.com/#sle.
 - 2. Brimar Industries, Inc; _____: www.pipemarker.com/#sle.
 - 3. Craftmark Pipe Markers; _____: www.craftmarkid.com/#sle.
 - 4. Kolbi Pipe Marker Co; _____: www.kolbipipemarkers.com/#sle.
 - 5. Seton Identification Products; _____: www.seton.com/#sle.
- B. Comply with ASME A13.1.
- C. Plastic Tape Pipe Markers: Flexible, vinyl film tape with pressure sensitive adhesive backing and printed markings.
- D. Color code as follows:
 - 1. Potable, Cooling, Boiler, Feed, Other Water: Green with white letters.
 - 2. Compressed Air: Blue with white letters.
 - 3. Sanitary and Storm: Green with white letters.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Install plastic nameplates with corrosive-resistant mechanical fasteners, or adhesive. Apply with sufficient adhesive to ensure permanent adhesion and seal with clear lacquer.
- B. Install tags with corrosion resistant chain.
- C. Install plastic pipe markers in accordance with manufacturer's instructions.
- D. Install plastic tape pipe markers complete around pipe in accordance with manufacturer's instructions.
- E. Use tags on piping 3/4 inch diameter and smaller.
 - 1. Identify service, flow direction, and pressure.
 - 2. Install in clear view and align with axis of piping.
 - 3. Locate identification not to exceed 20 feet on straight runs including risers and drops, adjacent to each valve and Tee, at each side of penetration of structure or enclosure, and at each obstruction.

3.03 SCHEDULES

- A. Equipment Type:
 - 1. Identification:
 - 2. Background:
 - a. Size:
 - b. Color:
 - 3. Lettering:
 - a. Size:
 - b. Color:

END OF SECTION 220553

SECTION 220719 - PLUMBING PIPING INSULATION

PART 1 GENERAL

1.01 SECTION INCLUDES

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

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 099113 - Exterior Painting: Painting insulation jacket.
- C. Section 099123 - Interior Painting: Painting insulation jacket.
- D. Section 221005 - Plumbing Piping: Placement of hangers and hanger inserts.

1.03 REFERENCE STANDARDS

- A. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
- B. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- C. ASTM C195 - Standard Specification for Mineral Fiber Thermal Insulating Cement.
- D. ASTM C449 - Standard Specification for Mineral Fiber Hydraulic-Setting Thermal Insulating and Finishing Cement.
- E. ASTM C547 - Standard Specification for Mineral Fiber Pipe Insulation.
- F. ASTM C552 - Standard Specification for Cellular Glass Thermal Insulation.
- G. ASTM C553 - Standard Specification for Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications.
- H. ASTM C578 - Standard Specification for Rigid, Cellular Polystyrene Thermal Insulation.
- I. ASTM C585 - Standard Practice for Inner and Outer Diameters of Thermal Insulation for Nominal Sizes of Pipe and Tubing.
- J. ASTM C795 - Standard Specification for Thermal Insulation for Use in Contact with Austenitic Stainless Steel.
- K. ASTM C1695 - Standard Specification for Fabrication of Flexible Removable and Reusable Blanket Insulation for Hot Service.
- L. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.

- M. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 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.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

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

2.02 GLASS FIBER

- 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; Fiberglas Pipe Insulation ASJ: www.ocbuildingspec.com/#sle.
 - 5. Owens Corning Corporation; VaporWick Pipe Insulation: www.ocbuildingspec.com/#sle.
- B. Insulation: ASTM C547 and ASTM C795; rigid molded, noncombustible, with wicking material to transport condensed water to the outside of the system for evaporation to the atmosphere.

1. K Value: ASTM C177, 0.23 at 75 degrees F.
 2. Maximum Service Temperature: 220 degrees F.
 3. Maximum Moisture Absorption: 0.2 percent by volume.
- C. Vapor Barrier Jacket: White Kraft paper with glass fiber yarn, bonded to aluminized film; moisture vapor transmission when tested in accordance with ASTM E96/E96M of 0.02 perm-inches.
- D. Vapor Barrier Lap Adhesive: Compatible with insulation.
- E. Insulating Cement/Mastic: ASTM C195; hydraulic setting on mineral wool.
- F. Insulating Cement: ASTM C449.

2.03 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.
 2. Covering Adhesive Mastic: Compatible with insulation.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

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

- 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. Continue insulation through walls, sleeves, pipe hangers, and other pipe penetrations. Finish at supports, protrusions, and interruptions. At fire separations, refer to Section 078400.

3.03 SCHEDULES

- A. Plumbing Systems:
 - 1. Domestic Hot Water Supply:
 - a. Glass Fiber Insulation:
 - 1) Pipe Size Range: All.
 - 2. Domestic Hot Water Recirculation:
 - a. Glass Fiber Insulation:
 - 1) Pipe Size Range: All sizes.
 - 2) Thickness: 1 inch.
 - 3. Domestic Cold Water: All Size Ranges, Glass Fiber 1 inch Thick.
 - 4. Roof Drain Bodies: All Size Ranges, Glass Fiber 1 inch Thick.
 - 5. Roof Drainage Above Grade: All Size Ranges, Glass Fiber 1 inch Thick.

END OF SECTION 220719

SECTION 220719.11 - UNDER-LAVATORY PIPE AND SUPPLY COVERS - PLUMBEREX

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Under-lavatory pipe and supply covers.

1.02 RELATED REQUIREMENTS

- A. Section 221005 - Plumbing Piping.

1.03 REFERENCE STANDARDS

- A. 28 CFR 36 - Nondiscrimination by Public Accommodations and in Commercial Facilities; Final Rule; Department of Justice.
- B. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines.
- C. ABA Standards - ABA Accessibility Standards.
- D. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design.
- E. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures.
- F. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- G. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- H. ASTM C1822 - Standard Specification for Insulating Covers on Accessible Lavatory Piping.
- I. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- J. ASTM G21 - Standard Practice for Determining Resistance of Synthetic Polymeric Materials to Fungi.
- K. ATBCB ADAAG - Americans with Disabilities Act Accessibility Guidelines.
- L. IAPMO (UPC) - Uniform Plumbing Code.
- M. ICC (IBC) - International Building Code.
- N. ICC A117.1 - Accessible and Usable Buildings and Facilities.
- O. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide catalog illustrations of covers, sizes, and finishes.
- C. Manufacturer's Instructions: Indicate installation methods and procedures.
- D. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.05 WARRANTY

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

PART 2 PRODUCTS

2.01 UNDER-LAVATORY PIPE and SUPPLY COVERS

- A. Manufacturers:
 - 1. Plumberex Specialty Products, Inc; _____: www.plumberex.com/#sle.
 - 2. Truebro IPS Corporation: <https://ipsplumbingproducts.com/brands/truebro/>
- B. General:
 - 1. Insulate exposed drainage piping including hot, cold, and tempered water supplies under lavatories or sinks per ADA Standards.
 - 2. Adhesives, sewing threads, and two-ply laminated materials are prohibited.
 - 3. Exterior Surfaces: Smooth nonabsorbent with no finger recessed indentations for easy cleaning.
 - 4. Construction: 1/8 inch PVC with antimicrobial, antifungal, and ultraviolet light (UV) resistant properties.
 - a. Provide one piece injected molded design with internal bridge at top of J-bend to prevent separating.
 - b. Comply with ASTM C1822 for covers on accessible lavatory piping.
 - c. Comply with ASME A112.18.9 for covers on accessible lavatory piping.
 - d. Thermal Resistance: R value of 0.504 or lower when tested by ASTM C177.
 - e. Thermal Conductivity: K value of 0.358 or density of 21.61 pcf per ASTM C518.
 - f. Microbial and Fungal Resistance for Interior and Exterior: Comply with ASTM G21.
- C. ASTM E84 Compliant, Under-Lavatory Insulators:
- D. Under-Lavatory Covers with Snap-Lock Fasteners:
 - 1. Construction: PVC with antimicrobial, antifungal, and UV-resistant properties, one piece injected molded design with internal bridge at top of J-bend to prevent separating.
 - 2. Fasteners: Reusable, snap-locking fasteners with no sharp or abrasive external surfaces. No cable ties allowed.
 - 3. Maintenance: Valve and supply cover shall be accessible for maintenance without removal and with removable, reusable access cap.
 - 4. Comply with:
 - a. ASTM C1822 Type III.
 - b. ADA Standards.
 - c. 36 CFR 1191.

- d. ADAAG Standards and 28 CFR 36.
- e. GSA and DOD ABA Standards.
- f. ICC A117.1.
- g. Requirement to protect against contact with sharp or abrasive surfaces.
- 5. Provide with weep hole for condensation drainage and ventilation.
- 6. Vandal Resistance: Internal line grooves for trimming not easily torn by hand. All trim line grooves shall require tool cutting only.
- 7. Color: High gloss white.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that walls, floor finishes, lavatories, and piping are prepared and ready for installation of under-lavatory guards.
- B. Confirm location and size of fixtures and piping before installation.

3.02 INSTALLATION

- A. Install under-lavatory guards according to manufacturer's written instructions..

3.03 CLEANING

- A. Clean installed under-lavatory guards.

3.04 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 220719.11

SECTION 221005 - PLUMBING PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe, pipe fittings, specialties, and connections for piping systems.
 - 1. Sanitary sewer.
 - 2. Domestic water.
 - 3. Storm water.
 - 4. Flanges, unions, and couplings.
 - 5. Pipe hangers and supports.
 - 6. Manufactured sleeve-seal systems.
 - 7. Ball valves.
 - 8. Balancing valves.
 - 9. Pressure reducing valves.
 - 10. Relief valves.
 - 11. Strainers.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 083100 - Access Doors and Panels.
- C. Section 099123 - Interior Painting.
- D. Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E. Section 220553 - Identification for Plumbing Piping and Equipment.
- F. Section 220719 - Plumbing Piping Insulation.
- G. Section 312316 - Excavation.
- H. Section 312316.13 - Trenching.
- I. Section 312323 - Fill.
- J. Section 330110.58 - Disinfection of Water Utility Piping Systems.

1.03 REFERENCE STANDARDS

- A. ANSI Z21.22 - American National Standard for Relief Valves for Hot Water Supply Systems.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- D. ASME B16.23 - Cast Copper Alloy Solder Joint Drainage Fittings - DWV.

- E. ASME B16.29 - Wrought Copper and Wrought Copper Alloy Solder Joint Drainage Fittings - DWV.
- F. ASME B31.1 - Power Piping.
- G. ASME B31.9 - Building Services Piping.
- H. ASME BPVC-IV - Boiler and Pressure Vessel Code, Section IV - Rules for Construction of Heating Boilers.
- I. ASME BPVC-IX - Boiler and Pressure Vessel Code, Section IX - Qualification Standard for Welding, Brazing, and Fusing Procedures; Welders; Brazers; and Welding, Brazing, and Fusing Operators.
- J. ASSE 1003 - Performance Requirements for Water Pressure Reducing Valves for Domestic Water Distribution Systems.
- K. ASTM A74 - Standard Specification for Cast Iron Soil Pipe and Fittings.
- L. ASTM B32 - Standard Specification for Solder Metal.
- M. ASTM B42 - Standard Specification for Seamless Copper Pipe, Standard Sizes.
- N. ASTM B75/B75M - Standard Specification for Seamless Copper Tube.
- O. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
- P. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).
- Q. ASTM B306 - Standard Specification for Copper Drainage Tube (DWV).
- R. ASTM B813 - Standard Specification for Liquid and Paste Fluxes for Soldering of Copper and Copper Alloy Tube.
- S. ASTM B828 - Standard Practice for Making Capillary Joints by Soldering of Copper and Copper Alloy Tube and Fittings.
- T. ASTM C564 - Standard Specification for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
- U. ASTM D1785 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe, Schedules 40, 80, and 120.
- V. ASTM D2235 - Standard Specification for Solvent Cement for Acrylonitrile-Butadiene-Styrene (ABS) Plastic Pipe and Fittings.
- W. ASTM D2466 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40.
- X. ASTM D2564 - Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems.
- Y. ASTM D2665 - Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Drain, Waste, and Vent Pipe and Fittings.
- Z. 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.

- AA. ASTM D3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- BB. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
- CC. AWWA C110/A21.10 - Ductile-Iron and Gray-Iron Fittings.
- DD. AWWA C111/A21.11 - Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings.
- EE. AWWA C151/A21.51 - Ductile-Iron Pipe, Centrifugally Cast.
- FF. AWWA C651 - Disinfecting Water Mains.
- GG. CISPI 301 - Standard Specification for Hubless Cast Iron Soil Pipe and Fittings for Sanitary and Storm Drain, Waste and Vent Piping Applications.
- HH. 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.
- II. ICC-ES AC106 - Acceptance Criteria for Predrilled Fasteners (Screw Anchors) in Masonry Elements.
- JJ. ICC-ES AC308 - Acceptance Criteria for Post-Installed Adhesive Anchors in Concrete Elements.
- KK. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- LL. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- MM. NSF 61 - Drinking Water System Components - Health Effects.
- NN. NSF 372 - Drinking Water System Components - Lead Content.

1.04 SUBMITTALS

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

1.05 QUALITY ASSURANCE

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

1.06 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.

1.07 FIELD CONDITIONS

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

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

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

2.02 SANITARY AND STORM SEWER PIPING, BELOW GRADE

- A. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.23, cast copper, or ASME B16.29, wrought copper.
 - 2. Joints: ASTM B32, alloy Sn50 solder.
- B. PVC Pipe: ASTM D2665 or ASTM D3034.
 - 1. Fittings: PVC.
 - 2. Joints: Solvent welded, with ASTM D2564 solvent cement.

2.03 SANITARY AND STORM 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.
- B. Copper Tube: ASTM B306, DWV.
 - 1. Fittings: ASME B16.29, wrought copper, or ASME B16.23, sovent.
 - 2. Joints: ASTM B32, alloy Sn50 solder.

2.04 DOMESTIC WATER PIPING, BELOW GRADE

- A. Ductile Iron Pipe: AWWA C151/A21.51.
 - 1. Fittings: AWWA C110/A21.10, 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.
- B. Copper Pipe: ASTM B42, hard drawn.

1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22 wrought copper and bronze.
2. Joints: ASTM B32, alloy Sn95 solder.
3. Joints: AWS A5.8M/A5.8, BCuP copper/silver braze.

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. Fittings: Cast iron, coated.
 3. Joints: ASTM B32, alloy Sn95 solder.

2.06 FLANGES, UNIONS, AND COUPLINGS

- A. Unions for Pipe Sizes 3 inch and Under:
1. Ferrous Pipe: Class 150 malleable iron threaded unions.
 2. Copper Tube and Pipe: Class 150 bronze unions with soldered joints.
- B. Flanges for Pipe Sizes 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. No-Hub Couplings:
1. Gasket Material: Neoprene complying with ASTM C564.
 2. Band Material: Stainless steel.
 3. Eyelet Material: Stainless steel.

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. 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.
- B. Plumbing Piping - Drain, Waste, and Vent:
1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, split ring.
 2. Hangers for Pipe Sizes 2 inch and Over: Carbon steel, adjustable, clevis.
 3. Floor Support: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 4. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- C. Plumbing Piping - Water:
1. Hangers for Pipe Sizes 1/2 to 1-1/2 inch: Carbon steel, adjustable swivel, clevis or split ring.
 2. Hangers for Cold Pipe Sizes 2 inch and Over: Carbon steel, adjustable, clevis.
 3. Hangers for Hot Pipe Sizes 2 to 4 inch: Carbon steel, adjustable, clevis.

4. Floor Support for Cold Pipe: Cast iron adjustable pipe saddle, lock nut, nipple, floor flange, and concrete pier or steel support.
 5. Floor Support for Hot Pipe Sizes to 4 inch: Cast iron adjustable pipe saddle, locknut, nipple, floor flange, and concrete pier or steel support.
 6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
- D. Hanger Fasteners: Attach hangers to structure using appropriate fasteners, as follows:
1. Concrete Wedge Expansion Anchors: Comply with ICC-ES AC193.
 2. Masonry Wedge Expansion Anchors: Comply with ICC-ES AC01.
 3. Concrete Screw Type Anchors: Comply with ICC-ES AC193.
 4. Masonry Screw Type Anchors: Comply with ICC-ES AC106.
 5. Concrete Adhesive Type Anchors: Comply with ICC-ES AC308.

2.08 MANUFACTURED SLEEVE-SEAL SYSTEMS

- A. Manufacturers:
1. The Metraflex Company; MetraSeal
 2. Enro Industries PSI; Link-Seal
- 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.

2.09 BALL VALVES

- A. Manufacturers:
1. Anvil International
 2. Apollo Valves
 3. Nibco, Inc
 4. Viega LLC
- B. Construction, 4 inch 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 or grooved ends with union.

2.10 BALANCING VALVES

- A. Manufacturers:
1. Anvil International
 2. ITT Bell & Gossett
 3. Jomar Valves, a division of Jomar Group
 4. Taco, Inc.
- B. Construction: Class 125, brass or bronze body with union on inlet and outlet, temperature and pressure test plug on inlet and outlet, blowdown/backflush drain.
- C. Manual Operated Y-Pattern Globe, Size 1/2 to 2 inch:

1. Class 125, brass or bronze body, multi-turn handwheel, memory stop, variable orifice, soldered connections, dual PT (hot and cold pressure-temperature) test ports for 300 psi, minus 4 to 250 deg F WOG service.
- D. Automatic Flow Limiting Cartridge, Size 3/4 inch:
 1. Class 125, brass or bronze body, stainless steel cartridge, threaded connections with built-in union, dual PT (hot and cold pressure-temperature) test ports for 400 psi, 0.5 gpm WOG service.
- E. Automatic Flow Limiting Cartridge with Ball Valve, Size 1/2 to 1 inch:
 1. Class 125, brass or bronze body, stainless steel cartridge, leak-proof stem, threaded or soldered connections with built-in union, dual PT (hot and cold pressure-temperature) test ports for 400 psi, 0.25 to 1.5 gpm WOG service.
- F. Calibration: Control flow within five percent of selected rating, over operating pressure range of 10 times minimum pressure required for control, maximum minimum pressure 3.5 psi.

2.11 PRESSURE REDUCING VALVES

- A. Manufacturers:
 1. Amtrol Inc.
 2. Apollo Valves
 3. Cash Acme, a brand of Reliance Worldwide Corporation
 4. Cla-Val Company
 5. Flomatic Valves
 6. Watts Regulator Company
- B. 2 inch and Smaller:
 1. ASSE 1003, bronze body, stainless steel, and thermoplastic internal parts, fabric reinforced diaphragm, strainer, threaded single union ends.
 2. Pressure Reducing Pilot-Operator:
 - a. Operating Range: 5 to 50 psi.
 - b. Connected into brass or bronze pilot piping and fittings.
 - c. Fixed flow restrictor, pressure gauges, and isolation valves.

2.12 RELIEF VALVES

- A. Temperature and Pressure:
 1. Manufacturers:
 - a. Cla-Val Co.
 - b. Henry Technologies
 - c. Watts Regulator Company
 2. 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.

2.13 STRAINERS

- A. Manufacturers:
 1. Armstrong International, Inc.
 2. Green Country Filter Manufacturing
 3. Jomar Valves, a division of Jomar Group; _____

4. WEAMCO

B. Size 1/2 inch to 3 inch:

1. Class 150, threaded forged bronze Y-pattern body, stainless steel perforated mesh screen with cap, and rated for 150 psi, 250 deg F WOG service.

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. See Section 220516.
- G. Provide clearance in hangers and from structure and other equipment for installation of insulation and access to valves and fittings.
 1. See Section 220719.
- H. Provide access where valves and fittings are not exposed.
 1. Coordinate size and location of access doors with Section 083100.
- I. Establish elevations of buried piping outside the building to ensure not less than 4 ft of cover.
- J. Install vent piping penetrating roofed areas to maintain integrity of roof assembly; see detail on architectural drawings.
- K. Provide support for utility meters in accordance with requirements of utility companies.
- L. Prepare exposed, unfinished pipe, fittings, supports, and accessories for finish painting.
 1. See Section 099123 for painting of interior plumbing systems and components.
- M. Excavate in accordance with Section 312316.

- N. Backfill in accordance with Section 312323.
- O. Install valves with stems upright or horizontal, not inverted. See Section 220523.
- P. Install water piping to ASME B31.9.
- Q. 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.
- R. PVC Pipe: Make solvent-welded joints in accordance with ASTM D2855.
- S. Sleeve pipes passing through partitions, walls, and floors.
- T. 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.
- U. 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. Provide copper plated hangers and supports for copper piping.
 - 9. Support cast iron drainage piping at every joint.
- V. Manufactured Sleeve-Seal Systems:
 - 1. Install manufactured sleeve-seal systems in sleeves located in grade slabs and exterior concrete walls at piping entrances into building.
 - 2. Provide sealing elements of the size, quantity, and type required for the piping and sleeve inner diameter or penetration diameter.
 - 3. Locate piping in center of sleeve or penetration.
 - 4. Install field assembled sleeve-seal system components in annular space between sleeve and piping.
 - 5. Tighten bolting for a watertight seal.
 - 6. Install in accordance with manufacturer's recommendations.

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 globe or ball 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 1/8 inch per foot slope for piping larger than 3" and larger. Slope piping a minimum of 1/4 inch per foot for piping smaller than 3 inch.

3.06 DISINFECTION OF DOMESTIC WATER PIPING SYSTEM

- A. Disinfect water distribution system in accordance with Section 330110.58.
- B. Prior to starting work, verify system is complete, flushed, and clean.
- C. Ensure acidity (pH) of water to be treated is between 7.4 and 7.6 by adding alkali (caustic soda or soda ash) or acid (hydrochloric).
- D. Inject disinfectant, free chlorine in liquid, powder, tablet, or gas form throughout system to obtain 50 to 80 mg/L residual.
- E. Bleed water from outlets to ensure distribution and test for disinfectant residual at minimum 15 percent of outlets.
- F. Maintain disinfectant in system for 24 hours.
- 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, and sand strainer.

3.08 SCHEDULES

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

- c. Pipe Size: 2-1/2 inch to 3 inch:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 1/2 inch.
 - d. Pipe Size: 4 inch to 6 inch:
 - 1) Maximum Hanger Spacing: 10 ft.
 - 2) Hanger Rod Diameter: 5/8 inch.
- 2. Plastic Piping:
 - a. All Sizes:
 - 1) Maximum Hanger Spacing: 6 ft.
 - 2) Hanger Rod Diameter: 3/8 inch.

END OF SECTION 221005

SECTION 221006 - PLUMBING PIPING SPECIALTIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Drains.
- B. Cleanouts.
- C. Hose bibbs.
- D. Hydrants.
- E. Washing machine boxes and valves.
- F. Backflow preventers.
- G. Double check valve assemblies.
- H. Water hammer arrestors.
- I. Sanitary waste interceptors.
- J. Mixing valves.
- K. Exterior penetration accessories.

1.02 RELATED REQUIREMENTS

- A. Section 016000 - Product Requirements: Procedures for Owner-supplied products.
- B. Section 221005 - Plumbing Piping.
- C. Section 223000 - Plumbing Equipment.
- D. Section 224000 - Plumbing Fixtures.
- E. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design.
- B. ASME A112.6.3 - Floor and Trench Drains.
- C. ASME A112.6.4 - Roof, Deck, and Balcony Drains.
- D. ASSE 1011 - Performance Requirements for Hose Connection Vacuum Breakers.
- E. ASSE 1012 - Performance Requirements for Backflow Preventers with an Intermediate Atmospheric Vent.

- F. ASSE 1013 - Performance Requirements for Reduced Pressure Principle Backflow Prevention Assemblies.
- G. ASSE 1019 - Performance Requirements for Wall Hydrant with Backflow Protection and Freeze Resistance.
- H. NSF 61 - Drinking Water System Components - Health Effects.
- I. NSF 372 - Drinking Water System Components - Lead Content.
- J. PDI-WH 201 - Water Hammer Arresters.

1.04 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. Manufacturer's Instructions: Indicate Manufacturer's Installation Instructions: Indicate assembly and support requirements.

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. Manufacturers:
 1. Jay R. Smith Manufacturing Company: www.jayrsmith.com/#sle.
 2. Josam Company: www.josam.com/#sle.
 3. Zurn Industries, LLC: www.zurn.com/#sle.
 4. MIFAB: www.mifab.com.
- B. Roof Drains:
 1. Assembly: ASME A112.6.4.
 2. Body: Lacquered cast iron with sump.
 3. Strainer: Removable polyethylene or cast metal dome with vandal proof screws.
 4. Accessories: Coordinate with roofing type, refer to Section _____:
 - a. Membrane flange and membrane clamp with integral gravel stop.
 - b. Adjustable under deck clamp.
 - c. Roof sump receiver.
 - d. Waterproofing flange.
 - e. Leveling frame.
 5. Manufacturers:
 - a. Jay R. Smith Manufacturing Company; _____: www.jrsmith.com/#sle.
 - b. Josam Company[<>]: www.josam.com/#sle.
 - c. MIFAB, Inc; _____: www.mifab.com/#sle.
 - d. Zurn: www.zurn.com.

- C. Floor Drains:
 - 1. Manufacturers:
 - a. Josam Company[<>]: www.josam.com/#sle.
 - b. Jay R. Smith Manufacturing Company; _____: www.jrsmith.com/#sle.
 - c. MIFAB, Inc; _____: www.mifab.com/#sle.
 - d. Zurn: www.zurn.com
 - e. Refer to schedule on drawing..
- D. Prefabricated Floor Trench:
 - 1. Body: Glass fiber reinforced polymer concrete cast in standard or custom assembly with integral aluminum load bearing frame and concrete anchors.
 - 2. Refer to schedule on drawing.
- E. Stainless Steel Shower Trench:
 - 1. Body: Material cast in standard or custom assembly with integral load bearing frame, cast concrete anchors, and flanged ends.
 - 2. Refer to schedule on drawing.

2.03 CLEANOUTS

- A. Manufacturers:
 - 1. Jay R. Smith Manufacturing Company; _____: www.jayrsmith.com/#sle.
 - 2. Josam Company; _____: www.josam.com/#sle.
 - 3. MIFAB, Inc; _____: www.mifab.com/#sle.
 - 4. Refer to schedule on drawings.

2.04 HOSE BIBBS

- A. Manufacturers:
 - 1. Jay R. Smith Manufacturing Company; _____: www.jayrsmith.com/#sle.
 - 2. Murdock Manufacturing, Inc; _____: www.murdockmfg.com/#sle.
 - 3. Watts Regulator Company; _____: www.wattsregulator.com/#sle.
 - 4. Zurn Industries, LLC; _____: www.zurn.com/#sle.
 - 5. Refer to schedule on drawings.

2.05 HYDRANTS

- A. Manufacturers:
 - 1. Arrowhead Brass & Plumbing, LLC; _____: www.arrowheadbrass.com/#sle.
 - 2. Jay R. Smith Manufacturing Company; _____: www.jayrsmith.com/#sle.
 - 3. Murdock Manufacturing, Inc; _____: www.murdockmfg.com/#sle.
 - 4. Refer to schedule on drawings.

2.06 WASHING MACHINE BOXES AND VALVES

- A. Box Manufacturers:
 - 1. IPS Corporation/Water-Tite: www.ipscorp.com/#sle.
 - 2. Oatey Supply Chain Services, Inc: www.oatey.com/#sle.
 - 3. Viega LLC: www.viega.us/#sle.
 - 4. Refer to schedule on drawings.

2.07 BACKFLOW PREVENTERS

A. Manufacturers:

1. Apollo Valves: www.apollovalves.com/#sle.
2. Cash Acme, a brand of Reliance Worldwide Corporation: www.cashacme.com/#sle.
3. MIFAB, Inc: www.mifab.com/#sle.
4. Watts Regulator Company, a part of Watts Water Technologies:
www.wattsregulator.com/#sle.
5. Zurn Industries, LLC: www.zurn.com/#sle.
6. Refer to schedule on drawings.

2.08 DOUBLE CHECK VALVE ASSEMBLIES

A. Manufacturers:

1. Apollo Valves; _____: www.apollovalves.com/#sle.
2. Cash Acme, a brand of Reliance Worldwide Corporation; _____:
www.cashacme.com/#sle.
3. Watts Regulator Company, a part of Watts Water Technologies; _____:
www.wattsregulator.com/#sle.
4. Zurn Industries, LLC; _____: www.zurn.com/#sle.
5. Refer to schedule on drawings.

2.09 WATER HAMMER ARRESTORS

A. Manufacturers:

1. Jay R. Smith Manufacturing Company: www.jayrsmith.com/#sle.
2. Watts Regulator Company, a part of Watts Water Technologies:
www.wattsregulator.com/#sle.
3. Zurn Industries, LLC: www.zurn.com/#sle.
4. MIFAB, Inc[<>]: www.mifab.com/#sle.
5. Refer to schedule on drawing.

2.10 SANITARY WASTE INTERCEPTORS

A. Manufacturers:

1. Jay R. Smith Manufacturing Company: www.jrsmith.com/#sle.
2. MIFAB, Inc: www.mifab.com/#sle.
3. Zurn Industries, LLC: www.zurn.com/#sle.
4. Striem Company: <https://striemco.com/>
- 5.

B. Oil Interceptors:

1. Construction and Rating:
2. Refer to schedule on drawing.
 - a. Material: Epoxy coated fabricated steel.
 - b. Rough-in: On floor.
 - c. Cover: Steel, epoxy coated, non-skid with gasket, securing handle, and enzyme injection port, recessed for floor finish.

2.11 MIXING VALVES

A. Thermostatic Mixing Valves:

1. Manufacturers:

- a. Cash Acme, a brand of Reliance Worldwide Corporation:
www.cashacme.com/#sle.
- b. ESBE: www.esbe.se/en.
- c. Honeywell International Inc: www.honeywellhome.com/#sle.
- d. Leonard Valve Company: www.leonardvalve.com/#sle.
- e. Watts: www.watts.com.

END OF SECTION 221006

SECTION 221500 - GENERAL-SERVICE COMPRESSED-AIR SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Pipe and pipe fittings.
- B. Air compressor.
- C. Air receiver and accessories.
- D. Aftercooler.
- E. Pressure reducing station.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 220523 - General-Duty Valves for Plumbing Piping.
- C. Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- D. Section 220553 - Identification for Plumbing Piping and Equipment: Identification of piping system.

1.03 REFERENCE STANDARDS

- A. ASME BPVC - Boiler and Pressure Vessel Code.
- B. ASME B16.18 - Cast Copper Alloy Solder Joint Pressure Fittings.
- C. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- D. ASME B16.26 - Cast Copper Alloy Fittings for Flared Copper Tubes.
- E. ASME B31.1 - Power Piping.
- F. ASTM B32 - Standard Specification for Solder Metal.
- G. ASTM B88 - Standard Specification for Seamless Copper Water Tube.
- H. ASTM B88M - Standard Specification for Seamless Copper Water Tube (Metric).
- I. MSS SP-80 - Bronze Gate, Globe, Angle, and Check Valves.
- J. MSS SP-110 - Ball Valves Threaded, Socket-Welding, Solder Joint, Grooved and Flared Ends.
- K. NFPA 70 - National Electrical Code.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturers catalog literature with capacity, weight, and electrical characteristics and connection requirements.
- C. Shop Drawings: Indicate piping system schematic with electrical characteristics and connection requirements.
- D. Test Reports: Submit inspector's certificate for air receiver for inclusion in Operating and Maintenance Manuals.
- E. Manufacturer's Instructions: Indicate manufacturer's installation instructions, hoisting and setting requirements, starting procedures.
- F. Operation Data: Submit for air compressor, air receiver, and accessories, and pressure reducing station.
- G. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Refer to schedule on drawing.
 - 2. See Section 016000 - Product Requirements, for additional provisions.
 - 3. Extra Compressor Oil: One container, quart size.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Accept air compressors, refrigerated air dryer on site in factory-fabricated containers with shipping skids and plastic pipe end protectors in place. Inspect for damage.
- B. Protect piping and equipment from weather and construction traffic.

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for reciprocating air compressors.

PART 2 PRODUCTS

2.01 PIPE AND PIPE FITTINGS

- A. Copper Tube: ASTM B88 (ASTM B88M), Type K (A), drawn.

1. Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought copper and bronze.
2. Joints: ASTM B32, solder, Grade Sn95.

2.02 AIR OUTLETS

- A. Quick Connector: 3/8 inch brass, snap-on connector with self closing valve, Style to be coordinated with owner..

2.03 UNIONS AND COUPLINGS

- A. Unions:
 1. Copper Tube and Pipe: 150 psi bronze unions with soldered joints.
- B. Flexible Connector: Neoprene with brass threaded connectors.

2.04 COMPRESSOR

- A. Manufacturers:
 1. Gardner Denver, Inc. (Champion): www.gardnerdenver.com/#sle.
 2. Ingersoll Rand Compressed Air Solutions: www.ingersollrandproducts.com/#sle.
 3. Sullair Corporation: www.sullair.com/#sle.
- B. Type: Simplex compressor unit consisting of air cooled compressor, air receiver, and aftercooler. Refer to schedule on drawing for basis of design.
- C. Reciprocating Compressors:
 1. Unit: Reciprocating compressor with positive displacement oil pump lubrication system, suction inlet screen, discharge service valves, on cast iron or welded steel base for motor and compressor with provision for V-belt adjustment.
 2. Automatic Capacity Reduction Equipment: Suction valve unloader with lifting mechanism operated by oil pressure. Provide for unloaded compressor start.
 3. Motor: Constant speed 1800 rpm with electronic overheating protection in each phase, full voltage starting.
- D. Motor: See Section 220513.
- E. Wiring Terminations: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. Enclose terminal lugs in terminal box sized to NFPA 70.
- F. Disconnect Switch: Factory mount disconnect switch in control panel.
- G. Cord and Plug: Provide unit with 6 foot cord and plug for connection to electric wiring system including grounding connector.

2.05 AFTERCOOLER

- A. Manufacturers:
 1. Gardner Denver, Inc. (Champion); _____: www.gardnerdenver.com/#sle.
 2. Ingersoll Rand Compressed Air Solutions; _____: www.ingersollrandproducts.com/#sle.
 3. Sullair Corporation; _____: www.sullair.com/#sle.

- B. Construction: Removable tube nests of non-ferrous metal tubes and corrosion-resistant tube plates, safety valves, pressure gauge, moisture separator, moisture drain valve, water inlet piping with automatic water valve, automatic condensate trap and overflow piping with open funnel.
- C. Working Pressure: 120 psi.

2.06 AIR RECEIVER

- A. Manufacturers:
 - 1. Gardner Denver, Inc. (Champion); _____: www.gardnerdenver.com/#sle.
 - 2. Ingersoll Rand Compressed Air Solutions; _____: www.ingersollrandproducts.com/#sle.
 - 3. Sullair Corporation; _____: www.sullair.com/#sle.
- B. Receiver: Vertical, built to ASME regulations for working pressure of 120 psi. Flange or screw inlet and outlet connections.
- C. Fittings: Adjustable pressure regulator, safety valve, pressure gauge, drain cock, and automatic float actuated condensate trap.
- D. Tank Finish: Shop primed.

2.07 PRESSURE REDUCING VALVE

- A. Pressure Reducing Station: Consisting of automatic reducing valve and bypass, and low pressure side relief valve and gauge.
- B. Valve Capacity: Reduce pressure from 120 to owner required pressure, adjustable upwards from reduced pressure.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install equipment in accordance with manufacturer's instructions.
- B. Install compressor unit on concrete housekeeping pad. See Section 033000.
- C. Install compressor unit on vibration isolators. Level and bolt in place. See Section 220548.
- D. Make air cock and drain connection on horizontal casing.
- E. Install replaceable cartridge type filter silencer of adequate capacity for each compressor.
- F. Place shut off valve on water inlet to aftercooler. Pipe drain to floor drain. See Section 220523.
- G. Connect condensate drains to nearest floor drain.
- H. Install takeoffs to outlets from top of main, with shut off valve after takeoff. Slope takeoff piping to outlets.
- I. Install compressed air couplings, female quick connectors, and pressure gauges where outlets are indicated.

- J. Identify piping system and components. See Section 220553.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Compressed Air Piping Leak Test: Prior to initial operation, clean and test compressed air piping in accordance with ASME B31.1.
- C. Repair or replace compressed air piping as required to eliminate leaks, and retest to demonstrate compliance.
- D. Cap and seal ends of piping when not connected to mechanical equipment.

END OF SECTION 221500

SECTION 223000 - PLUMBING EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Water Source Heat Pump Water Heater
- B. Domestic hot water storage tanks.
- C. Diaphragm-type expansion tanks.
- D. In-line circulator pumps.
- E. Elevator Submersible sump pump.

1.02 RELATED REQUIREMENTS

- A. Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- B. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. AHRI 550/590 (I-P) - Performance Rating of Water-chilling and Heat Pump Water-heating Packages Using the Vapor Compression Cycle.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.
- C. ASME BPVC-VIII-1 - Boiler and Pressure Vessel Code, Section VIII, Division 1: Rules for Construction of Pressure Vessels.
- D. ICC (IPC) - International Plumbing Code.
- E. NFPA 70 - National Electrical Code.
- F. NSF 61 - Drinking Water System Components - Health Effects.
- G. UL 778 - Standard for Motor-Operated Water Pumps.
- H. UL 1995 - Heating and Cooling Equipment.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data:
 - 1. Provide dimension drawings of water heaters indicating components and connections to other equipment and piping.
 - 2. 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.
- C. Shop Drawings:
 - 1. Indicate dimensions of tanks, tank lining methods, anchors, attachments, lifting points, tappings, and drains.
- D. Project Record Documents: Record actual locations of components.
- E. Operation and Maintenance Data: Include operation, maintenance, and inspection data, replacement part numbers and availability, and service depot location and telephone number.
- F. Warranty Documentation: Submit manufacturer warranty and ensure that forms have been completed in Owner's name and registered with manufacturer.
- G. Project Record Documents: Record actual locations of components.
- H. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements for additional provisions.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of documented experience.
- B. Certifications:
 - 1. Water Heaters: NSF approved.
 - 2. Water Tanks: ASME labeled to ASME BPVC-VIII-1.
 - 3. Products Requiring Electrical Connection: Listed and classified by Underwriters Laboratories Inc., as suitable for the purpose specified and indicated.
- C. Identification: Provide pumps with manufacturer's name, model number, and rating/capacity identified by permanently attached label.

1.06 DELIVERY, STORAGE, AND HANDLING

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

1.07 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for domestic water heaters.

PART 2 PRODUCTS

2.01 WATER SOURCE heat pump WATER HEATER

- A. Manufacturers:
 - 1. Bradford White Corporation; _____: www.bradfordwhite.com.
 - 2. Lochinvar LLC
 - 3. AO Smith
 - 4. Bradford White
 - 5. Nyle

6. Lync
- B. System: Electric water source heat pump with storage tank.
- C. Heat Pump:
 1. The **HEAT PUMP** shall have a scroll compressor (AHP/WHP025-185) and MHP (0270-2160) or reciprocating compressor (AHP/WHP250), factory charged with R134 refrigerant, NSF61 approved stainless steel circulator pump, and double wall stainless steel condenser for potable water applications. The complete heat pump assembly shall carry a one (1) year limited warranty.
 2. AHP models shall have a factory coated evaporator coil. WHP and MHP models shall be equipped with a stainless-steel single wall heat exchanger evaporator.
 3. The **HEAT PUMP** refrigerant circuit shall contain an adjustable thermal expansion valve, receiver, accumulator, serviceable filter drier and service ports for refrigerant gauges.
 4. The **HEAT PUMP** shall be certified and listed by TUV to CSA C22.2 No. 236:2015, UL 1995:2015-07 standards. The **HEAT PUMP** shall be certified for indoor and/or outdoor installation.
 5. The **HEAT PUMP** shall be constructed with a heavy gauge aluminum jacket assembly and painted on both sides.
 6. The **HEAT PUMP** shall utilize a 24 VDC control circuit and components. The control system shall have a display (PLC Option) for HEAT PUMP set-up, HEAT PUMP status, and HEAT PUMP diagnostics. All components shall be easily accessed and serviceable.
 7. The **HEAT PUMP** shall be equipped with low and high refrigerant pressure switches; short cycle control; outlet water temperature sensor and return water temperature sensor.
 8. The **HEAT PUMP** shall have an optional control for "Cascade" to sequence and rotate while maintaining operation of up to eight HEAT PUMPs of same Btu inputs. The **HEAT PUMP** shall be capable of controlling a valve (single pass option) that maintains constant delivery temperature to the storage tank. The **HEAT PUMP** shall have an optional gateway device which will allow integration with BACnet.
 9. The **HEAT PUMP** shall be equipped with terminal strips for electrical connection. A low voltage connection board connection points for safety and operating controls, i.e., Alarm Contacts, Runtime Contacts and Tank Thermostat, A high voltage terminal strip shall be provided for Supply voltage. Supply voltage shall be 208-230V/1PH/60Hz (AHP025-060), 208-230V/3PH/60Hz, 440-480V/3PH/60Hz, or 575V/3PH/60Hz (APH025-250, WHP025-250, and MHP0270-2160).
 10. The **HEAT PUMP** shall be suitable for use with polypropylene glycol, up to 50% concentration. The de-rate associated with the glycol will vary per glycol manufacturer.
 11. The heat pump refrigerant circuit shall contain an adjustable thermal expansion valve, receiver, accumulator, serviceable filter drier and service ports for refrigerant gauges.
 12. Performance: Refer to schedule on drawing.
- D. Vertical storage tank:
 1. Working Pressure: 150 psi ASME labeled.
 2. Refer to schedule on drawings.
 3. Lining: 15 mils thick epoxy lining extended through flanges and couplings.
 4. Support: Two welded tank saddles not less than 4 inches wide by 1/4 inch thick, mounted on 2 inch pipe stand with minimum four cross braced legs; sheet teflon isolation strip between tank and saddle; dielectric unions between tank and piping system.
 5. Insulation: 3 inch glass fiber insulation with steel jacket.
- E. Pump:

1. Type: All bronze, in-line circulation pump mounted on boiler, controlled by tank mounted immersion thermostat.
- F. Thermostatic Valve: Three-way, self-contained, full line size, bronze body 1/2 to 2 inches size, iron body 2-1/2 inches and over, set at 140 degrees F.

2.02 BLADDER TYPE EXPANSION TANKS

- A. Manufacturers:
1. Amtrol Inc: www.amtrol.com/.
 2. Bell & Gossett, a brand of Xylem, Inc: www.bellgossett.com/.
 3. Taco, Inc: www.taco-hvac.com/.
 4. Wessels: www.westanks.com.
- B. 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.
- C. Accessories: Pressure gauge and air-charging fitting, tank drain; precharge to 12 psig.
- D. Refer to schedule on drawing.

2.03 IN-LINE CIRCULATOR PUMPS

- A. Manufacturers:
1. Armstrong Fluid Technology; _____: www.armstrongfluidtechnology.com.
 2. Bell & Gossett, a brand of Xylem, Inc; _____: www.bellgossett.com.
 3. Sterling SIHI GmbH; _____: www.sterlingsihi.com.
- B. The pumps shall be a wet rotor inline pump, in cast iron or lead free bronze body construction specifically designed for quiet operation. Suitable standard operations at 230° F and 175 PSIG working pressure. The pump internals shall be capable of being serviced without disturbing piping connections.
- C. The pump internals shall be capable of being serviced without disturbing piping connections.
- D. Pump shall be equipped with a water-tight seal to prevent leakage.
- E. Pump volute shall be of a cast iron design for heating systems or lead free bronze for domestic water systems. The connection style on the cast iron and bronze pumps shall be flanged.
- F. Motor shall be a synchronous, permanent-magnet (PM) motor and tested with the pump as one unit. Conventional induction motors will not be acceptable.
- G. Each motor shall have an Integrated Variable Frequency Drive tested as one unit by the manufacturer.
- H. Integrated motor protection shall be verified by UL to protect the pump against over/under voltage, over temperature of motor and/or electronics, over current, locked rotor and dry run (no load condition).
- I. Pump shall have MODBUS or BACnet connections built into the VFD as standard options.
- J. Analog inputs, such as 0-10V and 4-20mA, are standard inputs built into the VFD.

- K. Pumps shall be UL 778 listed and bear the UL Listed Mark for USA and Canada with on-board thermal overload protection.
- L. Each pump shall be factory performance tested before shipment.
- M. Pump operating mode to be Delta-T Constant – This control mode will use a PI algorithm to vary the speed of the pump in order to maintain a constant differential temperature between the built-in temperature sensor and external temperature sensor.
- N. Casing: Bronze, rated for 125 psig working pressure, with stainless steel rotor assembly.
- O. Impeller: Bronze.
- P. Shaft: Alloy steel with integral thrust collar and two oil lubricated bronze sleeve bearings.
- Q. Seal: Carbon rotating against a stationary ceramic seat.
- R. Drive: Flexible coupling.

2.04 ELEVATOR SUBMERSIBLE SUMP PUMP

- A. Manufacturers:
 - 1. Armstrong Fluid Technology: www.armstrongfluidtechnology.com.
 - 2. Goulds Water Technology, a xylem brand: www.goulds.com.
 - 3. Zoeller Company: www.zoeller.com.
 - 4. Liberty Pumps: www.libertypumps.com.
- B. Type: Completely submersible, vertical, centrifugal.
- C. Casing: Cast iron pump body and oil filled motor chamber.
- D. Impeller: Cast iron; open non-clog, stainless steel shaft.
- E. Bearings: Ball bearings.
- F. Elevator Sump: Cast in place concrete.
- G. Accessories: Oil Guard System with Simplex Panel, Oil resistant 20 foot cord and plug with three-prong connector for connection to electric wiring system including grounding connector.
- H. Refer to schedule on drawing.
- I. Servicing: Slide-away coupling consisting of discharge elbow secure to sump floor, movable bracket, guide pipe system, lifting chain and chain hooks.

2.05 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 and electrical work to achieve operating system.
- C. Heat Pump Water Heater:
 - 1. Refer to drawing details.
 - 2. Pipe relief valves and drains to nearest floor drain.
- D. Domestic Water Storage Tanks:
 - 1. Provide steel pipe support, independent of building structural framing members.
 - 2. Clean and flush prior to delivery to site. Seal until pipe connections are made.
- E. Pumps:
 - 1. Refer to drawing details.
 - 2. 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.

END OF SECTION 223000

SECTION 224000 - PLUMBING FIXTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Flush valve water closets.
- B. Wall hung urinals.
- C. Lavatories.
- D. Sinks.
- E. Showers.
- F. Bottle filling drinking fountains.
- G. Electric water coolers.
- H. Mop sinks.
- I. Service sinks.

1.02 RELATED REQUIREMENTS

- A. Section 064100 - Architectural Wood Casework: Counters for sinks and lavatories.
- B. Section 079200 - Joint Sealants: Sealing joints between fixtures and walls and floors.
- C. Section 123600 - Countertops: Counters for sinks and lavatories.
- D. Section 221005 - Plumbing Piping.
- E. Section 221006 - Plumbing Piping Specialties.
- F. Section 223000 - Plumbing Equipment.
- G. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.

1.03 REFERENCE STANDARDS

- A. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design.
- B. ASHRAE Std 18 - Methods of Testing for Rating Drinking-Water Coolers with Self-Contained Mechanical Refrigeration.
- C. ASME A112.6.1M - Floor-Affixed Supports for Off-the-Floor Plumbing Fixtures for Public Use.
- D. ASME A112.18.1 - Plumbing Supply Fittings.
- E. ASME A112.18.9 - Protectors/Insulators for Exposed Waste and Supplies on Accessible Fixtures.

- F. ASME A112.19.2 - Ceramic Plumbing Fixtures.
- G. ASME A112.19.3 - Stainless Steel Plumbing Fixtures.
- H. ASME A112.19.4M - Porcelain Enameled Formed Steel Plumbing Fixtures.
- I. ASME A112.19.5 - Flush Valves and Spuds for Water Closets, Urinals, and Tanks.
- J. ASSE 1014 - Performance Requirements for Backflow Prevention Devices for Hand-Held Showers.
- K. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices.
- L. ASTM C177 - Standard Test Method for Steady-State Heat Flux Measurements and Thermal Transmission Properties by Means of the Guarded-Hot-Plate Apparatus.
- M. ASTM C518 - Standard Test Method for Steady-State Thermal Transmission Properties by Means of the Heat Flow Meter Apparatus.
- N. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- O. FM (AG) - FM Approval Guide.
- P. NSF 61 - Drinking Water System Components - Health Effects.
- Q. NSF 372 - Drinking Water System Components - Lead Content.
- R. UL (DIR) - Online Certifications Directory.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide catalog illustrations of fixtures, sizes, rough-in dimensions, utility sizes, trim, and finishes.
- 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.

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 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Provide five year manufacturer warranty for electric water cooler.

PART 2 PRODUCTS

2.01 GENERAL REQUIREMENTS

- A. Potable Water Systems: Provide plumbing fittings and faucets that comply with NSF 61 and NSF 372 for maximum lead content; label pipe and fittings.

2.02 REGULATORY REQUIREMENTS

- A. Comply with applicable codes for installation of plumbing systems.
- B. Comply with UL (DIR) requirements.
- C. Perform work in accordance with local health department regulations.

2.03 FLUSH VALVE WATER CLOSETS

- A. Water Closets:
 - 1. Vitreous china, ASME A112.19.2, wall hung, siphon jet flush action, china bolt caps.
 - 2. Bowl: ASME A112.19.2; 16.5 inches high with elongated rim.
 - 3. Flush Valve: Exposed (top spud).
 - 4. Flush Operation: Sensor operated, hard wired.
 - 5. Handle Height: 44 inches or less.
 - 6. Inlet Size: 1 inch.
 - 7. Trapway Outlet: 4 inch.
 - 8. Color: White.
 - 9. Manufacturers:
 - a. American Standard, Inc; Baby Devoro, 2-Piece Gravity: www.americanstandard-us.com/#sle.
 - b. Kohler Company; _____: www.kohler.com/#sle.
 - c. Zurn Industries, LLC; _____: www.zurn.com/#sle.
- B. Flush Valves:
 - 1. Valve Supply Size: 1 inch.
 - 2. Manufacturers:
 - a. American Standard, Inc: www.americanstandard-us.com/#sle.
 - b. Sloan Valve Company: www.sloanvalve.com/#sle.
 - c. Zurn Industries, LLC: www.zurn.com/#sle.
 - 3. Sensor-Operated:
 - a. Type: ASME A112.19.5; chloramine-resistant clog-resistant dual-seat diaphragm valve complete with vacuum breaker stops and accessories.
 - b. Mechanism: Solenoid-operated piston or electronic motor-actuated operator with low-voltage powered infrared sensor, and mechanical override or override push button.
 - c. Supplied Volume Capacity: 1.2 gal per flush.
 - 4. Concealed Type: Rough brass, exposed parts chrome-plated, wall escutcheon, wheel handle stop.
- C. Toilet Seats:
 - 1. Manufacturers:
 - a. American Standard, Inc: www.americanstandard-us.com/#sle.
 - b. Bemis Manufacturing Company: www.bemismfg.com/#sle.

- c. Church Seat Company: www.churchseats.com/#sle.
 - d. DXV by American Standard, Inc: www.d xv.com/#sle.
 - e. Olsonite: www.olsonite.com/#sle.
 - f. Zurn Industries, LLC: www.zurn.com/#sle.
 - 2. Plastic: Solid, white finish, elongated shape, open front, slow-closing hinged seat cover, and brass bolts with covers.
 - 3. Plastic: Black finish, open front, extended back, self-sustaining hinge, brass bolts, with cover.
 - 4. Plastic: Black finish, open front, extended back, self-sustaining hinge, brass bolts, with cover.
- D. Water Closet Carriers:
- 1. Manufacturers:
 - a. Jay R. Smith Manufacturing Company: www.jrsmith.com/#sle.
 - b. JOSAM Company: www.josam.com/#sle.
 - c. Zurn Industries, LLC; Z1201-N: www.zurn.com/#sle.
 - d. Mifab.
 - 2. ASME A112.6.1M; adjustable cast iron frame, integral drain hub and vent, adjustable spud, lugs for floor and wall attachment, threaded fixture studs with nuts and washers.

2.04 WALL HUNG URINALS

- A. Manufacturers:
- 1. Advanced Modern Technologies Corporation: www.amtcorporation.com/#sle.
 - 2. American Standard, Inc: www.americanstandard-us.com/#sle.
 - 3. Kohler Company: www.kohler.com/#sle.
 - 4. Zurn Industries, LLC: www.zurn.com/#sle.
- B. Vitreous china, ASME A112.19.2, wall hung with side shields and concealed carrier.
- 1. Consumption Volume: 0.125 gal per flush, maximum.
 - 2. Flush Style: Washout.
 - 3. Flush Valve: Exposed (top spud).
 - 4. Flush Operation: Sensor operated.
 - 5. Trapway Outlet: Integral.
 - 6. Removable stainless steel strainer.
 - 7. Supply Size: 3/4 inch.
 - 8. Outlet Size and Location: 2 inches, bottom side.
- C. Flush Valves:
- 1. Manufacturers:
 - a. American Standard, Inc: www.americanstandard-us.com/#sle.
 - b. Sloan Valve Company: www.sloanvalve.com/#sle.
 - c. Zurn Industries, LLC: www.zurn.com/#sle.
 - 2. Sensor-Operated:
 - a. Mechanism: Solenoid-operated piston or electronic motor-actuated operator with low-voltage powered infrared sensor, and mechanical override or override push button.
 - b. Supplied Volume Capacity: 0.28 gal per flush.
 - 3. Concealed Type: Rough brass, exposed parts chrome-plated, wall escutcheon, wheel handle stop.

- D. Urinal Carriers:
 - 1. Manufacturers:
 - a. Jay R. Smith Manufacturing Company: www.jrsmith.com/#sle.
 - b. JOSAM Company: www.josam.com/#sle.
 - c. Zurn Industries, LLC: www.zurn.com/#sle.
 - 2. ASME A112.6.1M; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded fixture studs for fixture hanger, bearing studs.

2.05 LAVATORIES

- A. Manufacturers:
 - 1. American Standard, Inc: www.americanstandard-us.com/#sle.
 - 2. Kohler Company: www.kohler.com/#sle.
 - 3. Zurn Industries, LLC: www.zurn.com/#sle.
- B. Wall-Hung Basin:
 - 1. Vitreous China, Grade A: ASME A112.19.2; white rectangular commercial-grade sink with predrilled holes, rear-center drain, front overflow, and hanger. Size as indicated on drawings with 4 inch centerset spacing.
 - 2. Carrier:
 - a. ASME A112.6.1M; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded studs for fixture hanger, bearing plate and studs.
 - b. Manufacturers:
 - 1) Jay R. Smith MFG. Co: www.jrsmith.com/#sle.
 - 2) JOSAM Company: www.josam.com/#sle.
 - 3) Zurn Industries, LLC: www.zurn.com/#sle.
- C. Drop-In Basin:
 - 1. Vitreous China: ASME A112.19.2; self-rimming, white, square shape, front overflow, soap depression, seal of putty, calking, or concealed vinyl gasket, and white finish. Size as indicated on drawings with 4 inch centerset spacing.
- D. Supply Faucet:
 - 1. Manufacturers:
 - a. American Standard, Inc: www.americanstandard-us.com/#sle.
 - b. Kohler Company: www.kohler.com/#sle.
 - c. Zurn Industries, LLC; Aqua Sense Series: www.zurn.com/#sle.
 - d. Sloan Valve; www.sloanvalve.com/.
- E. Sensor Operated Faucet: Cast brass, chrome-plated, deck mounted with sensor located on neck of spout.
 - 1. Cast brass, chrome plated, deck mounted with sensor located on neck of spout.
 - 2. Spout Style: Standard.
 - 3. Power Supply:
 - a. Wired: As indicated on drawings.
 - b. Wireless:
 - 1) Battery: Replaceable alkaline or lithium type with 200,000 cycles, minimum.
 - 2) Mini-Turbine: Sensor-operated hydro-powered micro-turbine that charges battery and powers mechanism using water flow energy.

- 3) Low Battery Warning: Provide red or yellow colored indicator to light periodically at 30 days of remaining capacity and continuously 2 weeks prior to get fully discharged.
 4. Mixing Valve: None, single line for tempered water.
 5. Water Supply: 3/8 inch compression connections.
 6. Aerator: Vandal resistant, 0.5 gpm, laminar flow device.
 7. Automatic Shut-off: 10 seconds.
 8. Sensor range: Factory set at 3 inch adjustable up to 24 inch.
 9. Finish: Polished chrome.
- F. Thermostatic Mixing Valve:
1. ASSE 1070 listed with combination stop, strainer, and check valves, and flexible stainless steel connectors.
 2. Slip-joint P-trap.
 3. Braided hot and cold water supply lines.
 4. Chrome plated 17 gauge, 0.0538 inch brass P-trap with clean-out plug and arm with escutcheon.
- G. Accessories:
- H. Accessories:
1. Offset waste with perforated open strainer.
 2. Combination stop and strainer.

2.06 SINKS

- A. Manufacturers:
1. American Bath Group; _____: www.americanbathgroup.com/#sle.
 2. Kohler Company: www.kohler.com/#sle.
 3. Advance Tabco.
 4. Elkay
 5. Just Manufacturing
 6. Refer to schedule on drawings.

2.07 ELECTRIC WATER COOLERS

- A. Manufacturers:
1. Elkay Manufacturing Company; _____: www.elkay.com/#sle.
 2. Haws Corporation; _____: www.hawscor.com/#sle.
 3. Murdock Manufacturing, Inc; _____: www.murdockmfg.com/#sle.
 4. Oasis International; _____: www.oasiscoolers.com/#sle.
- B. Water Cooler: Electric, mechanically refrigerated; surface mounted, ADA compliant; stainless steel top, vinyl on steel body, elevated anti-squirt bubbler with stream guard, automatic stream regulator, push button, mounting bracket; integral air cooled condenser and stainless steel grille.
1. Capacity: 8 gph of 50 degrees F water with inlet at 80 degrees F and room temperature of 90 degrees F, when tested in accordance with ASHRAE Std 18.
 2. Electrical: 115 VAC, 60 Hertz compressor, 6 foot cord and plug for connection to electric wiring system including grounding connector.
 3. Refer to schedule on drawings.

2.08 MOP SINKS

- A. Manufacturers:
 - 1. Acorn Engineering Company: www.acorneng.com/#sle.
 - 2. Zurn Industries, LLC: www.zurn.com/#sle.
 - 3. Fiat; www.fiat.com
 - 4. Mustee; www.mustee.com
 - 5. Refer to schedule on drawings.

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.

3.02 INSTALLATION

- A. Provide chrome-plated rigid or flexible supplies to fixtures with loose key stops, reducers, and escutcheons.
- B. Install components level and plumb.
- C. Install and secure fixtures in place with wall supports and bolts.
- D. Solidly attach water closets to floor with lag screws. Lead flashing is not intended hold fixture in place.

3.03 INTERFACE WITH WORK OF OTHER SECTIONS

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

3.04 ADJUSTING

- A. Adjust stops or valves for intended water flow rate to fixtures without splashing, noise, or overflow.

3.05 CLEANING

- A. Clean plumbing fixtures and equipment.

3.06 PROTECTION

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

- C. Repair or replace damaged products before Date of Substantial Completion.

3.07 SCHEDULES

- A. Fixture Heights: Install fixtures to heights above finished floor as indicated on architectural plans.

END OF SECTION 224000

SECTION 224500 - EMERGENCY PLUMBING FIXTURES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Eyewash equipment.
- B. Emergency-fixture water-tempering valves.

1.02 REFERENCE STANDARDS

- A. ANSI Z358.1 - American National Standard for Emergency Eyewash and Shower Equipment.
- B. ANSI Z535.2 - American National Standard for Environmental and Facility Safety Signs.
- C. ASSE 1070 - Performance Requirements for Water Temperature Limiting Devices.
- D. FM (AG) - FM Approval Guide.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- F. UL (DIR) - Online Certifications Directory.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's catalog sheets for fixtures, fittings, accessories, and supplies.
- C. Field Test Reports: Plumbing fixture operational tests.

PART 2 PRODUCTS

2.01 EYEWASH EQUIPMENT

- A. Manufacturers:
 - 1. Acorn Safety: www.acorneng.com/#sle.
 - 2. Bradley Corporation: www.bradleycorp.com/#sle.
 - 3. Guardian Equipment: www.gesafety.com/#sle.
 - 4. Haws Corporation: www.hawsco.com/#sle.
 - 5. Speakman Company: www.speakman.com/#sle.
- B. ANSI Z358.1, wall-mounted bowl with dual eye-spray head assembly.
- C. Product Certification: UL (DIR).
- D. Tepid Supply Water Temperature: Set to 85 degrees F.
- E. Water Supply Connection Size: 1/2 inch.

- F. Water Discharge Flow Rate: Minimum, 0.4 gpm for 15 minutes.
- G. Pipe and Fittings Material: Epoxy coated galvanized steel.
- H. Valve: Full flow, self close, quick to open using wide-handle manual hand operator.
- I. Drain: Built-into the bowl assembly with 1-1/4 inch female outlet.
- J. Accessories:
 - 1. Bowl Cover: Valve-operated stainless steel hinged assembly.
 - 2. Signage: ANSI Z535.2, emergency eye wash safety equipment.
 - 3. Shut Off Valve: Provide upstream full flow ball valve with detached operating handle.

2.02 EMERGENCY-FIXTURE WATER-TEMPERING VALVES

- A. Manufacturers:
 - 1. Acorn Controls: www.acorneng.com/#sle.
 - 2. Bradley Corporation: www.bradleycorp.com/#sle.
 - 3. Guardian Equipment: www.gesafety.com/#sle.
 - 4. Haws Corporation: www.hawesco.com/#sle.
 - 5. Speakman Company: www.speakman.com/#sle.
- B. Tepid Water Temperature: Set to 85 degrees F.
- C. Capacity: Sized for 20 gpm at 30 psi supply pressure.
- D. Valve Assembly: Thermostatic mixing (blending) type made of lead-free cast brass body with integral built-in cold water bypass (fail safe), color marked dual-scale outlet temperature gauge, integral inlet check valve, integral inlet strainer, locking-type regulator, and mounting bracket.
- E. Cabinet: 16 gauge, 0.0598 inch stainless steel, surface-mounted with keyed lock.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that fixtures and accessories are of the correct type and size prior to installation.
- B. Verify that deck, wall and floor finishes are prepared and ready for fixture installation.

3.02 INSTALLATION

- A. Install fixtures and fittings in accordance with the manufacturer's instructions.
- B. Adjust water flow rates to comply with manufacturer's rating of the fixture.

3.03 FIELD QUALITY CONTROL

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

3.04 CLEANING

- A. Thoroughly clean plumbing fixtures and equipment.

END OF SECTION 224500

SECTION 230010 - GENERAL MECHANICAL REQUIREMENTS

PART 1 GENERAL

- 1.01 section includes
 - A. HVAC.
 - B. Temperature Controls.
 - C. Testing, Adjusting, and Balancing of Mechanical Systems.
- 1.02 related requirements
 - A. 078400 - Firestopping.
 - B. 083100 - Access Doors and Panels.
 - C. 230553 - Identification for HVAC Piping and Equipment.
 - D. 230593 - Testing, Adjusting, and Balancing for HVAC.
 - E. 233300 - Air Duct Accessories.
- 1.03 reference standards
 - A. ASTM E84 - Standard for Test for Surface Burning.
 - B. ASTM E814 - Standard Test Method for Fire Tests of Penetration Firestop Systems.
 - C. UL 723 - Standard for Test for Surface Burning.
- 1.04 EQUIPMENT AND MATERIALS SPECIFIED
 - A. Where products are named on the Drawings or in the Specifications, a Basis of Design product may be named. Other product manufacturers named in the specifications are acceptable; however, first confirm that these products meet the requirements of the contract documents by demonstrating at minimum that they fit into the available space, and meet all performance requirements indicated on the Contract Documents, prior to submitting them for approval. Where the Engineer has determined the products do not meet the requirements of the contract documents, the product is not acceptable.
 - B. Where the equipment and/or materials are submitted for approval other than those that are the Engineer's basis for design, first demonstrate in writing that the equipment or materials will fit into available space, and will meet or exceed all performance requirements indicated on the drawings. Where, in the opinion of the Engineer, any characteristic of the product or material requires modification, such as larger motors, electrical feeders, circuit breakers, additional control devices, valves, fittings, larger support and other miscellaneous equipment, the cost of all such modifications to this and other Contracts shall be borne by the party offering the substitution.

- C. Retain the ultimate responsibility for function of equipment and materials which are not the basis of design for the Contract Documents. Responsibility includes coordinate with other trades for proper location of roughing, and connections to be made by other trades, as well as removal and replacement of any doors, frames, walls, ceilings, and floors without additional cost to be borne by the project.
- D. If revised arrangement submittal is rejected, revise and resubmit specified "design equipment" item which conforms to the Contract Documents.

1.05 ABSENCE OF SPECIFICATION

- A. Where the drawings or the specifications do not name a particular brand or manufacturer of any item, the item is still part of the Work, provide such item(s) that may be fairly and reasonably judged throughout the construction industry to be the most appropriate and best quality item for the intended application. Provide submittals for proposed items to the Engineer for review and approval.

1.06 ELECTRICAL CHARACTERISTICS FOR MECHANICAL EQUIPMENT

- A. Equipment of differing electrical characteristics may be furnished provided the Engineer is first notified in writing of the discrepancy, and that such proposed equipment is approved in writing by the Engineer, and that all connecting electrical services, feeders, branch circuits, disconnecting devices, over current devices, motor starting equipment, wiring, controls, boxes, and conduit sizes are appropriately modified, and the cost of all such modifications shall not be borne by the Engineer or Owner. If minimum energy ratings or efficiencies are specified, all equipment shall comply with requirements.

1.07 SUBSTITUTIONS

- A. The materials, products and equipment described in the Bidding Documents establish a standard of required quality, functions, dimensions and appearance that must be met by any proposed substitution.
- B. Proposed substitutions must be submitted in writing to the Architect and Engineer a maximum of 48 hours after the notice to proceed. Each request shall include the name of the proposed material, product or equipment being substituted, cut sheets, installation drawings, performance and test data, warranties and location of three (3) similar installations with reference names of owner or facility personnel responsible for maintaining equipment. At that time, the equipment or will be evaluated and if determined to be acceptable a submittal may be provided. Failure to follow the guidelines described above will result in equipment being rejected at submittal based solely on failure to follow the above guidelines.
- C. Approval by the Architect and/or Engineer to proceed with a substitution does not relieve the equipment and/or materials from meeting all of the requirements set forth in section "Equipment and Materials Specified" within this specification.

1.08 SCOPE OF WORK

- A. Include in bid all labor, materials, tools, plant, transportation, excavation, equipment, insurance, temporary protection, permits, taxes, services and all necessary and related items required to provide complete and operational systems shown and described.

- B. References to codes and standards called for in the Contract Documents means the latest edition, amendment and revisions to the codes and standards in effect on the date of these contract documents.

1.09 DRAWINGS AND SPECIFICATIONS

- A. The drawings are diagrammatic, and have been developed by the Engineer for the purpose of indicating the sizes, capacities, and the general arrangement of the systems to be installed under this Contract. Install all equipment in complete compliance with manufacturer's instructions, applicable codes and ordinances, and in a neat and workmanlike manner. Field inspect all existing conditions, and identify any obstacles or interferences which may affect the execution of the work. Carefully lay out the routing and location of all equipment and materials so as to accommodate obstacles and interferences, and to provide proper maintenance and access clearances.
- B. Notify the Engineer of any conflicts that will affect the quality, performance, or appearance of the systems installed under this Contract, prior to installing them. In the event of conflict between the drawings and specifications, or between different sheets within the drawing set, this shall be brought to the attention of the Engineer for resolution prior to submission of bids. Failure to note these discrepancies prior to the submission of bids or in writing within their bid submission will result in the Engineer shall resolve the discrepancy such that the design intent is provided. Provide as part of the bid, all labor, materials, and equipment to provide the most costly installation.

1.10 CODES AND STANDARDS

- A. All Work shall conform to rules and regulations of federal, state, and local governmental agencies having jurisdictional authority. All installations shall be installed and tested in accordance with these rules and regulations.
- B. In the event of a conflict between these contract documents and governing rules, regulations, and codes the more stringent practice shall apply.
- C. Install all work in complete compliance with the applicable provisions of the following:
 - 1. 2020 Building Code of New York
 - 2. 2020 Mechanical Code of New York
 - 3. 2020 Energy Conservation Construction Code of New York
 - 4. Local Codes and Ordinances for Ithaca, New York14221.
 - 5. New York State Department of Labor Rules and Regulations (DOL)
 - 6. National Electric Code (NEC)
 - 7. Underwriter's Laboratories (UL)
 - 8. National Fire Protection Association (NFPA)
 - 9. American Society of Mechanical Engineers (ASME)
 - 10. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE)
 - 11. ASHRAE Handbook HVAC Applications, Geothermal Energy Chapter
 - 12. IGSHPA - Geothermal Heat Pump Systems Design and Installation
 - 13. Occupational, Safety and Health Act (OSHA)
 - 14. International Standards Organization (ISO)
 - 15. Other requirements required by the Authorities having Jurisdiction.

1.11 LICENSING AND PERMITS

- A. Maintain all required licenses to perform the work of his respective trade in the locality where the project is constructed.
- B. Apply for all required permits associated with the work of this Contract and pay the cost of all associated permitting fees.

1.12 SUBMITTALS, SHOP DRAWINGS, WIRING DIAGRAMS

- A. Unless otherwise waived, provide submittals for all equipment and materials that are part of this Contract.
- B. Submittals shall include dimensions, weights, capacities, and a list of all specific features and accessories that are to be provided for this project in sufficient detail to permit the Engineer to determine compliance with specified requirements.
- C. Provide wiring diagrams for approval by the Engineer for all electrically powered and/or electrically controlled equipment that is part of this Contract.
- D. Provide complete temperature control wiring diagrams for approval by the Engineer for all temperature control systems and equipment.
- E. Approval of shop drawings and/or submittals does not relieve the responsibility for deviations from the contract documents. Meet the requirements of these documents. All errors and omissions in the product data are to be corrected by this Contractor irrespective of any approvals by the Architect or Engineer.

1.13 LAYOUT, COORDINATION AND SEQUENCING

- A. Coordinate the work with the work of other trades working on this project.
- B. Lay out and adjust the location of the work of this Contract. Layout shall accommodate all obstacles and interferences anticipated or encountered. Relocate obstacles and interferences where required, and as may additionally be directed by the Engineer.
- C. Store materials on a dry base, a least 6" above grade. Store materials so not to interfere with other work or obstruct access to the building. Provide covering, if stored outdoors, provide sight-proof covering. Protect against both theft and damage. Replace stolen or damaged items at no additional cost to the project.
- D. Install the work sequentially with respect to the work of other trades in a timely manner, and so as not to delay the work of other trades or of the Project schedule.
- E. Adhere to the established Construction Schedule for the Project.
- F. Order all equipment and materials in a timely manner so as not to delay the Project. Notify the Engineer of any delays in the timely procurement of equipment and materials.

1.14 ELECTRONIC CAD FILES

- A. The Engineer may provide the Contractor with CAD files for this project, at the request of the contractor. Contractor shall be required to supply the Engineer a completed CAD release form, to be supplied by the Engineer. These CAD files shall be used for reference purposes only, and not as shop drawings or as-built documents. It is the Contractors' responsibility to provide detailed, coordinated shop drawings and documentation prior to installation. The purpose of the

Contractors' coordination shop drawings is to account for all trades and field conditions and identify any conflicts that shall be resolved prior to installation.

- B. Any additional cost for changes due to conflicts as a result of the Contractors' failure to provide properly coordinated documents will be the responsibility of the Contractors and not of the Engineer or the Owner.

1.15 COORDINATION DRAWINGS

- A. Shop/Coordination Drawings: Produced in electronic format (compatible with AutoCAD) Detailed at 3/8" = 1'-0" scale, double lined. Drawings shall indicate duct and pipe layout and elevation, and all equipment with manufacturers' recommended maintenance access. The following items shall be shown and coordinated with each other, and coordinated with all installations from other trades such as division 21, 22, and 26:
1. Duct and piping installation in all spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct and piping layout.
 2. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 3. Fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides.
 4. Detail location of anchors, alignment guides, and expansion joints and loops.
 5. Factory- and shop-fabricated ducts and fittings.
 6. Duct layout indicating sizes, configuration, liner material, static-pressure class, and service.
 7. Piping layout indicating sizes, configuration, valve locations and service.
 8. Refrigerant piping installation indicating coordination with general construction, building components, and other building services. Indicate proposed changes to refrigerant pipe layout.
 9. Mechanical-room layout and relationships between components and adjacent structural and mechanical elements.
 10. Support location, type, and weight.
 11. Field measurements.
 12. Equipment layout indicating sizes, configuration, valve locations and service.
 13. Elevation of top of ducts and pipes.
 14. Dimensions of main duct runs from building grid lines.
 15. Duct and pipe fittings.
 16. Reinforcement and spacing.
 17. Suspended ceiling components.
 18. Structural members to which duct and piping will be attached.
 19. Structural members to which RTUs will be attached.
 20. Roof openings
 21. Roof curbs and flashing.
 22. Size and location of initial access modules for acoustical tile.
 23. Penetrations of smoke barriers and fire-rated construction.
 24. Room walk paths and equipment access
 25. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Sprinklers.
 - d. Access panels.

- B. No installations shall proceed until coordination drawings have been submitted and approved by the Engineer.

1.16 ROUGHING IN

- A. Due to small scale of Drawings, it is not possible to indicate all offsets, fittings, changes in elevation, etc. Verify final locations for rough-ins with field measurements and with the equipment being connected. Verify exact location and elevations at work site prior to any rough in work. **DO NOT SCALE PLANS.** If field conditions, details, changes in equipment or shop drawing information require a significant change to the original documents, contact the Owner's Representative for approval before proceeding.
- B. All equipment locations shall be coordinated with other trades to eliminate interference with required clearances for equipment maintenance and inspections.
- C. Coordinate work with other trades and determine exact routing of all duct, pipe, conduit, etc., before fabrication and installation. Coordinate with Architectural Drawings and all existing architecture. Verify with Owner's Representative exact location and mounting height of all equipment in finished areas, such as thermostats, fixtures, communication and electrical devices, including panels. Mechanical and electrical drawings show design arrangement only for Diffusers, grilles, registers, air terminals, lighting fixtures, sprinklers, speakers and other items. Do not rough-in contract work without reflected ceiling location plans. Report to the Engineer immediately for instances where to the mechanical/electrical/architectural plans show more than one device occupying the same ceiling location.
- D. For equipment and connections provided in this contract, prepare roughing drawings as follows:
 - 1. New equipment: Obtain equipment roughing drawings and dimensions, then prepare rough-in drawings.
- E. Where more than one trade is involved in an area, space or chase, all shall cooperate and install their own work to utilize the space equally between them in proportion to their individual requirements. In general, ductwork shall be given preference except where grading of piping becomes a problem, followed by piping then electrical wiring. If it is determined that ample maintenance and passage space has not been provided, rearrange work and/or furnish other equipment as required for ample maintenance space. Any changes in the size or location of the material or equipment supplied, which may be necessary in order to meet field conditions or in order to avoid conflicts between trades, shall be brought to the immediate attention of the Owner's Representative and approval received before such alterations are made.
- F. All equipment requiring service and / or access shall be provided adequate clearances for this purpose. Any clearances described in manufacturer's information, code requirements, etc., shall be taken into account in determining final rough-in positions. Reasonable access for maintenance and service shall be maintained. The most stringent standard, as determined by the Engineer, shall apply.

1.17 CUTTING AND PATCHING

- A. Provide cutting and patching for all work under this Contract:
 - 1. Provide steel lintels for all duct floor and wall penetrations and similar large openings.
 - 2. Provide steel sleeves for all floor and wall pipe penetrations.

1.18 CONCEALMENT

- A. Conceal all work above ceilings and within walls, below slabs, and elsewhere through the building, except in unfinished spaces. Where a conflict exists that renders concealment impossible, notify the Engineer before starting the work and install as directed.

1.19 FIRE-STOPPING

- A. Refer to Specification section 078400. Where the provisions contained in that section conflict with the requirements contained herein, the more stringent shall apply. Where 078400 is not included, the provisions contained herein shall apply.
- B. Provide materials and products listed by an independent testing laboratory for Through-Penetration Fire Stop Systems, to meet requirements of ASTM E814.
- C. Provide fire stop system at all locations where piping, tubing, conduit, cables, ductwork, and similar items pass through or penetrate any fire rated wall or floor assembly. Where fire ratings of wall and floor assemblies are not indicated on the drawings, assume that all floor and wall assemblies are two (2) hour fire rated assemblies.
- D. Maintain minimum required fire-resistance rating of the wall, floor, or ceiling assembly which is penetrated.
- E. Apply fire-stopping systems within the temperature and humidity limits permitted by the manufacturer.
- F. Provide rigid sleeves where non-armored cables pass through fire rated walls and barriers.
- G. Acceptable Manufacturers: Hilti Firestop Systems

1.20 FIRE AND SMOKE DAMPERS

- A. Fire dampers are required at all duct penetrations of all fire rated assemblies.
- B. Refer to Specification section 233300 for additional requirements for fire and smoke dampers.
- C. Where fire ratings of wall and floor assemblies are not indicated on the drawings, assume that all floor and wall assemblies are two (2) hour fire rated assemblies.

1.21 ACCESS DOORS AND PANELS

- A. Provide access doors for all recessed valves, dampers, junction boxes, controls, and for all other items of equipment that require access, where these items are installed above inaccessible ceiling.
- B. Refer to Specification section 083100; where the provisions contained in that section conflict with the requirements contained herein, the more stringent shall apply. Where section 083100 is not included, the provisions contained herein shall apply in their entirety.
- C. Access doors used shall be specifically designed for the material composing the wall or ceiling where installed.
- D. Unless otherwise indicated, access doors shall be prime painted steel, minimum 14-gauge frame and panel, except where used in toilet rooms, kitchens and showers, where they shall be 16-gauge frame and panel stainless steel. Unless otherwise indicated, hinges shall be piano hinge style.

- E. Access doors used in fire rated walls, partitions and ceilings shall be Underwriters Laboratories 1-1/2 hour class B fire rated.
- F. Locks shall be Screwdriver type, unless otherwise indicated.
- G. Access doors shall be securely attached to the wall, ceiling, or framing material, and installed in complete conformance to manufacturer's installation instructions.
- H. Coordinate the location of all access doors to permit unrestricted access to the equipment to be accessed. Where multiple items of equipment in the same vicinity can be grouped together, provide access panels of proper size to permit unrestricted access to all such items. Provide access panels for all items of equipment which require access.

1.22 EQUIPMENT INSTALLATION

- A. Minimum Requirements:
 - 1. Materials shall have a flame spread rating of 25 or less and a smoke developed rating of 50 or less, in accordance with ASTM E84 and UL 723.
 - 2. All equipment and material for which there is a listing service shall bear a UL label.
 - 3. Communications equipment shall meet all FCC Regulations.
 - 4. All materials, unless otherwise specified, shall be new and be the standard products of the manufacturer. Used equipment or damaged material will be rejected.
- B. Install all equipment in compliance with manufacturer's instructions and the Contract Documents. Notify the Engineer where manufacturer's instructions differ from the Contract Documents for resolution.
- C. Coordinate ordering all equipment with long lead times or equipment having major impact on work by other trades.
- D. Provide all scaffolding, rigging, hoisting, and services necessary for erection and delivery of equipment and apparatus furnished. Remove these apparatus' when they are no longer required.
- E. Where mounting heights are not indicated, install systems in a manner to maximize head room possible.
- F. Lay out equipment to provide access to all components requiring maintenance. Provide clearances as required by applicable codes and standards, as well as manufacturer's recommendations, and good practice.
- G. Lay out equipment so as to provide adequate removal clearance for coils, tubes, fan assemblies, and similar components.
- H. Equipment shall be plumb and level, and secured to supporting structures as specified, recommended by manufacturer, and as dictated by good practice.
- I. Take all necessary precautions with equipment, systems, and building to prevent any damage due to freezing and/or water. Repair or replace, any no additional cost to the project, any such damage which is a result of failure to take proper precautions against freezing and water damage.

1.23 EQUIPMENT SUPPORTS, ROOF CURBS AND CONCRETE BASES

- A. Provide supporting structures for all mechanical equipment.

B. Concrete Bases:

1. Provide concrete bases for all floor mounted equipment including, but not limited to, Chillers, Boilers, air-handling units, heat recovery units, furnaces, fans, pumps, generators, water heaters, storage tanks, expansion and compression tanks, heat exchangers, condensate pumps, vacuum pumps and all other similar equipment required for this project, as called for on the Contract Documents.
2. Floor mounted mechanical equipment shall be mounted on 4 inch high concrete bases. The plan dimensions of each base shall extend 6 inches beyond the outer extents of the equipment served.
3. Concrete bases shall be doweled into floor with steel dowels, minimum 4 dowels per pad, and shall consist of minimum 28 day minimum strength 4000-psi strength concrete. Concrete bases shall be steel reinforced, with minimum one 1/2 inch rebar for every 2 square feet of base area, and shall be smooth and level.
4. Corners of concrete bases shall be chamfered.

C. Refer to respective Specification sections for support of ductwork and piping.

D. Provide shop drawings for all concrete bases for review and approval by the Engineer.

1.24 START-UP AND TESTING

- A. Engage the services of a qualified factory representative for all manufactured equipment to assist in the start-up of all systems and equipment.
- B. Test all systems, equipment, components, and controls installed.
- C. Test all piping and related accessories installed.
- D. Testing requirements are contained in specifications for each specific equipment, component, and material type.
- E. Correct all deficient items detected and re-test until results are satisfactory.
- F. Upon completion of testing, submit a comprehensive written test report to the Engineer for review and approval.

1.25 ADJUSTMENTS AND BALANCING

- A. Balance all air and fluid flows associated with the systems installed per the Engineer's requirements. Where flow rates, speeds, and capacities are not stated on the drawings, the Engineer will, upon request, provide the required quantities. Refer to 230593 for additional requirements.

1.26 IDENTIFICATION

- A. Identify all equipment, piping, ductwork, valves, and controls with permanent, marking system as specified. Refer to Specification section 230553 for requirements.

1.27 CLEANING

- A. Keep the job site and premises clean at all times. Refer to Division 1 for requirements.
- B. Maintain all installed work clean throughout the duration of the project.

1. Remove debris, dirt, grease, paint, plaster, etc. from all equipment and materials installed.
 2. Restore original finish of any equipment and materials damaged during construction.
- C. Clean piping and ductwork prior to testing. Refer to specific specification sections covering piping and ductwork for specific cleaning requirements.

1.28 RECORD DRAWINGS

- A. Prepare record drawings of the completed work of this Contract.
1. Take dimensions from a given fixed bench mark, such as the corner of a building, and neatly and clearly indicate same on reproducible prints.
 2. Provide Record Drawings for all Contract Work. Document the location of control devices, isolation valves, safety devices, and equipment.
 3. Incorporate all field changes, change orders and other modifications into the final Record Drawings.
 4. Record drawings shall contain all corrections from construction documents to as-built conditions and shall be submitted for review and approval. Documents shall be provided in PDF format or, where fully developed in CAD, in AutoCAD compatible file format. Submittal media shall be as acceptable to the Owner and Engineer.

1.29 OPERATING AND MAINTENANCE INSTRUCTIONS

- A. Operation instruction: After all systems have been completely installed and satisfactorily tested, instruct the Owner's representative on the operation of all systems and equipment that are part of this Contract. Instruction shall be a "hands on" session, physically demonstrate the proper operation of all items of equipment. Provide written instructions for the Owner's use prior to the time of instruction, and amend same where required. Include sufficient time to permit the Owner to master the operation of all systems.
- B. Provide one (1) electronic version and one (1) bound set of maintenance manuals covering all systems installed under this contract. Manuals shall adhere to the following requirements:
1. Bound in three-ring binders.
 2. Cover sheet to include Project title, Contractor's name, contact person, contact information, name and contact information of all factory equipment representatives.
 3. Table of contents; tabulated section for each major system.
 4. Operations instructions for each major system.
 5. Include the following for each item of equipment furnished under this contract:
 - a. Maintenance instructions
 - b. Manufacturer's data sheets
 - c. Recommended spare parts inventory
 - d. Wiring diagrams
 6. Preventative maintenance schedule
 7. Record drawings
 8. Temperature controls drawings
 9. Provide approved submittal as part of O&M clearly identifying manufacturer and provided model number.
 10. Include vendor contact information for service and warranty
 11. Include all start-up and testing reports

PART 2 PRODUCTS

2.01 Not Used

PART 3 EXECUTION

3.01 Not Used

END OF SECTION 230010

SECTION 230513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Polyphase motors.
- B. Electronically commutated motors.
- C. Single-phase
- D. Shaft grounding rings.

1.02 RELATED REQUIREMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section
- B. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections.
- C. Section 262913 - Enclosed Controllers.

1.03 REFERENCE STANDARDS

- A. ABMA STD 9 - Load Ratings and Fatigue Life for Ball Bearings.
- B. IEEE 112 - IEEE Standard Test Procedure for Polyphase Induction Motors and Generators.
- C. NEMA MG 1 - Motors and Generators.
- D. NFPA 70 - National Electrical Code.

1.04 SUBMITTALS

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Baldor Electric Company/ABB Group

- B. Leeson Electric Corporation
- C. Regal-Beloit Corporation (Century)

2.02 GENERAL CONSTRUCTION AND REQUIREMENTS

- A. Electrical Service:
 - 1. Motors 1/2 HP and Smaller: 115 volts, single phase, 60 Hz.
 - 2. Motors Larger than 1/2 Horsepower: 208 volts, three phase, 60 Hz.

- B. Efficiency rating shall appear on nameplate and shall not be less than as follows:

MINIMUM NOMINAL FULL-LOAD EFFICIENCIES FOR NEMA DESIGN A, NEMA DESIGN B, AND IEC DESIGN N MOTORS AT 60 Hz (EXCLUDING FIRE PUMPS)

| | NOMINAL FULL LOAD (%) | | | | | | | |
|-----------|------------------------------|----------|----------------|----------|----------------|----------|----------------|----------|
| | 2 POLES | | 4 POLES | | 6 POLES | | 8 POLES | |
| HP (kW) | Open | Enclosed | Open | Enclosed | Open | Enclosed | Open | Enclosed |
| 1 (.75) | 77.0 | 77.0 | 85.5 | 85.5 | 82.5 | 82.5 | 75.5 | 75.5 |
| 1.5 (1.1) | 84.0 | 84.0 | 86.5 | 86.5 | 86.5 | 87.5 | 77.0 | 78.5 |
| 2 (1.5) | 85.5 | 85.5 | 86.5 | 86.5 | 87.5 | 88.5 | 86.5 | 84.0 |
| 3 (2.2) | 85.5 | 86.5 | 89.5 | 89.5 | 88.5 | 89.5 | 87.5 | 85.5 |
| 5 (3.7) | 86.5 | 88.5 | 89.5 | 89.5 | 89.5 | 89.5 | 88.5 | 86.5 |
| 7.5 (5.5) | 88.5 | 89.5 | 91.0 | 91.7 | 90.2 | 91.0 | 89.5 | 86.5 |
| 10 (7.5) | 89.5 | 90.2 | 91.7 | 91.7 | 91.7 | 91.0 | 90.2 | 89.5 |

MINIMUM NOMINAL FULL-LOAD EFFICIENCIES FOR NEMA DESIGN C, AND IEC DESIGN H MOTORS AND 60 Hz.

| | NOMINAL FULL-LOAD EFFICIENCY (%) | | | | | |
|-----------|-----------------------------------------|----------|----------------|----------|----------------|----------|
| | 4 POLES | | 6 POLES | | 8 POLES | |
| HP (kW) | Open | Enclosed | Open | Enclosed | Open | Enclosed |
| 1 (.75) | 85.5 | 85.5 | 82.5 | 82.5 | 75.5 | 75.5 |
| 1.5 (1.1) | 86.5 | 86.5 | 86.5 | 87.5 | 77.0 | 78.5 |
| 2 (1.5) | 86.5 | 86.5 | 87.5 | 88.5 | 84.0 | 84.0 |
| 3 (2.2) | 89.5 | 89.5 | 88.5 | 89.5 | 85.5 | 85.5 |
| 5 (3.7) | 89.5 | 89.5 | 89.5 | 89.5 | 86.5 | 86.5 |
| 7.5 (5.5) | 91.0 | 91.7 | 90.2 | 91.0 | 89.5 | 89.5 |
| 10 (7.5) | 91.7 | 91.7 | 91.7 | 91.0 | 89.5 | 90.2 |

MINIMUM AVERAGE FULL-LOAD EFFICIENCY OF POLYPHASE SMALL ELECTRIC MOTORS

| | Open Motors | | |
|------|--------------------|----------------|----------------|
| | 2 POLES | 4 POLES | 6 POLES |
| HP | 3600 RPM | 1800 RPM | 1200 RPM |
| 0.25 | 65.6 | 69.5 | 67.5 |
| 0.33 | 69.5 | 73.4 | 71.4 |
| 0.50 | 73.4 | 78.2 | 75.3 |

| | | | |
|-----------------------------------------------------------------------------------------------------------------------------------------------|--------------------|-----------------|-----------------|
| 0.75 | 76.8 | 81.1 | 81.7 |
| 1.0 | 77.0 | 83.5 | 82.5 |
| 1.5 | 84.0 | 86.5 | 83.8 |
| 2.0 | 85.5 | 86.5 | N/A |
| 3.0 | 85.5 | 86.9 | N/A |
| MINIMUM AVERAGE FULL-LOAD EFFICIENCY FOR CAPACITOR-START CAPACITOR-RUN AND CAPACITOR-START INDUCTION-RUN SMALL ELECTRIC MOTORS | | | |
| | Open Motors | | |
| | 2 POLES | 4 POLES | 6 POLES |
| HP | 3600 RPM | 1800 RPM | 1200 RPM |
| 0.25 | 66.6 | 68.5 | 62.2 |
| 0.33 | 70.5 | 72.4 | 66.6 |
| 0.50 | 72.4 | 76.2 | 76.2 |
| 0.75 | 76.2 | 81.8 | 80.2 |
| 1.0 | 80.4 | 82.6 | 81.1 |
| 1.5 | 81.5 | 83.8 | N/A |
| 2.0 | 82.9 | 84.5 | N/A |
| 3.0 | 84.1 | N/A | N/A |

2.03 MOTOR CHARACTERISTICS

- A. Open drip-proof type except where specifically noted otherwise.
- B. Design for continuous operation in 104 degrees F environment.
- C. Design for temperature rise in accordance with NEMA MG 1 limits for insulation class, service factor, and motor enclosure type.
- 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, and efficiency.

2.04 Wiring Terminations:

- A. 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.
- B. For fractional horsepower motors where connection is made directly, provide threaded conduit connection in end frame.

2.05 APPLICATIONS

- A. General Purpose: Open drip-proof with cast iron frame, TEFC with cast iron frame, or Encapsulated .
- B. Packaged refrigeration: Hermetic or Semi-hermetic .

2.06 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Efficiency: Energy efficient, as defined in NEMA MG 1.
- C. Service Factor: 1.15.
- D. Rotor: Random-wound, squirrel cage.
- E. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- F. Temperature Rise: Match insulation rating.
- G. Insulation: Class F.
- H. Code Letter Designation:
 - 1. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic

2.07 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Reduced-Voltage and Multispeed Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.
- B. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.
 - 1. Windings: Copper magnet wire with moisture-resistant insulation varnish, designed and tested to resist transient spikes, high frequencies, and short time rise pulses produced by pulse-width modulated inverters.
 - 2. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
 - 3. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
 - 4. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.08 ELECTRONICALLY COMMUTATED MOTORS (ECM)

- A. Motor Enclosure: Open Type
- B. DC ECM specifically designed for the stated application.
- C. Permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
- D. Internal motor circuitry to convert AC power supplied to the equipment to DC power to operate the motor.
- E. Motor shall be speed controllable down to 20% of full speed (80% turndown).
- F. Motor shall meet the stated efficiency based on HP, but shall be not be less than 85% efficient at any HP.

2.09 SINGLE PHASE MOTORS

- A. Motors larger than 1/20 hp shall be one of the following, to suit starting torque and requirements of specific motor application: Permanent-split capacitor, Split phase, Capacitor-

start, capacitor-run, or Capacitor-start, inductor-run.

- B. Bearings: Prelubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- C. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.

2.10 SHAFT GROUNDING RINGS

- A. Motors for use with Variable Speed Drives:
 - 1. Shaft Grounding ring on NEMA Premium and inverter duty motors consisting of conductive microfibers and grounding path.
- B. Shaft Grounding Kit for Field Installation:
 - 1. Field applied shaft grounding ring for motors controlled by variable frequency drives designed to be installed by the contractor.

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.
- D. Selected and installed for the intended use.
- E. Motors to be accessible for maintenance and, where applicable, belt adjustment.

3.02 SHAFT GROUNDING RINGS

- A. Wire Shaft Grounding Kit on motors for use with variable frequency drives:
- B. Ensure shaft grounding kit is installed on motor in accordance with manufacturer's recommendations.
- C. Shaft grounding ring (SGR) is bolted directly to the motor end bracket for installed with conductive epoxy to ensure ground connection from the SGR to the motor frame.

END OF SECTION 230513

SECTION 230517 - SLEEVES AND SLEEVE SEALS FOR HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Sleeves
 - 2. Stack-sleeve fittings.
 - 3. Sleeve-seal systems.
 - 4. Sleeve-seal fittings.
 - 5. Grout.

PART 2 - PRODUCTS

2.1 SLEEVES

- A. Galvanized-Steel Wall Pipes:
 - 1. ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.
 - 2. ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.
 - 3. 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

2.2 STACK-SLEEVE FITTINGS

- 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. Smith, Jay R. Mfg. Co.
 - 2. Zurn Specification Drainage Operation; Zurn Plumbing Products Group.
- B. Description: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring, bolts, and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with setscrews.

2.3 SLEEVE-SEAL FITTINGS

- A. 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:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Presealed Systems.
- C. Description: Manufactured plastic, sleeve-type, waterstop assembly made for imbedding in concrete slab or wall. Unit has plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- B. Characteristics: Nonshrink; recommended for interior and exterior applications.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION

- A. Install sleeves for piping passing through penetrations in floors, partitions, roofs, and walls.
- B. For sleeves that will have sleeve-seal system installed, select sleeves of size large enough to provide 1-inch annular clear space between piping and concrete slabs and walls.
 - 1. Sleeves are not required for core-drilled holes.
- C. Install sleeves in concrete floors, concrete roof slabs, and concrete walls as new slabs and walls are constructed.
 - 1. Permanent sleeves are not required for holes in slabs formed by molded-PE or -PP sleeves.
 - 2. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level.

3. Using grout, seal the space outside of sleeves in slabs and walls without sleeve-seal system.
- D. Install sleeves for pipes passing through interior partitions.
1. Cut sleeves to length for mounting flush with both surfaces.
 2. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 3. Seal annular space between sleeve and piping or piping insulation; use joint sealants appropriate for size, depth, and location of joint. Comply with requirements for sealants specified in Section 079200 "Joint Sealants."
- E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.2 STACK-SLEEVE-FITTING INSTALLATION

- A. Install stack-sleeve fittings in new slabs as slabs are constructed.
1. Install fittings that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 2. Secure flashing between clamping flanges for pipes penetrating floors with membrane waterproofing. Comply with requirements for flashing specified in Section 076200 "Sheet Metal Flashing and Trim."
 3. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level.
 4. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 5. Using grout, seal the space around outside of stack-sleeve fittings.
- B. Fire-Barrier Penetrations: Maintain indicated fire rating of floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Section 078413 "Penetration Firestopping."

3.3 SLEEVE-SEAL-FITTING INSTALLATION

- A. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- B. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position waterstop flange to be centered in concrete slab or wall.
- C. Secure nailing flanges to concrete forms.
- D. Using grout, seal the space around outside of sleeve-seal fittings.

3.4 SLEEVE AND SLEEVE-SEAL SCHEDULE

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

1. Exterior Concrete Walls above Grade:
 - a. Piping Smaller Than NPS 6: Galvanized-steel wall sleeves.
2. Concrete Slabs above Grade:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.
3. Interior Partitions:
 - a. Piping Smaller Than NPS 6: Galvanized-steel-pipe sleeves.

END OF SECTION

SECTION 230519 - METERS AND GAUGES FOR HVAC 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. Liquid-in-glass thermometers.
 - 2. Thermowells.
 - 3. Dial-type pressure gauges.
 - 4. Gauge attachments.
 - 5. Test plugs.

1.3 ACTION SUBMITTALS

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

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For meters and gauges to include in operation and maintenance manuals.

PART 2 - PRODUCTS

2.1 LIQUID-IN-GLASS THERMOMETERS

- A. Metal-Case, Industrial-Style, Liquid-in-Glass Thermometers:
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. Standard: ASME B40.200.
 - 3. Case: Cast aluminum; 9-inch nominal size unless otherwise indicated.
 - 4. Case Form: Adjustable angle unless otherwise indicated.
 - 5. Tube: Glass with magnifying lens and blue organic liquid.
 - 6. Tube Background: Non-reflective aluminum with permanently etched scale markings graduated in deg F.

7. Window: Glass.
8. Stem: Aluminum and of length to suit installation.
 - a. Design for Thermowell Installation: Bare stem.
9. Connector: 1-1/4 inches, with ASME B1.1 screw threads.
10. Accuracy: Plus or minus 1 percent of scale range or one scale division, to a maximum of 1.5 percent of scale range.

2.2 THERMOWELLS

A. Thermowells:

1. Standard: ASME B40.200.
2. Description: Pressure-tight, socket-type fitting made for insertion into piping tee fitting.
3. Material for Use with Copper Tubing: CNR or CUNI.
4. Material for Use with Steel Piping: CRES or CSA
5. Type: Stepped shank unless straight or tapered shank is indicated.
6. External Threads: NPS 1/2, NPS 3/4, or NPS 1, ASME B1.20.1 pipe threads.
7. Internal Threads: 1/2, 3/4, and 1 inch, with ASME B1.1 screw threads.
8. Bore: Diameter required to match thermometer bulb or stem.
9. Insertion Length: Length required to match thermometer bulb or stem.
10. Lagging Extension: Include on thermowells for insulated piping and tubing.
11. Bushings: For converting size of thermowell's internal screw thread to size of thermometer connection.

B. Heat-Transfer Medium: Mixture of graphite and glycerin.

2.3 PRESSURE GAUGES

A. Direct-Mounted, Metal-Case, Dial-Type Pressure Gauges:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Standard: ASME B40.100.
3. Case: Sealed type; cast aluminum; 6-inch nominal diameter.
4. Pressure-Element Assembly: Bourdon tube unless otherwise indicated.
5. Pressure Connection: Brass, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and bottom-outlet type unless back-outlet type is indicated.
6. Movement: Mechanical, with link to pressure element and connection to pointer.
7. Dial: Non-reflective aluminum with permanently etched scale markings graduated in psi.
8. Pointer: Dark-colored metal.
9. Window: Glass.
10. Ring: Brass.
11. Accuracy: Grade A, plus or minus 1 percent of middle half of scale range.

2.4 GAUGE ATTACHMENTS

- A. Snubbers: ASME B40.100, brass; with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads and piston-type surge-dampening device. Include extension for use on insulated piping.
- B. Siphons: Loop-shaped section of brass pipe with NPS 1/4 or NPS 1/2 pipe threads.
- C. Valves: Brass ball, with NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe threads.

2.5 TEST PLUGS

- A. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 1. Description: Test-station fitting made for insertion into piping tee fitting.
 - 2. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.
 - 3. Thread Size: NPS 1/4 or NPS 1/2 ASME B1.20.1 pipe thread.
 - 4. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F
 - 5. Core Inserts: EPDM self-sealing rubber.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install thermowells with socket extending to center of pipe and in vertical position in an oversized piping tees to reduce pressure drop on the hydronic system.
- B. Provide thermowells associated with each thermometer. Install thermowells of sizes required to match thermometer connectors. Include bushings if required to match sizes.
- C. Install thermowells with extension on insulated piping.
- D. Fill thermowells with heat-transfer medium.
- E. Install direct-mounted thermometers in thermowells and adjust vertical and tilted positions.
- F. Install direct-mounted pressure gauges in piping tees with pressure gauge located on pipe at the most readable position.
- G. Install valve and snubber in piping for each pressure gauge for fluids.
- H. Install test plugs in piping tees.
- I. Install permanent indicators on walls or brackets in accessible and readable positions.
- J. Install connection fittings in accessible locations for attachment to portable indicators.

K. Install siphons where required to protect from high temperature damage of gauges

L. Install thermometers in the following locations:

1. Inlet and outlet of each hydronic zone.
2. Inlet and outlet of each hydronic boiler.
3. Inlet and outlet of each hydronic coil.
4. As shown on drawings

M. Install pressure gauges in the following locations:

1. Discharge of each pressure-reducing valve.
2. Suction and discharge of each pump.
3. Inlet and outlet of each hydronic zone.
4. Inlet and outlet of each hydronic boiler
5. Inlet and outlet of each hydronic coil
6. As shown on drawings

3.2 CONNECTIONS

A. Install meters and gauges adjacent to machines and equipment to allow service and maintenance of meters, gauges, machines, and equipment.

3.3 ADJUSTING

- A. After installation, calibrate meters according to manufacturer's written instructions.
- B. Adjust faces of meters and gauges to proper angle for best visibility.

3.4 THERMOMETER SCHEDULE

A. Thermometers as listed above and as shown on drawings shall be the following:

1. Industrial-style, liquid-in-glass type.
2. Test plug with EPDM self-sealing rubber inserts.
3. Install thermometers in thermowells.

B. Thermometer stems shall be of length to match thermowell insertion length.

3.5 THERMOMETER SCALE-RANGE SCHEDULE

- A. Scale Range for Hot Water Piping: 0 to 250 deg F.
- B. Scale Range for Boiler or Heat Exchanger inlet and outlet: 30 to 300 deg F.

3.6 PRESSURE-GAUGE SCHEDULE

- A. Pressure gauges listed above and as shown on drawings shall be the following:
1. Sealed, direct-mounted, metal case.
 2. Test plug with EPDM self-sealing rubber inserts.
 3. Install pressure gauge in snubber

3.7 PRESSURE-GAUGE SCALE-RANGE SCHEDULE

- A. Scale Range for all Hydronic Systems: 0 to 100 psi

END OF SECTION

SECTION 230523 - GENERAL-DUTY VALVES FOR HVAC 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. Bronze ball valves.
- 2. High performance butterfly valves
- 3. Iron gate valves.
- 4. Bronze swing check valves
- 5. Iron swing check valves
- 6. Iron, grooved-end swing-check valves.
- 7. Chainwheels

- B. Related Sections:

- 1. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.
- 2. Division 23 Section "HVAC hydronic piping."
- 3. Division 23 Section "HVAC hydronic piping specialties."

1.3 DEFINITIONS

- 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. RS: Rising stem.
- G. SWP: Steam working pressure.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of valve indicated.
- B. Provide valve schedule indicating intended type of valve to be installed and installation location. Refer to valve schedule below.

1.5 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 2. ASME B31.1 for power piping valves.
 - 3. ASME B31.9 for building services piping valves.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Prepare valves for shipping as follows:
 - 1. Protect internal parts against rust and corrosion.
 - 2. Protect threads, flange faces, grooves, and weld ends.
 - 3. Set gate valves closed to prevent rattling.
 - 4. Set ball valves open to minimize exposure of functional surfaces.
- B. Use the following precautions during storage:
 - 1. Maintain valve end protection.
 - 2. Store valves indoors and maintain at higher than ambient dew point temperature. If outdoor storage is necessary, store valves off the ground in watertight enclosures.
- C. Use sling to handle large valves; rig sling to avoid damage to exposed parts. Do not use handwheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to HVAC valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.

- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Handwheel: For valves other than quarter-turn types.
 - 2. Handlever: For quarter-turn valves NPS 6 and smaller.
 - 3. Chainwheel: Device for attachment to valve handwheel, stem, or other actuator; of size and with chain for mounting height, as indicated in the "Valve Installation" Article
- E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Gate Valves: With rising stem.
 - 2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
- F. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Solder Joint: With sockets according to ASME B16.18.
 - 3. Threaded: With threads according to ASME B1.20.1.
 - 4. Grooved: With grooves according to AWWA C606.

2.2 BRONZE BALL VALVES

- A. Two-Piece, Full-Port, Bronze Ball Valves with Bronze Trim:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.; Apollo Valves.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Description:
 - a. Standard: MSS SP-110.
 - b. SWP Rating: 150 psig.
 - c. CWP Rating: 600 psig.
 - d. Body Design: Two piece.
 - e. Body Material: Bronze.
 - f. Ends: Threaded.
 - g. Seats: PTFE.
 - h. Stem: 316 Stainless Steel.
 - i. Ball: 316 Stainless Steel.
 - j. Port: Full.

2.3 CAST IRON BALL VALVE

A. Two-piece, Full-Port, Cast Iron Ball Valve with

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Conbraco Industries, Inc.; Apollo Valves.
 - c. Milwaukee Valve Company.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-72, ASTM A126 Class B
 - b. SWP Rating: 125 psig
 - c. CWP Rating: 200 psig
 - d. Body Design: Split Body
 - e. Body Material: Cast Iron
 - f. Ends: Flanged, Steel bolts, nuts, and washers
 - g. Seats: PTFE
 - h. Gasket: PTFE
 - i. Packing: PTFE
 - j. Stem: 304 Stainless Steel
 - k. Ball: 304 Stainless Steel
 - l. Port: Full
 - m. Operator: Handle (NPS 4 – NPS 6), Gear and Handwheel (NPS 8 – NPS 10)

2.4 HIGH-PERFORMANCE BUTTERFLY VALVES

A. Class 150, Single-Flange, High-Performance double eccentric Butterfly Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Apollo.
2. Description:
 - a. Standard: MSS SP-68, ASME B16.34A
 - b. CWP Rating: 285 psig at 100 deg F .
 - c. Temperature rating up to 250 deg F, suitable for hot water and chilled water applications.
 - d. Suitable for glycol services

- e. Body Design: Lug type; suitable for bidirectional dead-end service at rated pressure without use of downstream flange.
- f. Body Material: Carbon steel
- g. Seat: glass reinforced PTFE
- h. Stem: Stainless steel; offset from seat plane, Double Eccentric, blowout proof stem, one piece
- i. Disc: Stainless Steel
- j. Service: Bidirectional.
- k. Ends: Flanged

1) ASME B16.5

- l. Packing and Gasket: Asbestos free
- m. Powder coated epoxy finish
- n. Operation: Lever

2.5 IRON GATE VALVES

A. Class 125, NRS Bronze Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 200 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and screw-in bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron.

B. Class 125, OS&Y, Iron Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:

- a. Standard: MSS SP-70, Type I.
- b. NPS 2-1/2 to NPS 12,
- c. SWP Rating: 200 psig.
- d. Body Material: ASTM A 126, gray iron with bolted bonnet.
- e. Ends: Flanged.
- f. Trim: Bronze.
- g. Disc: Solid wedge.
- h. Packing and Gasket: Asbestos free.

C. Class 125, NRS, Iron Gate Valves:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. Standard: MSS SP-70, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - d. Ends: Flanged.
 - e. Trim: Bronze.
 - f. Disc: Solid wedge.
 - g. Packing and Gasket: Asbestos free

2.6 BRONZE SWING CHECK VALVES

A. Class 150, Bronze Swing Check Valves with Bronze Disc:

- 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. American Valve, Inc.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
- 2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 300 psig
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze

2.7 IRON SWING CHECK VALVES

A. Class 150, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Milwaukee Valve Company.
 - b. NIBCO INC.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-71, Type I.
 - b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
 - c. NPS 14 to NPS 24, CWP Rating: 150 psig.
 - d. Body Design: Clear or full waterway.
 - e. Body Material: ASTM A 126, gray iron with bolted bonnet.
 - f. Ends: Flanged.
 - g. Trim: Bronze.
 - h. Gasket: Asbestos free.

2.8 IRON, GROOVED-END SWING CHECK VALVES

A. 300 CWP, Iron, Grooved-End Swing Check Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Anvil International, Inc.
 - b. Shurjoint Piping Products.
 - c. Tyco Fire Products LP; Grinnell Mechanical Products.
 - d. Victaulic Company.
2. Description:
 - a. CWP Rating: 300 psig.
 - b. Body Material: ASTM A 536, ductile iron.
 - c. Seal: EPDM.
 - d. Disc: Spring operated, ductile iron or stainless steel

2.9 CHAINWHEELS

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

1. Babbitt Steam Specialty Co.

2. Roto Hammer Industries.
3. Trumbull Industries.

B. Description: Valve actuation assembly with sprocket rim, brackets, and chain.

1. Brackets: Type, number, size, and fasteners required to mount actuator on valve.
2. Attachment: For connection to ball valve stems.
3. Sprocket Rim with Chain Guides: Ductile iron, of type and size required for valve.
4. Chain: Hot-dip, galvanized steel, of size required to fit sprocket rim.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.
- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access from floor level and provide separate support where necessary. Provide piping and fittings as required to locate valves in an easily accessible area. Contractor shall coordinate valve location to maintain proper access and maintenance with all other building systems. (i.e. ductwork, equipment, structure, walls, etc.).
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install chain operated valve for any valve required to be installed 6 feet above finished floor or higher if it is below the ceiling or structure above.

F. Install check valves for proper direction of flow and as follows:

1. Swing Check Valves: In horizontal position with hinge pin level

3.3 ADJUSTING

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

3.4 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
1. Shutoff Service: Ball, gate, or high performance butterfly valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.

3.5 HOT WATER VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Smaller:
1. Bronze Ball Valves: Solder-joint, Two piece, full port, bronze with stainless steel ball and stem.
 2. Bronze Swing Check Valves: Solder-joint, bronze disc

3.6 HEAT PUMP VALVE SCHEDULE

- A. Pipe NPS 2-1/2 and Smaller:
1. Bronze Ball Valves: Solder-joint, Two piece, full port, bronze with stainless steel ball and stem.
 2. Bronze Swing Check Valves: Solder-joint, bronze disc
- B. Pipe NPS 3 and Larger:
1. Iron Gate Valves: Flanged for welded pipe fitting installation, OS&Y or NRS.
 2. High performance butterfly valve
 3. Cast Iron Ball Valve, flanged joint, two-piece, cast iron with stainless steel ball and stem.
 4. Iron swing check valves: Flanged or grooved fitting installation

END OF SECTION 230523

SECTION 230529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment components for equipment, piping, and other HVAC/hydronic work.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 055000 - Metal Fabrications: Materials and requirements for fabricated metal supports.
- C. Section 230548 - Vibration and Seismic Controls for HVAC.

1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C. ASTM A181/A181M - Standard Specification for Carbon Steel Forgings, for General - Purpose Piping.
- D. ASTM A36/A36M - Standard Specification for Carbon Structural Steel.
- E. ASTM A47/A47M - Standard Specification for Ferritic Malleable Iron Castings.
- F. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- H. MFMA-4 - Metal Framing Standards Publication.
- I. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.
- J. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with the actual equipment and components to be installed.
 - 2. Coordinate the work with other trades to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at the installed locations.

4. Coordinate the arrangement of supports with ductwork, piping, equipment and other potential conflicts installed under other sections or by others.
5. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
 1. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water.
 2. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for channel (strut) framing systems, nonpenetrating rooftop supports, post-installed concrete and masonry anchors, and thermal insulated pipe supports.
- D. Shop Drawings: Include fabrication and installation details for fabricated hangers and supports, including calculations, for the following:
 1. Trapeze pipe hangers.
 2. Metal framing systems.
 3. Pipe stands.
 4. Equipment supports.
- E. Manufacturer's Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

1.06 QUALITY ASSURANCE

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

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Provide all required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for the complete installation of plumbing work.
2. Provide products listed, classified, and labeled as suitable for the purpose intended, where applicable.
3. Do not use wire, chain, perforated pipe strap, or wood for permanent supports unless specifically indicated or permitted.
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. Materials for Metal Fabricated Supports: Comply with Section 055000.

C. 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. Provide factory-fabricated continuous-slot metal channel (strut) and associated fittings, accessories, and hardware required for field-assembly of supports.
2. Comply with MFMA-4.
3. 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.
4. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch.
5. Minimum Channel Dimensions: 1-5/8 inch width by 13/16 inch height.

D. 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 nominal: 1/4 inch diameter.
 - c. Piping larger than 1 inch nominal: 3/8 inch diameter.
 - d. Trapeze Support for Multiple Pipes: 3/8 inch diameter.

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.
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.

F. Pipe Stanchions: For pipe runs, use stanchions of same type and material where vertical adjustment is required for stationary pipe.

1. Material: Malleable iron, ASTM A47/A47M; or carbon steel, ASTM A36/A36M.
 2. Provide coated or plated saddles to isolate steel hangers from dissimilar metal tube or pipe.
- 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. Provide copper plated clamps for copper tubing support.
 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. 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.
- N. Pipe Shields for Insulated Piping:
1. General Construction and Requirements:
 - a. Surface Burning Characteristics: Comply with ASTM E84 or UL 723.
 - b. Shields Material: UV-resistant polypropylene with glass fill.
 - c. Maximum Insulated Pipe Outer Diameter: 12-5/8 inch.
 - d. Minimum Service Temperature: Minus 40 degrees F.
 - e. Maximum Service Temperature: 178 degrees F.
 - f. Pipe shields to be provided at hanger, support, and guide locations on pipe requiring insulation or additional support.
- O. 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 not permitted.
 11. Hammer-driven anchors and fasteners are not permitted.

12. Preset Concrete Inserts: Continuous metal channel (strut) and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Comply with MFMA-4.
 - b. Channel Material: Use galvanized steel.
 - c. Minimum Channel Thickness: Steel sheet, 12 gauge, 0.1046 inch minimum base metal thickness.
 - d. Manufacturer: Same as manufacturer of metal channel (strut) framing system.
13. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) for compliance with applicable building code.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, conduit, or other systems.
- D. Unless specifically indicated or approved by Engineer of Record, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Engineer of Record, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 1. Use metal fabricated supports or supports assembled from metal channel (strut) to support equipment as required.
 2. Use metal channel (strut) secured to studs to support equipment surface-mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel (strut) to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. Unless otherwise indicated, mount floor-mounted equipment on properly sized 3 inch high concrete pad constructed in accordance with Section 033000.
 5. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Preset Concrete Inserts: Use manufacturer-provided closure strips to inhibit concrete seepage during concrete pour.

- I. Secure fasteners according to manufacturer's recommended torque settings.
- J. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

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

END OF SECTION 230529

SECTION 230548 - VIBRATION AND SEISMIC CONTROLS FOR HVAC

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Seismic control requirements.
 - 1. Includes requirements for seismic qualification of equipment not specified in this section.
- C. Vibration-isolated equipment support bases.
- D. Vibration isolators.
- E. External seismic snubber assemblies.
- F. Seismic restraint systems.
- G. Vibration-isolated and/or seismically engineered roof curbs.

1.02 RELATED REQUIREMENTS

- A. Section 014533 - Code-Required Special Inspections and Procedures.
- B. Section 033000 - Cast-in-Place Concrete.
- C. Section 055000 - Metal Fabrications: Materials and requirements for fabricated metal supports.
- D. Section 220548 - Vibration and Seismic Controls for Plumbing Piping and Equipment.
- E. Section 230529 - Hangers and Supports for HVAC Piping and Equipment.

1.03 DEFINITIONS

- A. HVAC Component: Where referenced in this section in regards to seismic controls, applies to any portion of the HVAC system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., ductwork, piping).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

1.04 REFERENCE STANDARDS

- A. ASCE 7 - Minimum Design Loads and Associated Criteria for Buildings and Other Structures.
- B. ASCE 19 - Structural Applications of Steel Cables for Buildings.
- C. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.
- D. FEMA 412 - Installing Seismic Restraints for Mechanical Equipment.

- E. FEMA 413 - Installing Seismic Restraints for Electrical Equipment.
- F. FEMA 414 - Installing Seismic Restraints for Duct and Pipe.
- G. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage.
- H. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components.
- I. MFMA-4 - Metal Framing Standards Publication.
- J. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems.

1.05 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. Seismic Controls:
 - a. Coordinate the arrangement of seismic restraints with piping, conduit, equipment, and other potential conflicts installed under other sections or by others.
 - b. Coordinate the work with other trades to accommodate relative positioning of essential and nonessential components in consideration of seismic interaction.
 - 5. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install products on or provide attachment to concrete surfaces until concrete has fully cured in accordance with Section 033000.

1.06 SUBMITTALS

- A. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- 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 methods for spring element load capacities.
 - 2. Seismic Controls: Include seismic load capacities.
- C. Shop Drawings - Vibration Isolation Systems:
 - 1. Include dimensioned plan views and sections indicating proposed arrangement of vibration isolators; indicate equipment weights and static deflections.
- D. Shop Drawings - Seismic Controls:
 - 1. Include dimensioned plan views and sections indicating proposed HVAC component locations and distributed system routing, with locations and details of gravity supports

- and seismic restraints and associated attachments.
 - 2. Identify mounting conditions required for equipment seismic qualification.
 - 3. Identify anchor manufacturer, type, minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
 - 4. Indicate proposed arrangement of distributed system trapeze support groupings.
 - 5. Indicate proposed locations for distributed system flexible fittings and/or connections.
 - 6. Indicate locations of seismic separations where applicable.
 - 7. Include point load drawings indicating design loads transmitted to structure at each attachment location.
- E. Seismic Design Data:
- 1. Compile information on project-specific characteristics of actual installed HVAC components necessary for determining seismic design forces required to design appropriate seismic controls, including but not limited to the following.
 - a. Component operating weight and center of gravity.
 - b. Component elevation in the building in relation to the roof elevation (z/h).
 - c. Component importance factor (I_p).
 - d. Component amplification factor (a_p) and component response modification factor (R_p), determined in accordance with ASCE 7 tables.
 - e. Applicability of overstrength factor (for certain anchorage in concrete and masonry).
 - 2. Include structural calculations, stamped or sealed by seismic controls designer, demonstrating suitability of seismic controls for seismic design forces.
- F. Certification for seismically qualified equipment; identify basis for certification.
- G. Evaluation Reports: For products specified as requiring evaluation and recognition by a qualified evaluation service, provide current evaluation reports.
- H. 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.
- I. Evidence of qualifications for seismic controls designer.
- J. Evidence of qualifications for manufacturer.
- K. Manufacturer's detailed field testing and inspection procedures.
- L. Field quality control test reports.
- 1.07 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. Seismic Controls Designer Qualifications: Registered professional engineer licensed in the State of New York and with minimum five years experience designing seismic restraints for nonstructural components.
 - 1. Designer may be employed by the manufacturer of the seismic restraint products.

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

1.08 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SEISMIC CONTROL REQUIREMENTS

- A. Design and provide HVAC component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor HVAC components.
- B. Seismic Design Criteria: As indicated on drawings.
- C. Component Importance Factor (I_p): HVAC components essential to life safety to be assigned a component importance factor (I_p) of 1.5 as indicated or as required. This includes but is not limited to:
 - 1. HVAC components required to function for life safety purposes after an earthquake.
 - 2. HVAC components that support or otherwise contain hazardous substances.
- D. Seismic Qualification of Equipment:
 - 1. Provide special certification for HVAC equipment furnished under other sections and assigned a component importance factor (I_p) of 1.5, certifying that equipment will remain operable following a design level earthquake.
 - 2. Seismic qualification to be by shake table testing in accordance with recognized testing standard procedure, such as ICC-ES AC156, acceptable to authorities having jurisdiction.
 - 3. Notify Engineer of Record and obtain direction where mounting restrictions required by conditions of seismic certification conflict with specified requirements.
 - 4. Seismically qualified equipment to be furnished with factory-installed labels referencing certificate of compliance and associated mounting restrictions.
- E. Seismic Restraints:
 - 1. Provide seismic restraints for HVAC components except where exempt according to applicable codes and specified seismic design criteria, as approved by authorities having jurisdiction.
 - 2. Seismic Restraint Exemptions:
 - a. Exemptions for Seismic Design Category C:
 - 1) HVAC components where either of the following apply:
 - a) The component importance factor (I_p) is 1.0 and the component is positively attached to the structure.
 - b) The component weighs 20 pounds or less or, in the case of a distributed system, 5 pounds per foot or less.
 - 2) HVAC piping with component importance factor (I_p) of 1.5 and nominal pipe size of 2 inch or less, where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, and where piping is positively attached to the structure; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron,

- glass, nonductile plastics).
- b. Exemptions for Seismic Design Category D, E, and F:
 - 1) Discrete HVAC components that are positively attached to the structure where either of the following apply:
 - a) The component weighs 400 pounds or less, has a center of mass located 4 feet or less above the adjacent floor level, flexible connections are provided between the component and associated ductwork, piping, and conduit, and the component importance factor (I_p) is 1.0.
 - b) The component weighs 20 pounds or less or, in the case of a distributed system, 5 pounds per foot or less.
 - 2) HVAC piping with component importance factor (I_p) of 1.0 and nominal pipe size of 3 inch or less, or with component importance factor (I_p) of 1.5 and nominal pipe size of 1 inch or less, where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, and where piping is positively attached to the structure; exemption does not apply to piping constructed of low-deformability materials (e.g., cast iron, glass, nonductile plastics).
 - c. Duct System Exemptions, All Seismic Design Categories:
 - 1) Duct systems not designed to carry toxic, highly toxic, or flammable gases and not used for smoke control with component importance factor (I_p) of 1.0, where flexible connections or other assemblies are provided between duct system and associated components, where duct system is positively attached to the structure, and where one of the following apply:
 - a) Trapeze supported duct with trapeze assemblies using 3/8 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, and the total weight supported by any single trapeze is 100 pounds or less.
 - b) Trapeze supported duct with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, and the total weight supported by any single trapeze is 200 pounds or less.
 - c) Trapeze supported duct with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 24 inches in length from support point connection to the supporting structure, and the total weight supported by any single trapeze is 100 pounds or less.
 - d) Hanger supported duct with individual rod hangers 3/8 inch or 1/2 inch in diameter not exceeding 12 inches in length from support point connection to the supporting structure, and the total weight supported by any single rod is 50 pounds or less.
 - 2) Duct systems not designed to carry toxic, highly toxic, or flammable gases and not used for smoke control, where there are provisions to avoid impact with other ducts or mechanical components or to protect ducts in the event of such impact, and where duct system is positively attached to the structure and has a cross sectional area of less than 6 square feet and weighs 20 pounds per foot or less.
 - d. HVAC Piping Exemptions, All Seismic Design Categories:
 - 1) HVAC piping where flexible connections, expansion loops, or other assemblies are provided between piping and associated components, where piping is positively attached to the structure, and where one of the following apply:

- a) Trapeze supported piping weighing less than 10 pounds per foot, where all pipes supported meet size requirements for exemption as single pipes described under specific seismic design category exemptions above.
 - b) Trapeze supported piping with trapeze assemblies using 3/8 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (Ip) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 100 pounds or less.
 - c) Trapeze supported piping with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 12 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (Ip) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 200 pounds or less.
 - d) Trapeze supported piping with trapeze assemblies using 1/2 inch diameter rod hangers not exceeding 24 inches in length from support point connection to the supporting structure, where all pipes supported have a component importance factor (Ip) of 1.0 and meet size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single trapeze is 100 pounds or less.
 - e) Hanger supported piping with individual rod hangers 3/8 inch or 1/2 inch in diameter not exceeding 12 inches in length from support point connection to the supporting structure, where pipe has a component importance factor (Ip) of 1.0 and meets size requirements for exemption as single pipes described under specific seismic design category exemptions above, and where the total weight supported by any single rod is 50 pounds or less.
- 3. Comply with applicable general recommendations of the following, where not in conflict with applicable codes, seismic design criteria, or other specified requirements:
 - a. ASHRAE (HVACA).
 - b. FEMA 412.
 - c. FEMA 413.
 - d. FEMA 414.
 - e. FEMA E-74.
 - f. SMACNA (SRM).
- 4. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
- 5. Seismic Type Vibration Isolators:
 - a. Comply with seismic design requirements, including conditions of equipment seismic certification where applicable.
- 6. External Seismic Snubber Assemblies:
 - a. Provide quantity and arrangement of external seismic snubber assemblies as required to restrain equipment in all directions (both lateral and vertical).
 - b. Do not use external seismic snubber assemblies that restrain equipment only in one or more lateral directions (but not vertical) except where uplift forces are zero or are addressed by other restraints.

7. Seismic Restraint Systems:
 - a. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
 - b. Use only cable restraints to restrain vibration-isolated HVAC components, including distributed systems.
 - c. Use only one restraint system type for a given HVAC component or distributed system (e.g., ductwork, piping) run; mixing of cable and rigid restraints on a given component/run is not permitted.
 - d. Size restraint elements, including anchorage, to resist seismic loads as necessary to restrain HVAC component in all lateral directions; consider bracket geometry in anchor load calculations.
 - e. Use rod stiffener clips to attach bracing to hanger rods as required to prevent rod buckling from vertical (upward) compressive load introduced by cable or rigid restraints loaded in tension, in excess of downward tensile load due to supported HVAC component weight.
 - f. Select hanger rods and associated anchorage as required to accommodate vertical (downward) tensile load introduced by rigid restraints loaded in compression, in addition to downward tensile load due to supported HVAC component weight.
 - g. Clevis hangers may only be used for attachment of transverse restraints; do not use for attachment of longitudinal restraints.
 - h. Where seismic restraints are attached to clevis hangers, provide clevis bolt reinforcement accessory to prevent clevis hanger deformation.
 - i. Do not introduce lateral loads on open bar joist chords or the weak axis of beams, or loads in any direction at other than panel points unless approved by project Structural Engineer of Record.
8. Ductwork Applications:
 - a. Provide independent support and seismic restraint for in-line components (e.g., fans, heat exchangers, humidifiers) having an operating weight greater than 75 pounds.
 - b. Positively attach appurtenances (e.g., dampers, louvers, diffusers) with mechanical fasteners.

F. Seismic Attachments:

1. Attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
2. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) or qualified evaluation service acceptable to authorities having jurisdiction for compliance with applicable building code, and qualified for seismic applications; concrete anchors to be qualified for installation in both cracked and uncracked concrete.
3. Do not use power-actuated fasteners.
4. Do not use friction clips (devices that rely on mechanically applied friction to resist loads). Beam clamps may be used for supporting sustained loads where provided with restraining straps.
5. Comply with anchor minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
6. Concrete Housekeeping Pads:
 - a. Increase size of pad as required to comply with anchor requirements.
 - b. Provide pad reinforcement and doweling to ensure integrity of pad and connection and to provide adequate load path from pad to supporting structure.

G. Seismic Interactions:

1. Include provisions to prevent seismic impact between HVAC components and other structural or nonstructural components.
2. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.

H. Seismic Relative Displacement Provisions:

1. Use suitable fittings or flexible connections to accommodate:
 - a. Relative displacements at connections between components, including distributed systems (e.g., ductwork, piping); do not exceed load limits for equipment utility connections.
 - b. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.
 - c. Design displacements at seismic separations.
 - d. Anticipated drifts between floors.
2. Include provisions to prevent interruption of utility service due to seismic displacements.

2.02 VIBRATION ISOLATORS

A. Manufacturers:

1. Vibration Isolators:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.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.
3. Seismic Snubbing Elements for Seismic Isolators:
 - a. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - b. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

C. Vibration Isolators for Nonseismic 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, Nonseismic:

- 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. Bottom Load Plate: Nonskid, molded, elastomeric isolator material or steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - c. 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, nonadjustable type, for limiting equipment movement and preventing metal-to-metal contact between housing elements.
 - c. Bottom Load Plate: Steel with nonskid, elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - d. Furnished with integral leveling device for positioning and securing supported equipment.
5. Restrained Spring Isolators, Nonseismic:
 - 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.
 - b. Bottom Load Plate: Steel with nonskid elastomeric isolator pad with provisions for bolting to supporting structure as required.
 - c. Furnished with integral leveling device for positioning and securing supported equipment.
 - d. Provides constant free and operating height.
6. Resilient Material Isolator Hangers, Nonseismic:
 - 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, Nonseismic:
 - 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, Nonseismic:
 - 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.
9. Thrust Restraints:
 - a. Description: Assembly utilizing free-standing, laterally stable steel spring designed for resisting horizontal motion due to thrust (e.g., air pressure from a fan), and intended for installation in pairs.

D. Vibration Isolators for Seismic Applications:

1. Resilient Material Isolator Mounts, Seismic:
 - a. Description: Mounting assemblies for bolting equipment to supporting structure utilizing elastomeric (e.g., neoprene, rubber) isolator material; specifically designed and rated for seismic applications with integral snubbing in all directions.
2. Restrained Spring Isolators, Seismic:
 - a. Description: Isolator assembly consisting of single or multiple free-standing, laterally stable steel spring(s) in series with elastomeric (e.g., neoprene, rubber) isolator material within a metal housing designed to prevent movement of supported equipment above an adjustable vertical limit stop; specifically designed and rated for seismic applications with integral snubbing in all directions.
 - b. Bottom Load Plate: Steel with provisions for bolting to supporting structure as required.
 - c. Furnished with integral leveling device for positioning and securing supported equipment.
 - d. Provides constant free and operating height.
3. Resilient Material Isolator Hangers, Seismic:
 - a. Description: Isolator assembly designed for installation in hanger rod suspension system utilizing elastomeric (e.g., neoprene, rubber) isolator material for the lower hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
4. Spring Isolator Hangers, 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; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.
5. Combination Resilient Material/Spring Isolator Hangers, 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) isolator material for the upper hanger rod connection; specifically designed and rated for seismic applications with vertical limit stop to prevent upward travel of hanger rod and cushion impact.
 - b. Designed to accommodate misalignment of bottom hanger rod up to 30 degrees (plus/minus 15 degrees) without short-circuiting of isolation.

2.03 EXTERNAL SEISMIC SNUBBER ASSEMBLIES

A. Manufacturers:

1. External Seismic Snubber Assemblies:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.vec0-nyc.com/#sle.
2. Source Limitations: Furnish external seismic snubber assemblies and associated accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.

- B. Description: Steel snubbing assemblies designed for external attachment to both equipment and supporting structure that, as part of a complete system, restrain equipment motion in all directions during a seismic event while maintaining vibration isolation during normal operation.
- C. Seismic Snubbing Elements:
 - 1. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - 2. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

2.04 SEISMIC RESTRAINT SYSTEMS

- A. Manufacturers:
 - 1. Seismic Restraint Systems:
 - a. AFCON, a brand of Anvil International; _____: www.anvilintl.com/#sle.
 - b. Eaton Corporation; _____: www.eaton.com/#sle.
 - c. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - d. Mason Industries; _____: www.mason-ind.com/#sle.
 - 2. Source Limitations: Furnish seismic restraint system components and accessories produced by a single manufacturer and obtained from a single supplier.
- B. Description: System components and accessories specifically designed for field assembly and attachment of seismic restraints.
- C. Cable Restraints:
 - 1. Comply with ASCE 19.
 - 2. Cables: Pre-stretched, galvanized steel wire rope with certified break strength.
 - 3. Cable Connections: Use only swaged end fittings. Cable clips and wedge type end fittings are not permitted in accordance with ASCE 19.
 - 4. Use protective thimbles for cable loops where potential for cable damage exists.
- D. Rigid Restraints: Use MFMA-4 steel channel (strut), steel angle, or steel pipe for structural element; suitable for both compressive and tensile design loads.

2.05 VIBRATION-ISOLATED AND/OR SEISMICALLY ENGINEERED ROOF CURBS

- A. Manufacturers:
 - 1. Vibration-Isolated and/or Seismically Engineered Roof Curbs:
 - a. Kinetics Noise Control, Inc; _____: www.kineticsnoise.com/#sle.
 - b. Mason Industries; _____: www.mason-ind.com/#sle.
 - c. Vibration Eliminator Company, Inc; _____: www.veco-nyc.com/#sle.
 - 2. Source Limitations: Furnish vibration-isolated roof curbs and associated accessories produced by the same manufacturer as the vibration isolators and obtained from a single supplier.
- B. Vibration Isolation Curbs:
 - 1. Nonseismic Curb:
 - a. Location: Between structure and rooftop equipment.
 - b. Construction: Aluminum.
 - c. Integral vibration isolation to comply with requirements of this section.
 - d. Weather exposed components consist of corrosion resistant materials.
 - 2. Seismic Curb:

- a. Location: Between structure and rooftop equipment.
 - b. Construction: Steel.
 - c. Integral vibration isolation to comply with requirements of this section.
 - d. Snubbers consist of minimum 0.25 inch thick resilient pads to avoid metal-to-metal contact without compromising vibration isolating capabilities.
 - e. Weather exposed components consist of corrosion resistant materials.
- C. Seismic Type Nonisolated Curb and Fabricated Equipment Piers:
- 1. Location: Between structure and rooftop equipment.
 - 2. Construction: Steel.
 - 3. Weather exposed components consist of corrosion resistant materials.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.
- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 CODE-REQUIRED SPECIAL INSPECTIONS

- A. Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner or Engineer of Record in accordance with Section 014533 and statement of special inspections as required by applicable building code.
- B. Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 - 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 - 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C. Seismic special inspections include, but are not limited to:
 - 1. Seismically Qualified Equipment: Verification that label, anchorage, and mounting comply with the certificate of compliance.
 - 2. Installation and anchorage of piping systems designed to carry hazardous materials and their associated mechanical units for Seismic Design Categories C, D, E, and F; periodic inspection.
 - 3. Installation and anchorage of ductwork designed to carry hazardous materials for Seismic Design Categories C, D, E and F; periodic inspection.
 - 4. Installation and anchorage of vibration isolation systems for Seismic Design Categories C, D, E, and F where the approved Contract Documents require a nominal clearance of 1/4 inch or less between equipment support frame and seismic restraint; periodic inspection.
 - 5. Verification of required clearances between HVAC equipment, distribution systems, and associated supports and fire protection sprinkler system drops and sprigs for Seismic

Design Categories C, D, E, and F; periodic inspection.

- D. Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- E. Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.03 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. Field-Welding (where approved by Engineer of Record): Comply with Section 055000.
- E. Install flexible piping connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- F. 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. Thrust Restraints:
 - a. Adjust restraint movement under normal operating static pressure.
 - 5. Clean debris from beneath vibration-isolated equipment that could cause short-circuiting of isolation.
 - 6. Use elastomeric grommets for attachments where required to prevent short-circuiting of isolation.
 - 7. Adjust isolators to be free of isolation short circuits during normal operation.
 - 8. Do not overtighten fasteners such that resilient material isolator pads are compressed beyond manufacturer's maximum recommended deflection.
- G. Seismic Controls:
 - 1. Provide specified snubbing element air gap; remove any factory-installed spacers, debris, or other obstructions.
 - 2. Use only specified components, anchorage, and hardware evaluated by seismic design. Comply with conditions of seismic certification where applicable.

3. Where mounting hole diameter exceeds bolt diameter by more than 0.125 inch, use epoxy grout, elastomeric grommet, or welded washer to reduce clearance to 0.125 inch or less.
4. Equipment with Sheet Metal Housings:
 - a. Use Belleville washers to distribute stress over a larger surface area of the sheet metal connection interface as approved by manufacturer.
 - b. Attach additional steel as approved by manufacturer where required to transfer loads to structure.
 - c. Where mounting surface is irregular, do not shim housing; reinforce housing with additional steel as approved by manufacturer.
5. Concrete Housekeeping Pads:
 - a. Size in accordance with seismic design to meet anchor requirements.
 - b. Install pad reinforcement and doweling in accordance with seismic design to ensure integrity of pad and associated connection to slab.
6. Seismic Restraint Systems:
 - a. Do not attach seismic restraints and gravity supports to dissimilar parts of structure that may move differently during an earthquake.
 - b. Install restraints within permissible angles in accordance with seismic design.
 - c. Install cable restraints straight between component/run and structural attachment; do not bend around other nonstructural components or structural elements.
 - d. Install cable restraints for vibration-isolated components slightly slack to prevent short-circuiting of isolation.
 - e. Install hanger rod stiffeners where indicated using only specified clamps; do not weld stiffeners to hanger rod.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect vibration isolation and/or seismic control components for damage and defects.
- C. Provide manufacturer representative or authorized technician services to assist with inspection and testing of vibration isolation systems and seismic controls. Submit a detailed copy of manufacturer recommended inspection, testing, and field report procedures.
- D. Vibration Isolation Systems:
 1. Verify isolator static deflections.
 2. Verify required clearance beneath vibration-isolated equipment support bases.
 3. Verify vibration isolation performance during normal operation; investigate sources of isolation short circuits.
- E. Seismic Controls:
 1. Verify snubbing element air gaps.
- F. Correct deficiencies and replace damaged or defective vibration isolation and/or seismic control components.
- G. Submit detailed reports indicating inspection and testing results and corrective actions taken.

3.05 ATTACHMENTS

- A. Statement of special inspections.

END OF SECTION 230548

SECTION 230553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Equipment labels.
 - 2. Warning signs and labels.
 - 3. Pipe labels.
 - 4. Duct labels.
 - 5. Valve tags.
 - 6. Above Ceiling Location Indicators.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- C. Valve numbering scheme.
- D. Valve Schedules: For each piping system to include in maintenance manuals.

1.4 COORDINATION

- A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- B. Coordinate installation of identifying devices with locations of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT LABELS

A. Plastic Labels for Equipment:

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

B. Label Content: Include equipment's Drawing designation or unique equipment number.

C. Equipment Label Schedule: Tabulate equipment identification number for each item of equipment to be labeled on 8-1/2x11-inch bond paper. Equipment scheduled shall be included in the operation and maintenance data.

2.2 WARNING SIGNS AND LABELS

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

B. Letter Color: Black.

C. Background Color: Yellow.

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

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

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

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

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

2.3 PIPE LABELS

- A. General Requirements for Manufactured Pipe Labels: Preprinted, color-coded, with lettering indicating service, and showing flow direction.
- B. Pre-tensioned Pipe Labels: Pre-coiled, semi-rigid plastic formed to cover full circumference of pipe and to attach to pipe without fasteners or adhesive.
- C. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.4 DUCT LABELS

- A. Self-Adhesive Labels: Printed plastic with contact-type, permanent-adhesive backing.
- B. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- C. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch
- D. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- E. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.5 STENCILS

- A. Stencils: Prepared with letter sizes according to ASME A13.1 for piping; minimum letter height of 1-1/4 inches for ducts; and minimum letter height of 3/4 inch for access panel and door labels, equipment labels, and similar operational instructions.
 - 1. Stencil Material: Aluminum.
 - 2. Stencil Paint: Exterior, gloss, acrylic enamel black unless otherwise indicated. Paint may be in pressurized spray-can form.
 - 3. Identification Paint: Exterior, acrylic enamel in colors according to ASME A13.1 unless otherwise indicated

2.6 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link chain or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch bond paper, typed. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve-tag schedule shall be included in operation and maintenance data.
 - 2. Valve-tag schedule shall be framed and mounted in the mechanical room.

2.7 ABOVE CEILING EQUIPMENT LOCATOR STICKERS

- A. Provide 3/4" diameter colored stickers on ceiling at equipment above ceilings as follows:
 - 1. Fire, Smoke, and Fire/Smoke Dampers – RED
 - 2. Air Terminal Devices – GREEN
 - 3. Valves - ORANGE
- B. For lay in ceilings locate stickers at nearest ceiling grid bar. Do not place sticker(s) on ceiling tile.
- C. Provide typewritten chart of Above Ceiling Equipment location with 8-1/2x11 schematic of project area indicating location. Frame and place under clear glass. Hang in mechanical space or other location as designated by the Owner's Representative and provide a hard copy to the Owner's Representative.

PART 3 - EXECUTION

3.1 PREPARATION

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

3.2 EQUIPMENT LABEL INSTALLATION

- A. Install or permanently fasten labels on each major item of mechanical equipment.
- B. Locate equipment labels where accessible and visible.

- C. Coordinate naming convention of all equipment with the Owner and naming convention within the temperature control system. Tags on the contract documents may not accurately tag the equipment.

3.3 PIPE LABEL INSTALLATION

- A. Piping Color-Coding: Painting of piping is specified in Division 09 Section "Interior Painting".
- B. Locate pipe labels where piping is exposed or above accessible ceilings in finished spaces; machine rooms; accessible maintenance spaces such as shafts, tunnels, and plenums; and exterior exposed locations as follows:
 - 1. Near each valve and control device.
 - 2. Near each branch connection, excluding short takeoffs for fixtures and terminal units. Where flow pattern is not obvious, mark each pipe at branch.
 - 3. Near penetrations through walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
 - 8. At each identification location, provide a flow direction arrow

- C. Lettering:

| <u>Pipe Function</u> | <u>Identification</u> |
|-----------------------|-----------------------|
| Heating Water Supply | HWS |
| Heating Water Return | HWR |
| Refrigerant Suction | RS |
| Refrigerant Liquid | RL |
| Indirect Waste | IW |
| Condensate Drain | D |
| Heat Pump Loop Supply | HPS |
| Heat Pump Loop Return | HPR |

3.4 DUCT LABEL INSTALLATION

- A. Install self-adhesive labels on uninsulated or lined ducts and stencils on ducts with external insulation. At each identification location, provide a flow direction arrow.
- B. Lettering:

| <u>Duct Function</u> | <u>Identification</u> |
|----------------------|-----------------------|
| Supply Air | SA |
| Return Air | RA |
| Exhaust Air | EA |

| | |
|----------------------------|--------------------------------|
| Isolation Room Exhaust Air | IEA |
| Outside Air | OA |
| Laboratory Exhaust Air | LEA |
| Radioactive | International radiation symbol |

- C. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 50 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.5 VALVE-TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory-fabricated equipment units; shutoff valves; faucets; convenience hose connections; and HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve-Tag Application Schedule: Tags shall be 1-1/2 inches round, natural brass, black lettering.

3.6 WARNING-TAG INSTALLATION

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

END OF SECTION

SECTION 230593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Balancing Air Systems:
 - a. Constant-volume air systems.
 - b. Variable-air-volume systems.
 - 2. Balancing Hydronic Piping Systems:
 - a. Constant-flow hydronic systems.
 - b. Variable-flow hydronic systems.
 - c. Primary-secondary hydronic systems.

1.3 DEFINITIONS

- A. AABC: Associated Air Balance Council.
- B. NEBB: National Environmental Balancing Bureau.
- C. TAB: Testing, adjusting, and balancing.
- D. TAB Specialist: An entity engaged to perform TAB Work.

1.4 INFORMATIONAL SUBMITTALS

- A. Qualification Data: Within 45 days of Contractor's Notice to Proceed, submit documentation that the TAB contractor and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.
- B. Certified TAB reports.
- C. Instrument calibration reports, to include the following:
 - 1. Instrument type and make.
 - 2. Serial number.

3. Application.
4. Dates of use.
5. Dates of calibration.

1.5 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity currently and for the duration of the project, certified by NEBB or AABC.
 1. TAB Field Supervisor: Employee of the TAB contractor and currently certified by NEBB or AABC.
 2. TAB Technician: Employee of the TAB contractor and individual who is currently certified by NEBB or AABC as a TAB technician.
 3. TAB contractor shall maintain NEBB or AABC certification for the duration of the project.
- B. Certify TAB field data reports and perform the following:
 1. Review field data reports to validate accuracy of data and to prepare certified TAB reports.
 2. Certify that the TAB team complied with the approved TAB plan and the procedures specified and referenced in this Specification.
- C. TAB Report Forms: Use standard TAB contractor's forms approved by Engineer.
- D. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."
- E. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."
- F. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

1.6 PROJECT CONDITIONS

- A. Partial Owner Occupancy: Owner may occupy completed areas of building before Substantial Completion. Cooperate with Owner during TAB operations to minimize conflicts with Owner's operations.

1.7 COORDINATION

- A. Notice: Provide seven days' advance notice for each test. Include scheduled test dates and times.
- B. Perform TAB after leakage and pressure tests on air and water distribution systems have been satisfactorily completed.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS

- A. Provide all required instrumentation and tools, including but not limited to ladders, recording meters, gauges, thermometers, voltmeters, anemometers, Pitot tubes, inclined gauge manometers, magnehelic gauges, amprobes, psychometers, and tachometers. Instruments used shall be accurately calibrated as per AABC or NEBB requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine the Contract Documents to become familiar with Project requirements and to discover conditions in systems' designs that may preclude proper TAB of systems and equipment.
- B. Examine 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. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems' output, and statements of philosophies and assumptions about HVAC system and equipment controls.
- E. Examine equipment performance data including fan 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.
- F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.
- G. Examine test reports specified in individual system and equipment Sections.
- H. Examine HVAC equipment and filters and verify that bearings are greased, belts are aligned and tight, and equipment with functioning controls is ready for operation.
- I. Examine terminal units, such as variable-air-volume boxes, and verify that they are accessible and their controls are connected and functioning.

- J. Examine strainers. Verify that startup screens are replaced by permanent screens with indicated perforations.
- K. Examine automatic balancing valves. Remove balancing valve cartridge and flush clean prior to system balance and verification.
- L. Examine heat-transfer coils for correct piping connections and for clean and straight fins.
- M. Examine system pumps to ensure absence of entrained air in the suction piping.
- N. Examine operating safety interlocks and controls on HVAC equipment.
- O. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.2 PREPARATION

- A. Prepare a TAB plan that includes strategies and step-by-step procedures.
- B. 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.

3.3 GENERAL PROCEDURES FOR TESTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems" in this Section.
 - 1. Comply with requirements in ASHRAE 62.1-2007, 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. After testing and balancing, install test ports and duct access doors that comply with requirements in Division 23 Section "Air Duct Accessories."

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.

3.4 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

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

3.5 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer. Provide sheaves and belts as required to achieve indicated airflows.
 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 Architect 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. Provide sheaves and belts as required to achieve indicated airflows.

3.6 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. If fans are direct drive – verify that the maximum Hz on both supply and return VFD’s matches the selection point for the fans (for example, 2120rpm with a 1760 rpm motor would be 72 Hz.)
- C. Pressure-Independent, Variable Air Volume Systems – Supply Air: After the fan systems have been adjusted, adjust the variable air volume systems as follows:
 1. Set outside air dampers at minimum; return and relief air dampers at a position that simulates full cooling load.
 2. Perform air terminal TAB per NEBB / AABC procedures. Lock final terminal controller “K factor” into the operating programs for all air terminals.
 3. Select the terminal unit that is most critical to the supply fan airflow and static pressure. Adjust the total system air flow compensating for diversity and determine the necessary duct pressure and enter to the control system. This will be the design or peak static pressure requirement.
 4. For variable volume systems specified to operate with variable pressure control (VVP) – set all air terminals to control to minimum air delivery. Reduce the duct pressure setpoint until at least one terminal damper position is in excess of 80% open. Record and enter this value to the building management system as the minimum reset level for the VVP control strategy.
 5. Using diversity compensation, measure total system airflow by traverse for both supply and return air streams. Adjust to within 5% of design airflow. Compare to the sum of the diffusers / registers and report apparent duct leakage in percentage. Record supply fan apparatus data under peak performance conditions.
 6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outside airflow. Adjust the fan and balance the return air ducts and inlets as described for 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 adequate static pressure is maintained at the most critical unit.

D. Pressure Independent Variable Volume Systems – Return Air / Outdoor Air / Relief Air adjustment

1. Determine the supply to return air flow tracking number based on the sum of total supply and return shown on the construction documents.
2. Determine the proper normal operating speed for the exhaust fan to maintain the building static pressure. Based on the sum of supply vs return determine space need for relief to maintain a +0.001" static pressure. Enter the normal operating speed into the BMS.
3. Calibrate the outdoor air flow stations. Enter the outdoor air setpoint to the system per the equipment schedule.
4. Calibrate the building static pressure sensor.
5. Return the system to maximum air flow accounting for system diversity. Record return fan apparatus data under peak performance conditions.

3.7 GENERAL PROCEDURES FOR BALANCING 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.

3.8 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 Architect 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 pre-settings.
- 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.

3.9 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.
- B. Measure operating static pressure at the differential pressure sensor that controls the pumps and verify correct operation

3.10 PROCEDURES FOR PRIMARY-SECONDARY HYDRONIC SYSTEMS

- A. Balance the primary circuit flow first and then balance the secondary circuits.

3.11 FOR HEAT EXCHANGERS

- A. Measure water flow through all circuits.
- B. Adjust water flow to within specified tolerances.
- C. Measure inlet and outlet water temperatures.
- D. Check settings and operation of safety and relief valves. Record settings.

3.12 PROCEDURES FOR HEAT PUMP

- A. Measure, adjust, and record the following data for each unit:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Temperature of entering and leaving water.

3.13 PROCEDURES FOR HEAT-TRANSFER COILS

- A. Measure, adjust, and record the following data for each water coil:
 - 1. Entering- and leaving-water temperature.
 - 2. Water flow rate.
 - 3. Water pressure drop.
 - 4. Dry-bulb temperature of entering and leaving air.
 - 5. Wet-bulb temperature of entering and leaving air for cooling coils.
 - 6. Airflow.
 - 7. Air pressure drop.
- B. Measure, adjust, and record the following data for each refrigerant coil:
 - 1. Dry-bulb temperature of entering and leaving air.
 - 2. Wet-bulb temperature of entering and leaving air.

3. Airflow.
4. Air pressure drop.
5. Refrigerant suction pressure and temperature.

3.14 PROCEDURES FOR MOTORS

- A. Motors, 1/2 HP and Larger: Test at final balanced conditions and record the following data:
 1. Manufacturer's name, model number, and serial number.
 2. Motor horsepower rating.
 3. Motor rpm.
 4. Efficiency rating.
 5. Nameplate and measured voltage, each phase.
 6. Nameplate and measured amperage, each phase.
 7. Starter thermal-protection-element rating.
- B. Motors Driven by Variable-Frequency Controllers: Test for proper operation at speeds varying from minimum to maximum. Test the manual bypass of the controller to prove proper operation. Record observations including name of controller manufacturer, model number, serial number, and nameplate data.

3.15 TOLERANCES

- A. Set HVAC system's air flow rates and water flow rates within the following tolerances:
 1. Supply, Return, and Exhaust Fans and Equipment with Fans: Plus or minus 10 percent.
 2. Air Outlets and Inlets: Plus or minus 10 percent.
 3. Heating-Water Flow Rate: Plus or minus 10 percent.

3.16 REPORTING

- A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems' balancing devices. Recommend changes and additions to systems' balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.
- B. Status Reports: Prepare weekly progress reports to describe completed procedures, procedures in progress, and scheduled procedures. Include a list of deficiencies and problems found in systems being tested and balanced. Prepare a separate report for each system and each building floor for systems serving multiple floors.

3.17 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 2. Include a list of instruments used for procedures, along with proof of calibration.
- B. Final Report Contents: In addition to certified field-report data, include the following:
1. Pump curves.
 2. Fan curves.
 3. Manufacturers' test data.
 4. Field test reports prepared by system and equipment installers.
 5. Other information relative to equipment performance; do not include Shop Drawings and product data.
- C. General Report Data: In addition to form titles and entries, include the following data:
1. Title page.
 2. Name and address of the TAB contractor.
 3. Project name.
 4. Project location.
 5. Architect's name and address.
 6. Engineer's name and address.
 7. Contractor's name and address.
 8. Report date.
 9. Signature of TAB supervisor who certifies the report.
 10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.
 11. Summary of contents including the following:
 - a. Indicated versus final performance.
 - b. Notable characteristics of systems.
 - c. Description of system operation sequence if it varies from the Contract Documents.
 12. Nomenclature sheets for each item of equipment.
 13. Data for terminal units, including manufacturer's name, type, size, and fittings.
 14. Notes to explain why certain final data in the body of reports vary from indicated values.
 15. Test conditions for fans and pump performance forms including the following:
 - a. Settings for outdoor-, return-, and exhaust-air dampers.
 - b. Conditions of filters.
 - c. Cooling coil, wet- and dry-bulb conditions.
 - d. Face and bypass damper settings at coils.
 - e. Fan drive settings including settings and percentage of maximum pitch diameter.
 - f. Inlet vane settings for variable-air-volume systems.
 - g. Settings for supply-air, static-pressure controller.
 - h. Other system operating conditions that affect performance.
- D. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:
1. Unit Data:

- a. Unit identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and unit size.
 - e. Manufacturer's serial number.
 - f. Unit arrangement and class.
 - g. Discharge arrangement.
 - h. Sheave make, size in inches, and bore.
 - i. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - j. Number, make, and size of belts.
 - k. Number, type, and size of filters.
2. Motor Data:
- a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches, and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
3. Test Data (Indicated and Actual Values):
- a. Total air flow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Filter static-pressure differential in inches wg.
 - f. Coil static-pressure differential in inches wg.
 - g. Outdoor airflow in cfm
 - h. Return airflow in cfm
 - i. Relief airflow in cfm
 - j. Outdoor-air damper position.
 - k. Return-air damper position.
 - l. Relief-air damper position.

E. Fan Test Reports: For supply, return, and exhaust fans, include the following:

1. Fan Data:
- a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches, and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Motor Data:

- a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches (mm), and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches (mm).
 - g. Number, make, and size of belts.
 - 3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm (L/s).
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Discharge static pressure in inches wg.
 - e. Suction static pressure in inches wg.
- F. Round and Rectangular Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:
- 1. Report Data:
 - a. System and air-handling-unit number.
 - b. Location and zone.
 - c. Traverse air temperature in deg F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in sq. ft..
 - g. Indicated air flow rate in cfm.
 - h. Indicated velocity in fpm.
 - i. Actual air flow rate in cfm.
 - j. Actual average velocity in fpm.
- G. Heat Pump Reports:
- 1. Unit Data
 - a. Unit Identification
 - b. Location
 - c. Make and type
 - d. Model number and unit size
 - e. Manufacturer's serial number.
 - 2. Test Data:
 - a. Entering-water temperature in deg F.
 - b. Leaving-water temperature in deg F.
 - c. Water pressure drop in feet of head or psi.
 - d. Flow rates in gpm
- H. Air-Terminal-Device Reports:
- 1. Unit Data:
 - a. System and air-handling unit identification.
 - b. Location and zone.

- c. Apparatus used for test.
- d. Area served.
- e. Make.
- f. Number from system diagram.
- g. Type and model number.
- h. Size.

2. Test Data (Indicated and Actual Values):

- a. Air flow rate in cfm.
- b. Air velocity in fpm.
- c. Preliminary air flow rate as needed in cfm.
- d. Preliminary velocity as needed in fpm.
- e. Final air flow rate in cfm.
- f. Final velocity in fpm.
- g. Space temperature in deg F.

I. System-Coil Reports: For reheat coils and water coils of terminal units, include the following:

1. Unit Data:

- a. System and air-handling-unit identification.
- b. Location and zone.
- c. Room or riser served.
- d. Coil make and size.
- e. Flowmeter type.

2. Test Data (Indicated and Actual Values):

- a. Air flow rate in cfm.
- b. Entering-water temperature in deg F.
- c. Leaving-water temperature in deg F.
- d. Water pressure drop in feet of head or psi.
- e. Entering-air temperature in deg F.
- f. Leaving-air temperature in deg f.

J. Pump Test Reports: Calculate impeller size by plotting the shutoff head on pump curves and include the following:

1. Unit Data:

- a. Unit identification.
- b. Location.
- c. Service.
- d. Make and size.
- e. Model number and serial number.
- f. Water flow rate in gpm.
- g. Water pressure differential in feet of head or psig.
- h. Required net positive suction head in feet of head or psig.
- i. Pump rpm.
- j. Impeller diameter in inches.

- k. Motor make and frame size.
- l. Motor horsepower and rpm.
- m. Voltage at each connection.
- n. Amperage for each phase.
- o. Full-load amperage and service factor.
- p. Seal type.

2. Test Data (Indicated and Actual Values):

- a. Static head in feet of head or psig.
- b. Pump shutoff pressure in feet of head or psig.
- c. Actual impeller size in inches.
- d. Full-open flow rate in gpm.
- e. Full-open pressure in feet of head or psig .
- f. Final discharge pressure in feet of head or psig.
- g. Final suction pressure in feet of head or psig.
- h. Final total pressure in feet of head or psig.
- i. Final water flow rate in gpm (L/s).
- j. Voltage at each connection.
- k. Amperage for each phase.

K. Instrument Calibration Reports:

1. Report Data:

- a. Instrument type and make.
- b. Serial number.
- c. Application.
- d. Dates of use.
- e. Dates of calibration.

3.18 INSPECTIONS

A. Initial Inspection:

- 1. After testing and balancing are complete, operate each system and randomly check measurements to verify that the system is operating according to the final test and balance readings documented in the final report.
- 2. Check the following for each system:
 - a. Measure airflow of at least 10 percent of air outlets.
 - b. Measure water flow of at least 5 percent of terminals.
 - c. Measure room temperature at each thermostat/temperature sensor. Compare the reading to the set point.
 - d. Verify that balancing devices are marked with final balance position.
 - e. Note deviations from the Contract Documents in the final report.

B. Final Inspection:

1. After initial inspection is complete and documentation by random checks verifies that testing and balancing are complete and accurately documented in the final report, request that a final inspection be made by Architect.
 2. The TAB contractor's test and balance engineer shall conduct the inspection in the presence of Architect.
 3. Architect shall randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.
 4. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."
 5. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.
- C. TAB Work will be considered defective if it does not pass final inspections. If TAB Work fails, proceed as follows:
1. Recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
 2. If the second final inspection also fails, Owner may contract the services of another TAB contractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the original TAB contractor's final payment.
- D. Prepare test and inspection reports.

3.19 ADDITIONAL TESTS

- A. Provide additional TAB visits as required to accommodate project scheduling and phasing.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 230713 - DUCT INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Work shall comply with the requirements of the 2020 New York State Energy Conservation Code (NYSECC) including ASHRAE 90.1-2016, manufacturer's requirements for installation and these specifications. In the event of conflicts between these documents, the more stringent requirements shall met.

1.2 SUMMARY

- A. Section includes insulating the following duct services:
 - 1. Indoor, concealed and exposed air duct
- B. Related Sections:
 - 1. Division 23 Section "Metal Ducts" for duct liners.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory- and field-applied if any).
- B. Detail application schedule of intended insulation type for each type of application.
- C. Installation guide for each type of insulation specified. Highlight intended installation method.

1.4 INFORMATIONAL SUBMITTALS

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

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
 - 2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.6 DELIVERY, STORAGE, AND HANDLING

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

1.7 COORDINATION

- A. Coordinate sizes and locations of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with duct Installer for duct insulation application. Before preparing ductwork Shop Drawings, establish and maintain clearance requirements for installation of insulation and field-applied jackets and finishes and for space required for maintenance.

1.8 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Duct Insulation Schedule, General" and "Ductwork Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Fiberglass Blanket Insulation:
 - 1. Insulation Blanket meeting ASTM C 553, Type II, ASTM C 1290, Type III, and ASTM C 1138.
 - 2. 'K' Value of 0.27 at 75°F mean temperature. Maximum Service Temperature (Faced): 250°F.
 - 3. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, II, III, IV, VIII or FSK conforming to ASTM C 1136 Type II, IV. Provide ASJ jacket for ductwork to be painted.
 - 4. Installation: Maximum allowable compression is 25%.
 - 5. Density: Minimum 1.0 PCF.
- F. Fiberglass Board Insulation:
 - 1. Insulation Board meeting ASTM C 612 Type IA, IB and II, ASTM C 795 and ASTM C 1138.
 - 2. 'K' Value of 0.23 at 75°F mean temperature. Maximum Service Temperature: 450° F.
 - 3. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type I, or FSK or conforming to ASTM C 1136 Type II, IV. Provide ASJ jacket for ductwork to be painted.
 - 4. Concealed Areas: Minimum 3 lb./ft.3.
 - 5. Exposed Areas: 6 lb./ft.3 minimum density for duct less than 8 ft. - 0 in. above finished floor or where indicated in these specifications or on the drawings.
- G. Acceptable Manufacturers:
 - 1. Fiberglass: Knauf, John Manville, Owen-Corning, Certainteed.

2.2 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
- B. Fiberglass Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. FSK Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.3 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 3. Fire- and water-resistant, flexible, elastomeric sealant.
 - 4. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 5. Color: Aluminum.
 - 6. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.4 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.5 TAPES

- A. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 - 1. Products: Subject to compliance with requirements, provide one of the following:

- a. ABI, Ideal Tape Division; 428 AWF ASJ.
 - b. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0836.
 - c. Compac Corporation; 104 and 105.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ
- 2. Width: 3 inches
 - 3. Thickness: 6.5 mils
 - 4. Adhesion: 90 ounces force/inch in width.
 - 5. Elongation: 2 percent.
 - 6. Tensile Strength: 40 lbf/inch in width.
 - 7. FSK Tape Disks and Squares: Precut disks or squares of FSK tape

2.6 SECUREMENTS

A. Insulation Pins and Hangers:

- 1. Capacitor-Discharge-Weld Pins:
 - a. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - b. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated.
- 2. Cupped-Head, Capacitor-Discharge-Weld Pins:
 - a. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - b. Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.106-inch-diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
- 3. Insulation-Retaining Washers:
 - a. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - b. Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - c. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
 2. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of ducts and fittings.
- B. Install insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each item of duct system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Keep insulation materials dry during application and finishing.
- G. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- H. Install insulation with least number of joints practical.
- I. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
- J. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- K. Install insulation with factory-applied jackets as follows:

1. Draw jacket tight and smooth.
 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches O.C.
 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches O.C.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
- L. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- M. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- N. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- B. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Terminate insulation at fire damper sleeves for fire-rated wall and partition penetrations. Externally insulate damper sleeves to match adjacent insulation and overlap duct insulation at least 2 inches.
1. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping"
- C. Insulation Installation at Floor Penetrations:
1. Duct: For penetrations through fire-rated assemblies, terminate insulation at fire damper sleeves and externally insulate damper sleeve beyond floor to match adjacent duct insulation. Overlap damper sleeve and duct insulation at least 2 inches.
 2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 INSTALLATION OF FIBERGLASS INSULATION

- A. Blanket Insulation Installation on Ducts and Plenums: Secure with insulation pins.

1. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. Draw jacket tight and smooth.
 - b. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - c. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 4 inches o.c.
 - d. On rectangular duct sides with dimensions 24 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 18 inches O.C.
 - e. On rectangular duct sides with dimensions larger than 24 inches, place pins 18 inches O.C. each way and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing. Provide pins and clip washers at 18" O.C. in the bottom of duct, minimum of 2 rows longitudinally.
 - f. On round ductwork at 24" diameter and greater provide pins and clip washers at 18" O.C. in both directions from the horizontal centerline of duct downward.
 - g. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - h. Do not over-compress insulation during installation.
 - i. Impale insulation over pins and attach speed washers.
 - j. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - k. At all ductwork with external flanges, provide an 8" (min) piece of insulation wrapped around the duct, centered on the flange and securely taped.
 - l. Sagging duct insulation will not be acceptable.
 - m. Vapor retarders should overlap a minimum of two inches at all seams and be sealed with appropriate pressure sensitive tape. When applying pressure sensitive tapes, the tape must be firmly rubbed with the proper sealing tool to make sure the closure is secured. Follow tape manufacturers recommendations.
 - n. For below ambient services, apply vapor-barrier mastic over staples.
 - o. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - p. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.
2. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch O.C. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
 - a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.

- b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches
 3. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
 4. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
 5. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
 6. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches O.C.
 7. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 8. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch- wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches O.C.
- B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 50 percent coverage of duct and plenum surfaces.
 2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
 3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:
 - a. On all duct sides, space pins 12 inches O.C. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - b. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - c. Do not overcompress insulation during installation.
 - d. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
 - e. Vapor retarders should overlap a minimum of two inches at all seams and be sealed with appropriate pressure sensitive tape. When applying pressure sensitive tapes, the tape must be firmly rubbed with the proper sealing tool to make sure the closure is secured. Follow tape manufacturers recommendations.
 4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch

O.C. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.

- a. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 - b. Install vapor stops for ductwork and plenums operating below 50 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.
5. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
 6. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
 7. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints
 8. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
 9. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches O.C. Tape and seal all ends and joints.
 10. Vapor retarders should overlap a minimum of two inches at all seams and be sealed with appropriate pressure sensitive tape. When applying pressure sensitive tapes, the tape must be firmly rubbed with the proper sealing tool to make sure the closure is secured. Follow tape manufacturers recommendations.

3.6 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 1. Inspect ductwork, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to one location for each duct system defined in the "Duct Insulation Schedule, General" Article.
- B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.7 DUCT INSULATION SCHEDULE, GENERAL

A. Items Not Insulated:

1. Metal ducts with duct liner of sufficient thickness to comply with energy code and ASHRAE/IESNA 90.1.
2. Factory-insulated flexible ducts.
3. Factory-insulated plenums and casings.
4. Flexible connectors.
5. Vibration-control devices.
6. Factory-insulated access panels and doors.

3.8 DUCTWORK INSULATION SCHEDULE

| <u>Service</u> | <u>Insulation Material</u> | <u>Thickness</u> | <u>Remarks</u> |
|-----------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------|------------------|-------------------------------------------------------------------|
| HVAC Supply including OA, etc. | Within mechanical rooms or exposed at 8 feet or less above finished floor: Rigid fiberglass | 1-1/2 in. | Min. installed R value of 6 |
| | Concealed: Flexible fiberglass | 2 in. | Min. installed R value of 6 |
| Interior ductwork indicated to be lined | | Not Insulated | |
| Return and exhaust air ducts within heated building envelope | | Not Insulated | |
| Neutral ventilation air supply (between 65°F and 80°F) | | Not Insulated | |
| Outside air ducts and plenums, connections and mixing boxes and Combustion air ductwork | Rigid fiberglass | 3 in. | Min. installed R value of 12 Provide neat fit at intake plenum |

END OF SECTION

SECTION 230719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Work shall comply with the requirements of the 2020 New York State Energy Conservation Code, ASHRAE 90.1-2016, manufacturer's requirements for installation and these specifications. In the event of conflicts between these documents, the more stringent requirements shall met.

1.2 SUMMARY

- A. Section includes insulating the following HVAC piping systems:
 - 1. Condensate drain piping
 - 2. Heating hot-water piping
 - 3. Refrigerant suction, refrigerant liquid, and hot-gas piping
 - 4. Outdoor piping insulation.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, water-vapor permeance thickness, and jackets (both factory and field applied if any).
- B. Detail application schedule of intended insulation type for each type of applications.

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.
 - 1. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less.

2. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

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

1.6 COORDINATION

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

1.7 SCHEDULING

- A. Schedule insulation application after pressure testing systems and, where required, after installing and testing heat tracing. Insulation application may begin on segments that have satisfactory test results.
- B. Complete installation and concealment of plastic materials as rapidly as possible in each area of construction.

PART 2 - PRODUCTS

2.1 INSULATION MATERIALS

- A. Comply with requirements in "Piping Insulation Schedule, General" and "Piping Insulation Schedule" articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.

2.2 PIPE INSULATION (RIGID FIBERGLASS TYPE)

- A. Glass Fiber insulation meeting ASTM C 552, Type II, Class 2, ASTM C 585, ASTM C 795 and ASTM C 1138; rigid, molded, noncombustible.
- B. Minimum 'K' Value: ASTM C 335, 0.23 at 75°F mean temperature installed value. Maximum Service Temperature: 1000°F.

- C. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C 1136 Type I, secured with self-sealing longitudinal laps and butt strips.
- D. Field-Applied PVC 30 mil Fitting Covers with Flexible Fiberglass Insulation complying with ASTM C 450 and ASTM C 585: Proto Corporation LoSmoke, UV-resistant fittings and accessories, white. Fitting cover system consists of pre-molded, high-impact PVC materials with blanket type fiberglass wrap inserts. Blanket fiberglass wrap inserts shall have a thermal conductivity ('K') of 0.26 at 75°F mean temperature. Closures to be stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.

2.3 PIPE INSULATION (FLEXIBLE ELASTOMERIC FOAM)

- A. Flexible, elastomeric thermal insulation, with expanded closed-cell foam structure, antimicrobial protection and free of CFC's, HFC's, HCFC's, formaldehyde, fibers and dust, with low VOC's. Maximum water vapor transmission of 0.10 perm-inch based on ASTM E96, Procedure A. Maximum thermal conductivity (k) shall be 0.27 Btu/ft²•hr.° F/in. at 75°F mean temperature. Fire spread/smoke developed rating of 25/50 or less based on ASTM E84 for up to 2" material thickness.
- B. Pipe Insulation: ASTM C534, Type I.

2.4 ACCEPTABLE MANUFACTURERS

- A. Fiberglass: Knauf, John Manville, Owen-Corning, Certainteed.
- B. Flexible Elastomeric: Armstrong, Rubatex International

2.5 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated unless otherwise indicated.
 - 1. Small-Scale Environmental Chambers," including 2004 Addenda.
- B. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. For indoor applications, use adhesive that has a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- C. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:

2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

D. PVC Jacket Adhesive: Compatible with PVC jacket.

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

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

1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Aeroflex USA, Inc.; Aero seal.
 - b. Armacell LLC; Armaflex 520 Adhesive.
 - c. Foster Brand, Specialty Construction Brands, Inc., a business of H. B. Fuller
2. Insulation finish shall be the insulation manufacturers recommended finish.
3. Adhesive shall be the insulation manufacturers recommended contract adhesives.
4. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
5. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
6. Composition- synthetic rubber base with synthetic resins and fillers added.

F. Flexible Membrane Jacket Adhesive: Compatible with jacket.

1. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Aeroflex USA Inc.; Aero seal.
 - b. Armacell LCC; 520 Adhesive.
 - c. Foster Products Corporation, H. B. Fuller Company; 85-75.
 - d. RBX Corporation; Rubatex Contact Adhesive.
2. For indoor applications, use adhesive that has a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24)

2.6 SEALANTS

A. Joint Sealants:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Permanently flexible, elastomeric sealant.

- c. Service Temperature Range: Minus 100 to plus 300 deg F.
 - d. Color: White or gray.
 - 2. For indoor applications, sealants shall have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
- B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
- 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - a. Materials shall be compatible with insulation materials, jackets, and substrates.
 - b. Fire- and water-resistant, flexible, elastomeric sealant.
 - c. Service Temperature Range: Minus 40 to plus 250 deg F.
 - d. Color: White.
 - e. For indoor applications, use sealants that have a VOC content of 420 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).

2.7 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
- 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - 3. PVDC Jacket for Outdoor Applications:
 - a. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - b. 6-mil- thick, white PVDC biaxially oriented barrier film with a permeance at 0.01 perm when tested according to ASTM E 96/E 96M and with a flame-spread index of 5 and a smoke-developed index of 25 when tested according to ASTM E 84.

2.8 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, Type I, unless otherwise indicated.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
- 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. Adhesive: As recommended by jacket material manufacturer.
 - 3. Color: Color as selected by Architect.

4. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.

2.9 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 2. Width: 3 inches.
 3. Thickness: 11.5 mils.
 4. Adhesion: 90 ounces force/inch in width.
 5. Elongation: 2 percent.
 6. Tensile Strength: 40 lbf/inch in width.
 7. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive; suitable for indoor and outdoor applications.
 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 2. Width: 2 inches
 3. Thickness: 6 mils
 4. Adhesion: 64 ounces force/inch in width.
 5. Elongation: 500 percent.
 6. Tensile Strength: 18 lbf/inch in width.

2.10 SECUREMENTS

- A. Staples:
 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 2. Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application.

1. Verify that systems to be insulated have been tested and are free of defects.
2. Verify that surfaces to be insulated are clean and dry.
3. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

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

3.3 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of pipe system as specified in insulation system schedules.
- C. Install accessories compatible with insulation materials and suitable for the service. Install accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- E. Install multiple layers of insulation with longitudinal and end seams staggered.
- F. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- G. Keep insulation materials dry during application and finishing.
- H. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- I. Install insulation with least number of joints practical.
- J. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 1. Install insulation continuously through hangers and around anchor attachments.
 2. For insulation application where vapor barriers are indicated, extend insulation on anchor legs from point of attachment to supported item to point of attachment to structure. Taper and seal ends at attachment to structure with vapor-barrier mastic.
 3. Install insert materials and install insulation to tightly join the insert. Seal insulation to insulation inserts with adhesive or sealing compound recommended by insulation material manufacturer.
 4. Cover inserts with jacket material matching adjacent pipe insulation. Install shields over jacket, arranged to protect jacket from tear or puncture by hanger, support, and shield.

- K. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap.
 - a. For below-ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.

3.4 PENETRATIONS

- A. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- C. Insulation Installation at Fire-Rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire-rated walls and partitions.

1. Comply with requirements in Division 07 Section "Penetration Firestopping" for firestopping and fire-resistive joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Pipe: Install insulation continuously through floor penetrations.
2. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Penetration Firestopping."

3.5 GENERAL PIPE INSULATION INSTALLATION

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

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

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

8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. Label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at locations indicated. Installation shall conform to the following:
1. Make removable flange and union insulation from sectional pipe insulation of same thickness as that on adjoining pipe. Install same insulation jacket as adjoining pipe insulation.
 2. When flange and union covers are made from sectional pipe insulation, extend insulation from flanges or union long at least two times the insulation thickness over adjacent pipe insulation on each side of flange or union. Secure flange cover in place with stainless-steel or aluminum bands. Select band material compatible with insulation and jacket.
 3. Construct removable valve insulation covers in same manner as for flanges, except divide the two-part section on the vertical center line of valve body.
 4. When covers are made from block insulation, make two halves, each consisting of mitered blocks wired to stainless-steel fabric. Secure this wire frame, with its attached insulation, to flanges with tie wire. Extend insulation at least 2 inches over adjacent pipe insulation on each side of valve. Fill space between flange or union cover and pipe insulation with insulating cement. Finish cover assembly with insulating cement applied in two coats. After first coat is dry, apply and trowel second coat to a smooth finish.
 5. Unless a PVC jacket is indicated in field-applied jacket schedules, finish exposed surfaces with a metal jacket.

3.6 INSTALLATION OF FLEXIBLE ELASTOMERIC INSULATION

- A. Seal longitudinal seams and end joints with manufacturer's recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
- B. Install pipe insulation by sliding unslit sections over open ends of piping. Seal all seams and butt joints. It is unacceptable to field slit insulation sections for installation. Factory slit self seal tube insulation shall be provided for locations where slit tubes are required.
1. Insulation shall be pushed onto piping – never pulled.
 2. All edges shall be clean cut.
- C. Insulation Installation on Flanges and Fittings:
1. All fittings shall be same thickness as adjacent piping.

D. Insulation Installation on Pipe Flanges:

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

E. Insulation Installation on Pipe Fittings and Elbows:

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

F. Insulation Installation on Valves and Pipe Specialties:

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

3.7 INSTALLATION OF FIBERGLASS INSULATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Secure each layer of preformed pipe insulation to pipe with wire or bands and tighten bands without deforming insulation materials.
2. Where vapor barriers are indicated, seal longitudinal seams, end joints, and protrusions with vapor-barrier mastic and joint sealant.
3. For insulation with factory-applied jackets on above-ambient surfaces, secure laps with outward-clinched staples at 6 inches o.c.
4. For insulation with factory-applied jackets on below-ambient surfaces, do not staple longitudinal tabs. Instead, secure tabs with additional adhesive as recommended by insulation material manufacturer and seal with vapor-barrier mastic and flashing sealant.

B. Insulation Installation on Pipe Flanges:

1. Install preformed pipe insulation to outer diameter of pipe flange.
2. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation.

3. Fill voids between inner circumference of flange insulation and outer circumference of adjacent straight pipe segments with mineral-fiber blanket insulation.
4. Install jacket material with manufacturer's recommended adhesive, overlap seams at least 1 inch, and seal joints with flashing sealant.

C. Insulation Installation on Pipe Fittings and Elbows:

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

D. Insulation Installation on Valves and Pipe Specialties:

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

3.8 FIELD-APPLIED JACKET INSTALLATION

- A. Where jackets for exterior use are indicated, PVC or Flexible Membrane, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.

1. Utilizing stiff bristled brush or short pile fabric roller, brush adhesive or roll adhesive. Apply adhesive in a thin, uniform layer to both insulation surface and mating jacket surface. All overlapping joints shall be fully covered with adhesive on mating edges prior to joining.
2. Install seams and joints to prevent any direct paths which may allow water ingress.
3. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

3.9 FINISHES

- A. Pipe Insulation with ASJ or Other Paintable Jacket Material: Paint jacket with paint system identified below and as specified in Division 09 painting Sections.

1. Flat Acrylic Finish: Two finish coats over a primer that is compatible with jacket material and finish coat paint. Add fungicidal agent to render fabric mildew proof.
 - a. Finish Coat Material: Interior, flat, latex-emulsion size.

- B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- C. Do not field paint aluminum or stainless-steel jackets.

3.10 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 pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.
- D. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.11 PIPING INSULATION SCHEDULE, GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated: Unless otherwise indicated, do not install insulation on the following:
 - 1. Underground piping.

3.12 PIPING INSULATION SCHEDULE

| <u>Service</u> | <u>Insulation Material</u> | <u>Pipe Size</u> | <u>Insulation Thickness</u> | <u>Remarks</u> |
|------------------------------------------------------------------|----------------------------|-------------------------------------------|-----------------------------|----------------|
| Hot water (200°F and lower) | Glass fiber | 1-1/2" and Larger: 1-1/4" and Smaller: | 2" 1-1/2" | |
| Refrigeration Piping (Suction, liquid, discharge and hot gas) | Elastomeric Foam | 1" and Larger: 3/4" and Smaller: | 1" 1/2" | |

| <u>Service</u> | <u>Insulation Material</u> | <u>Pipe Size</u> | <u>Insulation Thickness</u> | <u>Remarks</u> |
|----------------------------------------------------------------------------------------------|----------------------------|----------------------------------------------------------|-----------------------------|------------------------------|
| Outdoor Refrigeration Piping (Suction, liquid lines, discharge and hot gas) | Elastomeric Foam | 1" and Larger: ¾" and Smaller: | 1" ½" | Covered with Aluminum Jacket |
| Make-up water | Glass fiber | All sizes: | ½" | |
| Concealed AC unit condensate drains | Elastomeric Foam | All Sizes: | ½" | |
| Ground Source Heat Pump & Building Side Heat Pump Water | Glass fiber | All Sizes: | 1" | |
| Piping in exterior walls, spaces, overhangs, attics, exterior, or where subject to freezing. | | Insulate pipe with double the thickness called for above | | |

END OF SECTION

SECTION 230800 - COMMISSIONING OF HVAC

1.1 GENERAL

1.2 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions.

1.3 SUMMARY

- A. Section includes commissioning process requirements for HVAC&R systems, assemblies, and equipment.
- B. Related Sections:
 - 1. Mechanical sections
 - 2. Electrical sections
 - 3. Division 01 Section "General Commissioning Requirements" for general commissioning process requirements.

1.4 ALLOWANCES

- A. Labor, instrumentation, tools, and equipment costs for technicians for the performance of commissioning testing are covered by the "Schedule of Allowances" Article in Division 01 Section "Allowances."

1.5 DEFINITIONS

- A. The commissioning agent; the commissioning agent shall be as designated by the owner, architect or engineer. The commissioning agent shall represent the owner in matters relative to the commissioning procedures as defined in this and other related section of the contract documents.
 - 1. The contractor shall be as defined in the general conditions and in the contract documents.
 - 2. The owner shall be as defined in the general conditions and in the contract documents.
 - 3. The architect/designer shall be as defined in the general conditions and in the contract documents.
- B. Commissioning terms
 - 1. Design intent: The designer intention is as defined by the architect as to the purpose of the specific complete system or any of the system components.

2. Commissioning procedures; Documenting, calibrating, checking, inspecting, starting, testing, verifying and training required to assure the proper operations of the mechanical and electrical systems defined in the contract documents.
 - a. Pre-commissioning: checklists, commissioning checklists, pre-start checklist, commissioning functional documentation, deviation reports, preliminary and final test reports completed by the contractor to assure the mechanical systems and electrical systems are completed in accordance with the contract documents, manufactures requirements and in compliance with the design intent.
 - b. Commissioning functional tests are test that are of more detail than the start up tests performed by the contractor and/or the manufacture at start up.
 - c. The commissioning procedure is a cooperative effort by the designer, installing contractor, manufacture and the commissioning agent to ensure that mechanical, electrical, and control equipment, systems and components meet the design intent and to document the systems operation and compliance to the design intent.
 - d. The commissioning process includes the contractors' functions of start up, testing, balancing, calibration and set up of controls, training by the contractor.
 - e. The commissioning procedure testing and monitoring may include specific testing, trending and logging of the systems and /or components.
 - f. The contractor representative is an authorized contractor representative that shall be assigned as a qualified skilled technician to assist in the commissioning procedures.
3. Skilled technicians:
 - a. Personnel with specific expert knowledge of the system, components and/or control of the mechanical or electrical elements of the commissioned systems.
 - b. The skilled technician shall be qualified and have all tools required for commissioning the elements of the systems.
 - c. The skilled technician shall demonstrate a willingness and attitude of cooperation. The technician may be removed from the process at the request of the designer. The contract must replace the technician in this event with a technician meeting the above requirements.
4. Seasonal commissioning:
 - a. Seasonal commissioning pertains to testing under full load conditions during peak heating and peak cooling seasons, as well as part load conditions.
 - b. Initial commissioning tests will be done as soon as contract work is completed, regardless of season.
 - c. Subsequent commissioning tests will be undertaken as soon as practical to verify performance during the two seasons (peak heating, peak cooling or part load) not covered in initial testing.
 - d. Individual mechanical and electrical systems specifications indicate which systems require seasonal testing.

C. Commissioning team

1. Each contractor will designate one person, responsible for representing that facet of the project, to be on the Commissioning team. This person shall be the same person that is the lead person for installing and/or supervising the work of the trade being represented.
2. The commissioning team shall consist of the Owner, Commissioning Agent, Construction Manager, Mechanical Contractor, Electrical Contractor, General Contractor, Mechanical Contractor and sub contractors, Electrical Contractor and sub contractors, Test and Balance Contractor, Temperature Controls Contractor and the Engineer.

1.6 COMMISSIONING DUTIES

A. Duties of Architect:

1. Submit copy of the Design Intent Data to Owner, and review with Owner for acceptability.
2. Incorporate Design Intent data into bid and contract documents for contractor pricing and performance.
3. Prepare Commissioning Procedures for each the system based on actual system configuration.
4. Incorporate Commissioning Procedures into bid and contract documents for contractor pricing and performance.
5. Develop an integrated commissioning schedule with input from the contractor and representatives of all the installers.
6. Not authorize commissioning tests until each system is complete, including start-up procedures.
7. Coordinate communications related to commissioning by receiving and distributing submittal reviews, deficiency notices, and test results.
8. Identify problems; notify responsible parties, and direct actions required to correct deficiencies in EEM equipment and systems.
9. Remove Energy Efficiency Measures disputes by performing research to determine the scope of the dispute, and informing the involved parties on the possible solutions to the dispute.
10. Notify the Contractor if Contractor-initiated system changes have been made that alter the commissioning process.
11. Determine the acceptance procedures for each item of the equipment and system. The criteria for acceptance of the equipment and systems will closely follow the test outline in each Section specifying the equipment.
12. Submit the final commissioning report including all submittals and test results for each to the Utility and Owner. Commissioning Report shall be included in Part 5 of each section of the Closeout Manual.
13. Recommend final acceptance of contractor's work to the Owner when commissioning tests have been successfully completed.

B. Duties of Contractor:

1. Provide Commissioning Agent with access to the building and the work.
2. Provide input (in coordination with the installers) to the designer to develop an integrated commissioning schedule.
3. Coordinate work with commissioning work.

4. Ensure commissioning tasks and deliveries are performed in accordance with the Commissioning Schedule and Contract Documents.
5. Provide training to the Owner relative to the equipment components and the overall operation of the entire systems

C. Duties of Equipment and Systems Installers:

1. Review and approve Commissioning Procedures.
 - a. Review is confined to ensuring test procedures are executable, will not damage equipment or systems, and will not affect warranties.
 - b. Review pre-commissioning checklists and functional performance test plans and data sheets for capability of verifying that the equipment and systems meet the Design Intent.
 - c. Provide assistance in functional performance testing and test and balancing, i.e. the TC contractor shall open all the vav boxes to test the unit at 100% speed so that the air flow measuring stations can be accurately calibrated.
 - d. Consult with equipment and systems manufacturers as required to verify that tests will not damage equipment and systems.
 - e. If installer deems it necessary for protecting equipment, they shall forward these documents to the appropriate manufacturer's representatives for review and editing.
2. Provide Skilled Technicians for execution of commissioning procedures including seasonal testing required after initial commissioning when required by Contract Documents.
3. Participate in resolution of disputes related to commissioning.
4. Provide qualified personnel for correction of deficiencies.
5. Train Owner's maintenance personnel in operation and maintenance of equipment and systems.
6. Submit operation and maintenance and as-built drawings for equipment and systems to Designer.
7. Installers shall cooperate with other Installers on commissioning Work that requires participation of multiple Installers.
8. Provide input (in coordination with the Contractor and other installers) to the Architect to develop an integrated commissioning schedule.
9. Commissioning does not relieve Installers from participating in the review process not diminish the Installer's role and obligations to complete other Work as required by Contacts Documents.

D. Duties of Commissioning Agent

1. Engage Commissioning Team
 - a. The Commissioning Team assists in planning, reviewing and coordination of commissioning activities with all disciplines involved in the building project. The Commissioning Team shall include the following members at a minimum. Contractors will not join the team until they are selected through the normal procurement process.
 - i) Commissioning Leader

- ii) Facility Operations Manager (FOM)
- iii) Project Manager
- iv) Designers
- v) Contractors
- vi) Energy Modeler (if energy modeling is part of the project)
- vii) Guideline Leader

2. The Commissioning Leader facilitates and coordinates the efforts of the commissioning team. For Design and Construction Commissioning, the commissioning leader shall have a distinct role from the design team but may be employed within a firm providing design services. The Facility Operations Manager is accountable for facility performance during ongoing occupancy and will manage or perform ongoing operations and maintenance following construction. This person is available to participate throughout the design and construction process for continuity into final operation.
3. Coordination of Owner's Project Requirements (as required by guideline P.1A)
The Owner's Project Requirements (OPR) shall quantify functional performance expectations and parameters for each system to be commissioned. The OPR provides the common understanding that focuses design, construction, and commissioning activities on the desired outcome. The OPR shall be written in objective and measurable terms. Quantify parameters such as space temperatures, humidity levels, lighting levels, sound levels, and ventilation rates when applied to the conditioned building spaces. The OPR shall be updated every time the owner accepts an alternate requirement or performance criteria – due to owner desires, schedule, or budget. This might occur through normal design evolution, value engineering, change orders, or other supplemental instructions during construction.
The OPR shall include an updated SB 2030 Energy and Carbon Standard for the project related to Guidelines E.1 and renewable energy requirements under E.2 and updated as the program and the project are refined. During the Correction Period and On-Going Operations, the OPR helps the owner/operators understand the requirements of the owner. It also provides the benchmark for maintenance, repair, and replacement decisions
4. Coordination with Basis of Design (as required by guideline P.1C)
The Basis of Design (BOD) is a narrative description of how the systems will be designed in order to achieve the Owner's Project Requirement acceptance criteria.
5. Commissioning Design Review
At least once during each of the Design, Final Design, review the design progress against the goals of the Owners Project Requirements. Commissioning Design Review comments shall be documented in writing and responses prepared by the appropriate designers
6. Coordinate and direct the commissioning activities in a logical, sequential and efficient manner using consistent protocols and forms, centralized documentation, clear and regular communications and consultations with all necessary parties, frequently updated timelines and schedules and technical expertise.
7. Coordinate the commissioning work with the contractor and construction manager, to ensure that commissioning activities are being incorporated into the master schedule.
8. Plan and conduct commissioning meetings as needed and distribute minutes.
9. Performance Check: Commissioning Team shall review design as documented to verify that it meets the physical outcomes and operational performance defined at that phase. Performance areas include, but are not limited to:

- a. Owner's Project Requirements acceptance criteria for all required and additional pursued Guidelines.
 - b. Requirements for specific operational scenarios of the building.
- 10. Measurability/Testability Check: Commissioning Team shall review design as documented to verify that it meets criteria for testing and verification of performance for Design and Construction Commissioning as well as Operations Commissioning monitoring during Ongoing Occupancy. Performance areas include, but are not limited to:
 - a. Measurements and testing required during all phases of Design and Construction Commissioning.
 - b. Measurement, monitoring, and control of energy, water, indoor environmental quality during ongoing occupancy.
- 11. Coordinate with Operations Commissioning and Energy Efficient Operations Manual Cooperate with the Operations Commissioning Team by incorporating design features required to perform Operations Commissioning. Refer to and coordinate with the completion of Guideline P.2A: SB 2030 Energy Efficient Operations Manual process.
- 12. List of I/O Data Points
 - a. Submit a list of input and output (I/O) data points or sequence of operations as part of outcome documentation before the completion of the Final Design Phase. These shall be submitted for all computer-based control systems, e.g., HVAC, lighting controls which have programmable control logic.
- 13. Provide Cx Criteria & Scope for Construction Documents
 - a. Provide a commissioning specification section for Division 1 of the project manual. The commissioning specification shall define and elaborate on the contractor's responsibilities as defined in the Commissioning Plan. Incorporate the Commissioning Plan into the contract documents by reference in order to communicate the context of the commissioning specification and information regarding other team member responsibilities.
- 14. Request and review additional information required to perform commissioning tasks, including O&M materials, contractor start-up and checkout procedures. Before startup, gather and review the current control sequences and interlocks and work with contractors and design engineers until sufficient clarity has been obtained, in writing, to be able to write detailed testing procedures.
- 15. Coordinate and direct commissioning activities.
- 16. Review normal Contractor submittals applicable to systems being commissioned for compliance with commissioning needs, concurrent with the A/E reviews.
- 17. Review requests for information and change orders for impact on commissioning and owner's objectives.
- 18. Review coordination drawings to ensure that trades are making a reasonable effort to coordinate.
- 19. Write and distribute construction checklists for commissioned equipment.
- 20. Develop an enhanced start-up and initial systems checkout plan with contractors for selected equipment.

21. Perform site visits, as necessary, to observe component and system installations. Attend selected planning and job-site meetings to obtain information on construction progress. Review construction meeting minutes for revisions/substitutions relating to the commissioning process. Assist in resolving any discrepancies.
22. Perform the following pre-functional tasks:
 - a. Witness HVAC piping pressure test and flushing, enough to be confident that proper procedures were followed. Include testing documentation in the Commissioning Record.
 - b. Witness any ductwork testing and cleaning enough to be confident that proper procedures were followed. Include documentation in the Commissioning Record.
 - c. Document construction checklist completion by reviewing completed construction checklists and by selected site observation.
 - d. Document systems startup by reviewing start-up reports and by selected site observation.
 - e. Approve air and water systems balancing by spot testing and by reviewing completed reports and by selected site observation.
23. With necessary assistance and review from installing contractors, write the functional performance test procedures for equipment and systems. This will include manual functional testing, energy management control system trending and may include stand-alone datalogger monitoring.
24. Coordinate, witness and document manual functional performance tests performed by installing contractors. Coordinate retesting as necessary until satisfactory performance is achieved. The functional testing shall include operating the system and components through each of the written sequences of operation, and other significant modes and sequences, including startup, shutdown, unoccupied mode, manual mode, staging, miscellaneous alarms, power failure, security alarm when impacted and interlocks with other systems or equipment. Sensors and actuators shall be calibrated during construction check listing by the installing contractors and spot-checked by the commissioning provider during functional testing. Analyze functional performance trend logs and monitoring data to verify performance. a. Tests on respective HVAC equipment shall be executed, if possible, during both the heating and cooling season. However, some overwriting of control values to simulate conditions shall be allowed. Functional testing shall be done using conventional manual methods, control system trend logs, and read-outs or stand-alone dataloggers, to provide a high level of confidence in proper system function, as deemed appropriate by the commissioning provider and the Owner.
25. Prepare test plans for, assist with execution of, and document tests of commissioned equipment overseen by regulatory authorities and ensure that such tests meet the testing rigor desired by the Owner.
26. Maintain a master issues log and a separate record of functional testing. Report all issues as they occur directly to the Owner's Representative. Provide directly to the Owner's Representative written progress reports and test results with recommended actions.
27. Review equipment warranties to ensure that the Owner's responsibilities are clearly defined.
28. Oversee and review the training of the Owner's operating personnel prior to construction completion and system acceptance by the owner.
 - a. Oversee the videotaping of this training.

- b. Review the creation of a classroom “owner’s manual” that is to be kept in the classroom.
 - c. Review the preparation of the O&M manuals for commissioned equipment.
- 29. Compile a Commissioning Record, which shall include:
 - a. A brief summary report that includes a list of participants and roles, brief building description, overview of commissioning and testing scope, and a general description of testing and verification methods. For each piece of commissioned equipment, the report should contain the disposition of the commissioning provider regarding the adequacy of the equipment, documentation and training meeting the contract documents in the following areas:
 - 1) Equipment meeting the equipment specifications,
 - 2) Equipment installation,
 - 3) Functional performance and efficiency,
 - 4) Equipment documentation, and
 - 5) Operator training.
- 30. All outstanding non-compliance items shall be specifically listed. Recommendations for improvement to equipment or operations, future actions, commissioning process changes, etc. shall also be listed. Each non-compliance issue shall be referenced to the specific functional test, inspection, trend log, etc. where the deficiency is documented.
- 31. Also included in the Commissioning Record shall be the issues log, commissioning plan, progress reports, submittal and O&M manual reviews, training record, test schedules, construction checklists, start-up reports, functional tests, and trend log analysis.
- 32. Compile a Systems Manual that consists of the following and at least the parts listed under ASHRAE 202-2013 Part 14.2.3: Owner’s Project Requirements (by owner); Design Narrative and Basis of Design (by designer); Performance Metrics, if completed during design; space and use descriptions, single line drawings and schematics for major systems (by designer); control drawings, sequences of control (by contractor); and a table of all setpoints and implications when changing them, schedules, instructions for operation of each piece of equipment for emergencies, seasonal adjustment, startup and shutdown, instructions for energy savings operations and descriptions of the energy savings strategies in the facility, recommendations for recommissioning frequency by equipment type, energy tracking recommendations, and recommended standard trend logs with a brief description of what to look for in them (all by commissioning leader).
- 33. Deferred Verification
 Some of the system functional performance test procedures will not be practical or meaningful to complete prior to the Correction Period. This may be due to construction phasing, climate or other constraints. Those test procedures shall be completed at the earliest appropriate time, and the results of the tests shall be reported to the Owner and Project team. It shall be expected that deficiencies identified as part of this deferred testing executed after the Correction Period will be resolved by the project team as if they had been identified prior to the end of the Correction Period.
- 34. Warranty Period

- a. Coordinate and supervise required opposite season or deferred testing and deficiency corrections and provide the final testing documentation for the Commissioning Record and O&M manuals.
- b. Return to the site at 10 months into the 12-month warranty period as scheduled by the Owner's Representative, and review with facility staff the current building operation and the condition of outstanding issues related to the original and seasonal commissioning. Also interview facility staff and identify problems or concerns they have with operating the building as originally intended. Make suggestions for improvements and for recording these changes in the O&M manuals. Identify areas that may come under warranty or under the original construction contract. Assist facility staff in developing reports and documents and requests for services to remedy outstanding problems.

E. Duties of all parties

1. Attend all commissioning scope meetings and commissioning team meetings. These will take place on an every other week schedule unless progress of the project dictates otherwise.

1.7 PRODUCTS

A.

1.8 TEST EQUIPMENT

A. Test Equipment:

1. Contractor or installer shall furnish industry standard test equipment for performing tests.

B. Proprietary Test Equipment:

1. Contractor or Installer shall provide proprietary test equipment required by equipment manufacturer.
2. The contractor shall demonstrate test equipment use and assist in the commissioning process.
3. The contractor shall provide instrument calibration and maintain test equipment a recommended by manufacturer.

1.9 EXECUTION

1.10 TESTING PREPARATION - COMMISSIONING PROCEDURES AT THE SITE

A. Coordination of Tests:

1. The commissioning agent shall develop an integrated Commissioning Schedule with input from the Contractor and all installers.
2. Contractor shall coordinate schedules of all installer representatives, and enforce participation in commissioning tests according to the Commissioning Schedule.
3. An installer shall not test work by another installer.
4. When testing systems that include work by multiple installers, representatives of all effected installers must be present.
5. Installer shall complete commissioning checklists during equipment and system start-up.
6. Commissioning tests of systems may proceed prior to final completion of systems to expedite the testing progress if approved by Designer.
7. Do not initiate functional performance testing for equipment or systems in advance of their start-up and checkout by all affected Installers for that equipment or system.
8. Test and record Mechanical, Control, and Electrical systems through each mode of operation using Commissioning procedures.

B. Test Acceptance Criteria:

1. The criteria for acceptance of each test is only if that test results will be in accordance with and demonstrate the Design Intent.
2. Input will be sought when necessary from the Designer to determine if test results indicate compliance with the Design Intent.
3. The Designer will recommend acceptance or rejection of work based on the test results.

C. Resolution of Deficiencies:

1. Designer will review performance tests and notify the Contractor indicating the nature of deficiencies and steps to be taken.
2. Installer shall adjust defective equipment and systems to meet performance requirements under varying loads.
3. Contractor shall set the date for completion of corrective activities. This date shall be within fifteen (15) working days of the date the deficiency report was generated.
 - a. The correction of issues described in the deficiency report must be signed by the party responsible for correcting the deficiency, and returned to the Commissioning Agent within the 15 day period.
4. If the date for completion of corrective work passes without resolution of deficiencies, Owner reserves the right to obtain supplementary services and equipment to correct the problem as indicated in the General Conditions.
5. Commissioning procedures shall be aborted and considered failed, if any commissioning team member, for whom participation is scheduled, is not present for the test.
 - a. This will not be considered a failure if the test is rescheduled 48 hours (minimum) in advance of the scheduled testing.
6. Installer shall perform additional commissioning procedures until the required system performance is obtained.

D. Re-checking and Re-testing Charges:

1. In the event of a second failure of a commissioning procedure for equipment and systems, the Contractor will be assessed charges by the Designer, and other commissioning review parties to do additional testing on the site for re-testing equipment and systems.
2. Charges will be based on each party's expenses, including normal hourly billing rates, time for re-testing, travel time, travel expenses, and per diem, if required.

1.11 O&M MANUAL

1. Ensure that Operation and Maintenance Manuals are accurate and complete. Forward this document to the Owner.

1.12 PRE-FUNCTIONAL START-UP

- A. Start-up reports shall be completed by qualified installers responsible for installing the piece of equipment.
- B. The Contractor shall be responsible for performing any additional manufacturers or local codes officials' start-up requirements at no additional cost to the Owner.
- C. The Contractor is responsible for ensuring a factory-authorized service representative is present for start-up procedures where such representation is mandated to attend start-up.
- D. The Contractor shall verify the equipment checklist is completed before operating the equipment.
- E. The completed start-up checklists shall be returned to the Commissioning Agent.
- F. The equipment requiring prefunctional testing include, but are not limited to, the following:
 1. Chillers
 2. Boilers
 3. Pumps
 4. Air Handling Units
 5. Ventilation Fans
 6. VFD's
 7. Air Terminal Units
 8. Ductwork/Pipe Insulation
 9. Pipework
 10. Temperature Control
 11. Temperature/Humidity Sensors
 12. Pressure Sensors and Controllers
 13. Sequence of Operation
 14. Airflow Stations
 15. Damper/Valve Actuators
 16. Plumbing Equipment
 17. Plumbing Piping Systems
 18. Fire Pump
 19. Normal Power Electrical Systems
 20. Lighting Control/Daylighting Systems
 21. Emergency Power Systems
 22. Fire/Life Safety Systems
 23. Security Systems
 24. Communication Systems (including voice, data, PA)

- 25. Renewable and Alternative Energy Technologies
- 26. Waste Heat Recovery Systems
- 27. I.A.Q. Pre-Occupancy – Office
- 28. I.A.Q. Post-Occupancy - Office

G. Functional Start-Up

- 1. The equipment requiring functional testing may include all components of the mechanical system and is at the discretion of the Owner and Commissioning Agent. The minimum required shall be all components of the following:
 - a. HVAC system
 - b. Hydronic System
 - c. Domestic system
 - d. The smoke control system shall be commissioned to verify performance meets IBC 909.

END OF SECTION

SECTION 23 0923 – DIRECT DIGITAL CONTROL SYSTEM FOR HVAC

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the Building Management System (BMS) control equipment for HVAC systems and components, including open protocol control components for terminal heating and cooling units. Depending on the scope of the project, the complete specification may have numerous sections that interface to this section, including several from Divisions 26.
- B. Commonly included related Sections include the following:
 - 1. Section 230593 "Testing, Adjusting, and Balancing for HVAC Equipment" for requirements that relate to this section.
 - 2. Section 230993 "Sequence of Operations for HVAC Controls" for requirements that relate to this Section.

1.3 REFERENCED CODES AND STANDARDS

- A. Provide BMS components and ancillary equipment, which are UL-916 listed and labeled.
- B. All equipment, wiring, and piping used in conditioned air streams, spaces or return air plenums shall comply with NFPA 90A Flame/Smoke/Fuel contribution rating of 25/50/0 and all applicable building codes or requirements.
- C. All wiring shall conform to the National Electrical Code.
- D. Comply with FCC rules, Part 15 regarding Class A radiation for computing devices and low power communication equipment operating in commercial environments.
- E. Comply with FCC, Part 68 rules for telephone modems and data sets.
- F. Comply with ASHRAE 135-2004 for BACnet systems.

1.4 ABBREVIATIONS AND DEFINITIONS

- A. Abbreviations and definitions listed within this section shall also apply to specification section 230993 "Sequence of Operation"

B. Abbreviations:

| | |
|--------|--------------------------------------|
| AAC | Advanced application controller |
| ADJ | Adjustable |
| AI | Analog Input |
| AO | Analog Output |
| ASC | Application specific controller |
| ASD | Application specific device |
| AUTO | Automatic |
| AUX | Auxiliary |
| AV | Analog Value |
| BACnet | Building Automation Controls Network |
| BC | Building controller |
| BMS | Building Management System, |
| BI | Binary Input (DI: Digital Input), |
| BO | Binary Output (DO: Digital Output) |
| BV | Binary Value |
| C | Common |
| CAC | Custom application controller |
| DA | Discharge air |
| DCU | Distributed control unit |
| DDC | Direct Digital Control |
| DR | Demand response |
| FTP | File transfer protocol |
| EA | Exhaust air |
| GUI | Graphical User Interface |
| HOA | Hand-off-auto |
| I/O | Input/output |
| IP | Internet protocol |
| LAN | Local area network |
| LCM | Local control module |
| LON | Local Operating Network |
| LPES | LON portable operator's |
| MAX | Maximum |
| MIN | Minimum |

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|--------|-----------------------------------------------|
| MPC | Multi-purpose controller |
| MS/TP | Master slave / Token passing |
| NC | Normally closed |
| NO | Normally open |
| NSC | Network server controller |
| OA | Outside air |
| OBIX | Open building information exchange |
| OWS | Operator workstation |
| PC | Personal computer |
| PEM | Packaged equipment module |
| PEMS | Power and energy management software |
| PICS | Protocol Implementation Conformance Statement |
| PID | Proportional plus integral plus derivative |
| POT | Portable operator's terminal |
| PPC | Programmable process controller |
| RA | Return air |
| RC | Room controller |
| RH | Relative humidity |
| RTD | Resistance temperature detector |
| SA | Supply air |
| SDCU | Standalone digital control unit |
| SLC | Supervisory logic controller |
| SNVT | Standard network variable type |
| SP | Static pressure |
| TCP | Transmission control protocol |
| TEMP | Temperature |
| UEC | Unitary equipment controller |
| VAVDDC | Variable air volume direct digital controller |
| W/ | With |
| W/O | Without |
| XML | eXtensible markup language |

C. Definitions:

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|---------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Advanced Application Controller | A fully programmable control module. This control module may be capable of some of the advanced features found in Building Controllers (storing trends, initiating read and write requests, etc.) but it does not serve as a master controller. Advanced Application Controllers may reside on either the Ethernet/IP backbone or on a subnet. |
| Analog Input | A continuously varying voltage or amperage signal that is varied by a sensor in relation to a sensed variable. This signal is processed in the controller after an analog-to-digital converter on the controller that converts the analog signal to a digital value. |
| Analog Output | A continuously varying voltage or amperage signal that is generated from the controller after digital-to-analog conversion. The voltage or amperage signal will be used, for instance, to drive a modulating actuator or reset a hardwired set point on a packaged device. 6. Analog Value (AV): A network-visible analog point whose value is determined by a controller computation. |
| Analog Value | A network-visible analog point whose value is determined by a controller computation. |
| Application Specific Controller | A pre-programmed control module which is intended for use in a specific application. ASCs may be configurable, in that the user can choose between various pre-programmed options, but it does not support full custom programming. ASCs are often used on terminal equipment such as VAV boxes or fan coil units. In many vendors' architectures ASCs do not store trends or schedules but instead rely upon a Building Controller to provide those functions. |
| BACnet/IP | An approved BACnet network type which uses an Ethernet carrier and IP addressing. |
| BACnet MS/TP | An approved BACnet network type which uses a Master-Slave Token Passing configuration. MS/TP networks are unique to BACnet and utilize EIA485 twisted pair topology running at 9600 to 76,800 bps. |
| BACnet over ARCNET | An approved BACnet network type which uses an ARCNET (attached resource computer network) carrier. ARCNET is an industry standard that can utilize several speeds and wiring standards. The most common configuration used by BACnet controllers is an EIA485 twisted pair topology running at 156,000 bps. |
| Binary Input | An on/off indication that has a maximum cycle rate of 1 Hz. This is typically sensing a contact closure. |
| Binary Output | A contact closure on the controller that will cause inaction in the system. |
| Binary Value | A network-visible binary point whose value is determined by a controller computation. |

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|---------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Building Controller | A fully programmable control module which is capable of storing trends and schedules, serving as a router to devices on a subnet, and initiating read and write requests to other controllers. Typically this controller is located on the Ethernet/IP backbone of the BAS. In many vendors' architectures a Building Controller will serve as a master controller, storing schedules and trends for controllers on a subnet underneath the Building Controller. |
| Building Management System | Integrated DDC Temperature control system used both for system operation and troubleshooting meeting the requirements of this specification. |
| Direct Digital Control | A control system in which a digital computer or microprocessor is directly connected to the valves, dampers, and other actuators which control the system, as opposed to indirectly controlling a system by resetting set points on an analog pneumatic or electronic controller. |
| Integrate | The physical connections from a control system to all specified equipment through an interface as required to allow the specified control and monitoring functions of the equipment to be performed via the control system. |
| Interface | The physical device required to provide integration capabilities from an equipment vendor's product to the control system. The equipment vendor most normally furnishes the interface device. An example of an interface is the chilled water temperature reset interface card provided by the chiller manufacturer in order to allow the control system to integrate the chilled water temperature reset function into the control system. |
| kW Demand Limiting | An energy management strategy that reduces energy consumption when a system's electric power meter exceeds an operator-defined threshold. When power consumption exceeds defined levels, the system automatically adjust set points, de-energizes low priority equipment, and takes other pre-programmed actions to avoid peak demand charges. As the demand drops, the system restores loads in a predetermined manner. |
| Local Operating Network | A control network technology platform for designing and implementing interoperable control devices and networks. |
| Occupant Override Switch; or Timed Local Override | A control option that allows building occupants to override the programmed HVAC schedule for a limited period of time. When the override time expires, the zone returns to its unoccupied state. |
| Occupant set point adjustment | A control option that allows building occupants to adjust – within limits set by the HVAC control system – the heating and cooling set points of selected zones. Typically the user interface for this function is built into the zone sensor. |

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|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Optimal Start/ Start-up | A control strategy that automatically starts an HVAC system at the latest possible time yet ensures comfort conditions by the time the building becomes occupied. In a typical implementation, a controller measures the temperature of the zone and the outside air. Then, using design heating or cooling capacity at the design outside air temperature, the system computes how long a unit must run at maximum capacity to bring the zone temperature to its occupied set point. The optimal start algorithm often includes a self-learning feature to adjust for variations from design capacity. A distributed system must use Run on Request with Optimal Start. (See below.) |
| Protocol Implementation Conformance Statement | A written document, created by the manufacturer of a device, which identifies the particular options specified by BACnet that are implemented in the device. |
| Provide | Furnish and Install |
| Requested, or Run on Request | <p>A control strategy that optimizes the runtime of a source piece of equipment that supplies one or more receiving units – such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. Source equipment runs only when needed, not on a fixed schedule. The source equipment runs when one or more receiving units request its services. An operator determines how many requests are required to start the source equipment.</p> <p>For example, if all the zones in a building are unoccupied and the zone terminal units do not need heating or cooling, the AHU will shut down. However, if a zone becomes occupied or needs cooling, the terminal unit will send a run request to the AHU to initiate the start-up sequence. If this AHU depends on a central chiller, it can send a run request to the chiller. The run on request algorithm also allows an operator to schedule occupancy for individual zones based on the needs of the occupants without having to adjust the schedules of related AHUs and chillers.</p> |
| Smart Actuator | An actuator which is controlled by a network connection rather than a binary or analog signal. (0-10v, 4-20mA, relay, etc.) |
| Smart Sensor | A sensor which provides information to the BAS via network connection rather than a binary or analog signal. (0-10000 ohm, 4-20mA, dry contact, etc.) |
| Trimmed and Respond, or Set point Optimization | A control strategy that optimizes the set point of a source piece of equipment that supplies one or more receiving units – such as an air handler unit supplying zone terminal units with heating, cooling, ventilation, or similar service. The source unit communicates with receiving units to determine heating, cooling, and other requirements, and then adjusts its set point. For example, if all zones are comfortable and do not request cooling, the AHU will gradually increase (trim) its supply air set point. When a zone requests cooling, the AHU responds by dropping its set point. The more zones that request cooling, the more it drops the set point. The AHU repeats this process throughout the day to keep zones cool, but with a supply air set point that is no cooler than necessary. |

Web Services Web services are a standard method of exchanging data between computer systems using the XML (extensible markup language) and SOAP (simple object access protocol) standards. Web services can be used at any level within a Building Automation System (BAS), but most commonly they are used to transfer data between BAS using different protocols or between a BAS and a non-BAS system such as a tenant billing system or a utility management system.

1.5 DESCRIPTION

- A. Provide labor, materials, equipment and services as required for the complete installation indicated in Contract Documents. The workstation shall display dynamic, real-time point data on color graphic displays for all points. Provide all required software and hardware. Provide wiring and conduit required to connect devices furnished as a part of, or accessory to, this automatic control system.
- B. The BMS shall be as indicated on the drawings and described in these specifications. System must be fully integrated and coordinated with mechanical equipment DDC controllers furnished and installed in the equipment manufacturer's factory as specified in those sections. The intent of the BMS is to integrate all mechanical equipment into one system for global monitoring, control, and alarming associated with the building. BMS manufacturer is responsible to provide all the design, engineering, and field coordination required to ensure all equipment sequence of operations are met as specified and the designated BMS operators have the capability of managing the building mechanical system to ensure occupant comfort while maintaining energy efficiency
- C. The BMS shall meet open protocol communication standards to ensure the system maintains "interoperability" to avoid proprietary arrangements that will make it difficult for the Owner to consider other BMS manufacturers in future projects
- D. DDC technology shall be used to provide the functions necessary for control of mechanical systems and terminal devices on this project.
- E. The BMS shall accommodate simultaneous multiple user operation. Access to the control system data should be limited only by operator password. Multiple users shall have access to all valid system data. An operator shall be able to log onto any workstation on the control system and have access to all appropriate data
- F. The mechanical systems and terminal devices shall be provided with factory mounted DDC controls that will permit each system to operate in a stand-alone fashion where indicated on drawing schedules. As such, in the event of a BMS network communication failure, or the loss of an individual controller, the other DDC controllers shall continue to independently operate and communicate to the BMS.
- G. Communication between DDC controllers and all workstation(s) shall be over a high-speed network. All nodes on this network shall be peers. The operator shall not have to know the controller identifier or location to view or control a point (object). Application Specific Controllers shall be constantly scanned by the Building Controllers to update point information and alarm information globally

- H. The BMS manufacturer shall provide all hardware and software necessary to implement the functions and sequence of operations specified
- I. Provide all required devices for proper system operation, including, but not limited to: transformers, relays, pushbutton stations, controllers, panels, actuators, sensors, meters, etc. Provide wiring to all devices provided, in accordance with requirements of "Electric Wiring" in Section 260519, and the National Electrical Code. Control wiring 'Wiring' is defined as wiring up to and including 120 volts, and included power distribution wiring to operate devices. Coordinate and provide all power distribution and breakers from panel boards to the control panels.
- J. Freestanding panels shall be supported from "Unistrut" securely fastened to walls.
- K. Coordinate and provide Ethernet data drops at main building controller and at operator workstations.

1.6 ACTION SUBMITTALS

- A. BMS manufacturer shall provide shop drawings and manufacturers' standard specification data sheets on all hardware and software being provided for this project. No work may begin on any segment of this project until the Engineer and Owner have reviewed submittals for conformity with the plan and specifications.
- B. Provide the Engineer and Owner, any additional information or data which is deemed necessary to determine compliance with the specifications or which is deemed valuable in documenting and understanding the system to be provided.
- C. Submit for review the following:
 - 1. A complete bill of materials of equipment to be used indicating quantities, manufacturers and model numbers
 - 2. Provide all manufacturers' technical cut sheets for major system components. When technical cut sheets apply to a product series rather than a specific product, the data specifically applicable to the project shall be highlighted or clearly indicated by other means.
 - 3. Each submitted product literature and drawings shall clearly reference the specification page and section number and/or drawing number associated with the product. Include:
 - a. Building Controllers
 - b. Custom Application Controllers
 - c. Application Specific Controllers
 - d. Operator Workstations
 - e. Auxiliary Control Devices
 - f. Proposed Building Automation System architectural diagram depicting various controller types, workstations, device locations, addresses, and communication cable requirements.
 - g. Detailed termination drawings showing all required field and factory terminations, as well as terminal tie-ins to DDC controls provided by mechanical equipment manufacturers. Terminal numbers shall be clearly labeled.

- h. Points list showing all system objects and the proposed English language object names.
 - i. Sequence of operation for each controlled mechanical system and terminal end devices.
 - j. Provide a Protocol Implementation Conformance Statement (PICS) for each system level device (i.e. Building Controller & Operator Workstations) type. This defines the point list for proper coordination of interoperability with other building systems if applicable for this project.
 - k. Provide Certification and functional profile SNVT's for unitary-level controllers (i.e. RTU's, Terminal VAV boxes, etc.) for interoperability with other building systems if applicable for this project.
- 4. Detailed piping and wiring control diagrams, components, and systems description for each system under control.
 - 5. Detailed layout and nameplate list for component control panels and DDC panels.
 - 6. Submit a valve, actuator, and damper schedule showing size, manufacturer, model number, pressure drop configuration, capacity, and locations. Provide apparatus Bulletins and data sheets for all control system components.
 - 7. Submit an airflow station schedule showing size, manufacturer, model number, airflow, velocity, and locations.
 - 8. A complete listing of input and output points, control loops and/or routines, including time of day functions, and facilities management system functions for each controlled system. This listing shall include point logical names, identifiers, and alarmable ranges.
 - 9. Provide as part of a separate submittal a hard copy of all graphics showing system components, sensor locations, set points and fixed/variable data. Submit to the Engineer for review and approval of graphic format prior to final acceptance of system.

1.7 CLOSEOUT SUBMITTALS

- A. Upon completion of installation, submit three (3) copies of record (as-built) documents. The documents shall be submitted for approval prior to final completion and include:
 - 1. Project Record Drawings - These shall be as-built versions of the submittal shop drawings. One set of electronic media including CAD .dwg or .dxf drawing files and .pdf files shall also be provided.
 - 2. Testing Reports and Checklists signed off by trained factory (equipment manufacturers) and field (BMS) commissioning personnel
 - 3. Operating and Maintenance (O & M) Manuals - These shall be as-built versions of the submittal product data. In addition to the information required for the submittals, Operating & Maintenance manual shall include:
 - a. Names, address and 24-hour/7-day per week telephone numbers of personnel managing and installing equipment, along with service personnel responsible for supporting the ongoing warranty and services of the control system.
 - b. Procedures for operating the BMS including logging on/off, alarm management, generation of reports, trends, overrides of computer control, modification of set points, and other interactive system requirements.
 - c. Description of the programming language including syntax, statement descriptions, algorithms, calculations, point database creation and modification, program creation and modification, and operator use of the editor.

- d. Explanation of how to design and install new points, new DDC controllers, and other BMS hardware.
- e. Preventative Maintenance and calibration procedures; hardware troubleshooting; and hardware repair and/or replacement procedures.
- f. Documentation of all software program logic created for Custom Programmable Controllers including the overall point database. Provide one set of magnetic media containing files of the software and point database.
- g. One set of electronic media containing files of all operator color graphic screens for the project.
- h. A list of recommended spare parts including pricing, manufacturer, supplier, and part numbers.
- i. Documentation, installation, and maintenance information for all third-party hardware/software products provided including personal computers, printers, hubs, sensors, valves, etc.
- j. Original issue media for all software provided, including operating systems, programming language, operator workstation software, and graphics software.
- k. Licenses, Guarantee, and Warranty documents for all equipment and systems.
- l. Recommended preventive maintenance procedures for all system components including a schedule of tasks (inspection, cleaning, calibration, etc.) and task descriptions

1.8 QUALITY ASSURANCE

- A. The BMS manufacturer authorized representative shall have an established business office within 50 miles of the project site and must provide 24 hours/day, 7 days/week response in the event of a customer warranty or service call.
- B. The BMS Manufacturer authorized representative installer shall have a minimum of five years' experience in systems of similar size, type and complexity installed within a 50-mile radius.
- C. The BMS Manufacturer authorized representative shall have factory trained and certified personnel, in the regular employment of the approved manufacturer's local office, providing all engineering, service, startup, and commissioning field labor for the project from their local office location. BMS manufacturer authorized representative shall be able to provide training certifications for all local office personnel upon request.
- D. The BMS shall be provided by a single manufacturer and this manufacturer's equipment must consist of operator workstation software, Web-based hardware/software, Open Standard Protocol hardware/software, Custom application Programming Language, Graphical Programming Language, Building Controllers, Custom Application Controllers, and Application Specific Controllers. All other products specified herein (i.e., sensors, valves, dampers, actuators, etc.) need not be manufactured by the BMS manufacturer.
- E. BMS vendor must be corporate owned authorized representative entity of BMS manufacturer.
- F. The complete automatic temperature control system shall be comprised of electric control devices with a microprocessor based Direct Digital Control System. All work shall be installed only by skilled mechanics employed by the BMS Manufacturer authorized representative.
- G. All components shall be fully tested and documented to operate as a complete system.

- H. Supplier must guarantee that all replacement parts will be carried in stock for a period of 5 years minimum from the date that the system is commissioned.
- I. All products used in this installation shall be currently manufactured and shall have been applied to a minimum of three previous projects. This installation shall not be used as a test site for any new products unless explicitly approved by the Owner's representative in writing prior to bid date.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. System Software: Update to latest version of software at Project completion.

1.10 COORDINATION

- A. Coordinate location of thermostats, carbon dioxides sensors, pressure sensors, humidistats, and other exposed control sensors with plans and room details before installation.
- B. Coordinate equipment location.
- C. Coordinate supply of conditioned electrical branch circuits and power requirements for control units and operator workstation.
- D. Coordinate with the Owner's IT department/provider on locations of NSC's, Ethernet communication cabling, and TCP/IP addresses.
- E. Work incidental to the Temperature Control installer:
 - 1. Products furnished, but not installed under this section:
 - a. Piping:
 - 1) Control valves.
 - 2) Temperature sensor wells and sockets.
 - b. Ductwork:
 - 1) Automatic dampers.
 - 2) Airflow stations.
 - 3) Terminal unit controllers.
 - 2. Products not furnished or installed, but integrated with the work of this section:
 - a. Heat generation equipment: boilers, boiler pump(s), etc.
 - b. Variable frequency drives: pump controls, fan controls.
 - c. Smoke detectors.

3. Miscellaneous:

- a. All automatic dampers, the temperature control installer shall assemble multiple section dampers with required interconnecting linkages and extend required number of shafts through duct for external mounting of damper motors.
- b. Provide access doors or other means of access through ducts and/or ceilings/walls for service and adjustment of controllers, valves, and dampers.
- c. Control system manufacturer shall furnish written details, instructions and supervision for the above trades to ensure proper installation, size, and location of any equipment furnished.

1.11 SYSTEM COMMISSIONING

- A. Each point in the system shall be tested for both hardware and software functionality. In addition, each mechanical and electrical system under control of the BAS will be tested against the appropriate sequence of operation specified herein. Successful completion of the system test shall constitute the beginning of the warranty period. A written report will be submitted to the owner indicating that the installed system functions in accordance with the plans and specifications.
- B. Commission and set in operating condition all major equipment and systems, such as the chilled water, hot water and all air handling systems, in the presence of the equipment manufacturer's representatives, as applicable, and the Owner and Architect's representatives.
- C. Provide a technician to assist in testing, adjusting, and balancing all systems in the building per the requirements of section 230593 "Testing, Adjusting, and Balancing for HVAC." Coordinate all requirements to provide a complete air and hydronic balance. Include all labor and materials.
- D. Equipment Start-up: Upon completion of installation, all equipment being controlled shall be initially started and tested on site. If the permanent workstation is not available, provide a temporary workstation able to communicate with all individual controllers of entire installed system. Additionally, perform the following:
 1. Measurement of voltage sources, primary and secondary
 2. Verification of proper controller power wiring.
 3. Verification of labeling on components and wiring.
 4. Verification of connection integrity and quality (loose strands and tight connections).
 5. Verification of bus topology, grounding of shields and installation of termination devices.
 6. Verification of component inventory when compared to the submittals.
 7. Each I/O device is landed per the submittals and functions per the sequence of control.
 8. Verification of point checkout.
 9. Measure, calibrate and adjust all analog inputs.
 10. Analog sensors are properly scaled and a value is reported.
 11. Documentation of analog sensor calibration (measured value, reported value and calculated offset).
 12. Binary sensors have the correct normal position and the state is correctly reported.
 13. Analog outputs have the correct normal position and move full stroke when so commanded. Verify that all linkage adjustments are set properly.

14. Binary outputs have the correct normal state and respond appropriately to energize/de-energize commands.
 15. Valves and Dampers shall fully close and provide tight shut-off.
 16. Adjust set points so that equipment operates properly. Tune all PID control loops to avoid unnecessary cycling of control equipment, it's overheating, sub-cooling, tripping the freezestats and other limit switches and safeties. Create trends and print the results to verify tuning operation.
 17. Documentation of Loop tuning (sample rate, gain and integral time constant).
 18. Provide reasonable control and operational assistance to the balancing personnel as needed to achieve reliable and energy-efficient system operation.
- E. A performance verification test shall also be completed for the operator interaction with the system. Test elements shall be written to require the verification of all operator interaction tasks including, but not limited to the following:
1. Graphics navigation.
 2. Trend data collection and presentation.
 3. Alarm handling, acknowledgement and routing.
 4. Time schedule editing.
 5. Application parameter adjustment.
 6. Manual control.
 7. Report execution.
 8. Automatic backups.
 9. Web Client access.
- F. Communication Network Start-up: Verify from a host computer that all configured controllers are engaged in proper communication passing all configured points to viewing stations. Verify communication speed and level of transactions until it is acceptable and meets the requirements of this specification.
- G. Software Verification: All programs and software functions shall be verified for proper sequence of operation.
- H. During the ensuing four seasons (one year) conduct periodic inspections to fine-tune all dynamic elements of the system with all costs of testing to be included in this scope of work. In addition, dedicate one full day during each of the four subsequent seasons, during which all necessary tuning of dynamic parameters shall be conducted in the field.
- I. As built Drawings: All drawings shall be reviewed after the final installation and corrected to provide accurate, as-built representation of the complete system.
- J. Systems Startup Report: A report shall be provided to the Engineer detailing the dates, times and person(s) performing the start-up. This report shall detail when and who performed the individual processes mentioned above.
- K. Commissioning is considered completed only if the physical walk-through of the project has completed and the complete set of required documentation and software has been transferred to the Owner. The Owner has no right to refuse or delay a reasonably scheduled walk through meeting, during which time every major components should be inspected if the Owner wishes so

1.12 INSTRUCTIONS TO THE OWNER'S REPRESENTATIVE

- A. Provide competent control technicians to instruct the Owner's operating personnel and turn over three copies of maintenance manual. Provide a minimum of 12 hours of instruction at the site, 8 hours during start-up and 4 hours after six months. Instruction sessions shall be scheduled at the owner's convenience.
- B. Training Manuals: The BMS manufacturer shall provide a course outline and copies of training manuals at least two weeks prior to the start of any corporate training class to be attended by the Owner.
- C. All project developed hardware and software shall become the property of the Owner. This includes but is not limited to:
 - 1. Operator Graphic files
 - 2. As-built hardware design drawings
 - 3. Operating & Maintenance Manuals
 - 4. BMS System software database
 - 5. Controller application programming databases
 - 6. Application Specific Controller configuration files
 - 7. Required Licensed software

1.13 CONTROL SYSTEM GUARANTEES/WARRANTY.

- A. BMS system labor and materials shall be warranted free from defects for a period of twelve (12) months after final completion acceptance by the Owner. BMS failures during the warranty period shall be adjusted, repaired, or replaced at no charge to the Owner. The BMS manufacturer shall respond to the Owner's request for warranty service within 24 hours of the initiated call and will occur during normal business hours (8AM-5PM).
- B. At the end of the final start-up/testing, if equipment and systems are operating satisfactorily to the Owner and Engineer, the Owner shall sign certificates certifying that the BMS is operational and has been tested and accepted in accordance with the terms of this specification. The date of Owner's acceptance shall be the start of the warranty period.
- C. Operator workstation software, project specific software, graphics, database, and firmware updates shall be provided to the Owner at no charge during the warranty period. Written authorization by the Owner must be granted prior to the installation of these updates
- D. The BMS manufacturer shall provide a web-accessible Users Network for the proposed System and give the Owner free access to question/answer forum, graphics library, user tips, upgrades, and training schedules for a one-year period of time correlating with the warranty period.

1.14 SYSTEM MAINTENANCE

- A. Perform Building Automation System preventative maintenance and support for a period of 1 year (beginning the date of substantial completion)

1. Make a minimum of 4 complete Building Automation System inspections, in addition to normal warranty requirements. Inspections to include:
 - a. System Review – Review the BMS to correct programming errors, failed points, points in alarm, and points that have been overridden manually.
 - b. Seasonal Control Loop Tuning – Control loops are reviewed to reflect changing seasonal conditions and / or facility heating and cooling loads.
 - c. Sequence of operation verification – Systems all verified to be operating as designed and in automatic operation. Scheduling and set points are reviewed and modified.
 - d. Database back-up.
 - e. Operator coaching.
 2. Technician shall review critical alarm log and advise owner of additional services that may be required
 3. Technician shall provide a written report to owner after each inspection
- B. The BAS manufacturer shall setup a secure remote connection for data collection, analytics and remote technical support for the HVAC systems included in this contract.
1. Provide technician support during the warranty period to diagnose issues remotely through the secure remote connection.
 2. The building owner is responsible for providing adequate internet access.
- C. Connectivity / Remote Access / Network Security
1. Provide and maintain secure remote access to the facilities BMS or other building systems. Users accessing service through this connection shall not have access to the building owners network. Secure remote access to the BMS shall not require ANY inbound ports on a firewall to be “exposed” or “forwarded”.
 2. Secure remote access to the BMS shall be available anywhere, anytime, using a compatible client device (PC/tablet/phone)
 3. The Owner will provide up to Three (3) IP drops and IP addresses on the owners network to gain access to the internet. The BMS manufacture shall coordinate with the Owners IT team, verify the proposed system shall meet all network security requirements and any other network configuration information necessary to each control contractor for the purpose of configuring each Area Controller on the network. It shall be the responsibility of the BMS manufacture to coordinate with the owner for network connectivity.
- D. Do not assign or transfer maintenance service without prior written consent of owner.

PART 2 - PRODUCTS

2.1 CONTROL SYSTEM

- A. Provide a complete building automation system including all necessary hardware and all operating and applications software necessary to perform the control sequences per specification section 230993 “Sequences of Operation for HVAC Controls.” Network level components of the system – workstations, servers, etc shall communicate using the BACnet protocol. No gateways shall be used for communication to controllers furnished under this section

- B. Control system shall consist of, but not be limited to, all necessary Ethernet Network Controllers, Standalone Digital Control Units, Room Controllers, workstations, software, sensors, transducers, relays, valves, dampers, damper operators, control panels, and other accessory equipment, along with complete system of electrical interlocking wiring to fill the intent of the specification and provide for a complete and operable system.
 - 1. Except as otherwise specified, provide operators for equipment, such as dampers, if the equipment manufacturer does not provide them. Coordinate these requirements with the equipment manufacturer.
- C. Control system shall consist of sensors, indicators, actuators, final control elements, interface equipment, other apparatus, and accessories to control mechanical systems.

2.2 MANUFACTURER

- 1. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to:
 - a. Trane Tracer (Basis of Design)
 - b. Or Approved Equal
- 2. All bidders must be authorized distributors of branch offices of the manufacturer specified.

2.3 SYSTEM PERFORMANCE

- A. Performance Standards. The BMS system shall conform to the following:
 - 1. Graphic Display. The system shall display a graphic with a minimum of 20 dynamic points. All current data shall be displayed within 20 seconds of the operator's request.
 - 2. Graphic Refresh. The system shall update all dynamic points with current data within 30 seconds.
 - 3. Object Command. The maximum time between the command of a binary object by the operator and the reaction by the device shall be 10 seconds. Analog objects shall start to adjust within 10 seconds.
 - 4. Object Scan. All changes of state and change of analog values shall be transmitted over the high-speed network such that any data used or displayed at a controller or workstation will be current within the prior 60 seconds.
 - 5. Alarm Response Time. The maximum time from when an object goes into alarm to when it is annunciated at the workstation shall not exceed 45 seconds.
 - 6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 seconds. Select the execution times consistent with the mechanical process under control.
 - 7. Programmable Controllers shall be able to execute DDC PID control loops at a selectable frequency from at least once every 5 seconds. The controller shall scan and update the process value and output generated by this calculation at this same frequency.
 - 8. Multiple Alarm Annunciations. All workstations on the network shall receive alarms within 5 seconds of each other.
 - 9. Reporting Accuracy. Table below lists minimum acceptable reporting accuracies for all values reported by the specified system

| Measured Variable | Reported Accuracy |
|-----------------------------------|---------------------------|
| Space temperature | ±1°F |
| Ducted air | ±2°F |
| Outside air | ±2°F |
| Water temperature | ±1°F |
| Delta-T | ±0.25°F |
| Relative humidity | ±5% RH |
| Water flow | ±5% of full scale |
| Air flow (terminal) | ±10% of reading *Note 1 |
| Air flow (measuring stations) | ±5% of reading |
| Air pressure (ducts) | ±0.1 "W.G. |
| Air pressure (space) | ±0.01 "W.G. |
| Water pressure | ±2% of full scale *Note 2 |
| Carbon Monoxide (CO) | ± 50 PPM |
| Carbon Dioxide (CO ₂) | ± 50 PPM |

Note 1: (10%-100% of scale) (cannot read accurately below 10%)

Note 2: for both absolute and differential pressure

General Note: Sensors to be selected such that the measured media is near the middle third of sensor range

2.4 ENCLOSURES

- A. For all I/O requiring field interface devices, these devices where practical will be mounted in a field interface panel (FIP). Provide an enclosure which protects the device(s) from dust, moisture, conceals integral wiring and moving parts.
- B. FIPs shall contain power supplies for sensors, interface relays and contactors, and safety circuits.
- C. The FIP enclosure shall be of steel construction with baked enamel finish; NEMA 1 rated with a hinged door and keyed lock. The enclosure will be sized for twenty percent spare mounting space. All locks will be keyed identically.
- D. All wiring to and from the FIP will be to screw type terminals. Analog or communications wiring may use the FIP as a raceway without terminating. The use of wire nuts within the FIP is prohibited.
- E. All outdoor mounted enclosures shall meet the NEMA-4 rating.
- F. The wiring within all enclosures shall be run in plastic track. Wiring within controllers shall be wrapped and secured.

2.5 DIRECT DIGITAL CONTROL SYSTEM

- A. The basic elements of the Direct Digital Control System structural shall consist of standard components kept in inventory by the equipment supplier. The components shall not require customizing other than setting jumpers and switches, adding firmware modules or software

programming to perform required functions. The system may be expanded to its full capacity by adding sensors and entering programs in available random access memory (RAM). Future expansion shall not require hardware modifications to the controller. The entire system shall be a Direct Digital processing type.

B. The DDC system shall consist of the following:

1. Central DDC panels (UNC).
2. Application specific controllers (ASCI).
3. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC panel (Central or ASC) shall operate independently by performing its own specified control, alarm management, operator I/O, and historical data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.

2.6 Central DDC panels shall be able to access any data form, send control commands and alarm reports directly to any other DDC panel, operator workstation, or printer on the network

2.7 ARCHITECTURE/COMMUNICATION

A. This project shall be comprised of a high speed Ethernet network communications between System Controllers and Workstations. Communications between System Controllers and sub-networks of Custom Application Controllers and/or Application Specific Controllers shall utilize open protocol communications.

1. Each System Controller shall perform communications to a network of Custom Application and Application Specific Controllers using open protocol communication.
2. The Owner will provide all communication media, connectors, repeaters, network switches, and routers necessary for the high speed Ethernet network. An active Ethernet port will be provided adjacent to each System Controller and operator interface (PC) for connection to this high speed Ethernet network.
3. All values within the system (i.e. schedules, datalogs, points, software variables, custom program variables) shall be readable and controllable (where appropriate) by any System Controller
4. Provide all required convertor control panels between equipment manufacturer supplied controllers and BMS to allow for required communication. Example includes Modbus to BACnet convertors.

B. Variable Refrigerant Flow (VRF) Communications

1. The VRF system shall communicate with the BMS using one of the following communications methods.
 - a. The VRF system and the BMS shall utilize ANSI®/ASHRAE® Standard 135 (BACnet) protocol revision 12 or greater.
 - b. When a device is capable of data exchange with the BACnet protocol across non-IP network segments, the BACnet protocol shall be used to exchange data. If a device does not support the BACnet protocol an alternative protocol may be used. Data exchanged using the alternative protocol shall be converted to the BACnet protocol to allow integration to the BMS.

2. To promote BMS interoperability, each instance of the following VRF system components shall be visible to the BMS network as a virtual BACnet device.
 - a. Indoor Equipment
 - b. Outdoor Equipment
 - c. Refrigerant Manifolds
3. Virtual BACnet device functionality shall conform to BACnet protocol revision 12 or greater and meet the minimum functionality defined by BACnet device profile B-ASC.
4. The VRF indoor equipment shall support wireless zone sensors. Sensing options shall include temperature, relative humidity, CO2, and occupancy. Each zone sensor wireless communication interface shall be capable of many-to-one sensors per controller to support averaging, monitoring, and multiple zone applications.

2.8 OPERATOR INTERFACE

- A. Provide Building Operator Web Interface. Manufacturer shall provide a user interface with time-of-day schedules, data collection, dashboards, reports and building summary, system applications, and self-expiring timed overrides. Manufacturer shall provide a published user and applications guide(s) that detail the system application operation, configuration, setup and troubleshooting
- B. The building operator web interface shall be accessible via a web browser without requiring any “plug-ins” (i.e. JAVA Runtime Environment (JRE), Adobe Flash).
- C. System Security
 1. Each operator shall be required to login to the system with a user name and password in order to view, edit, add, or delete data.
 2. User Profiles shall restrict the user to only the objects, applications, and system functions as assigned by the system administrator.
 3. Each operator shall be allowed to change their user password
 4. The System Administrator shall be able to manage the security for all other users
 5. The system shall include pre-defined “roles” that allow a system administrator to quickly assign permissions to a user.
 6. User logon/logoff attempts shall be recorded.
 7. The system shall protect itself from unauthorized use by automatically logging off following the last keystroke. The delay time shall be user definable.
 8. All system security data shall be stored in an encrypted format.
- D. Database
 1. Database Save. A system operator with the proper password clearance shall be able to archive the database on the designated operator interface PC.
 2. Database Restore. The system operator shall also be able to clear a panel database and manually initiate a download of a specified database to any panel in the system.
- E. On-Line Help and Training
 1. Provide a context sensitive, on line help system to assist the operator in operation and configuration of the system.

2. On-line help shall be available for all system functions and shall provide the relevant data for each particular screen.

F. System Diagnostics

1. The system shall automatically monitor the operation of all network connections, building management panels, and controllers.
2. The failure of any device shall be annunciated to the operators

G. Equipment & Application Pages

1. The operator interface shall include standard pages for all equipment and applications. These pages shall allow an operator to obtain information relevant to the operation of the equipment and/or application, including:
2. Animated Equipment Graphics for each major piece of equipment and floor plan in the System. This includes all scheduled equipment.
 - a. These graphics shall show all points dynamically as specified in the points list
 - b. Animation capabilities shall include the ability to show a sequence of images reflecting the position of analog outputs, such as valve or damper positions. Graphics shall be capable of launching other web pages.
3. Alarms relevant to the equipment or application without requiring a user to navigate to an alarm page and perform a filter.
4. Historical Data (As defined in Automatic Trend Log section below) for the equipment or application without requiring a user to navigate to a data log page and perform a filter

H. System Graphics. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each cooling system and heating system, and graphics that summarize conditions on each floor of each building included in this contract. Indicate thermal comfort on floor plan summary graphics using colors to represent zone temperature relative to zone set point

1. Functionality. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point and-click navigation between zones or equipment, and to edit set points and other specified parameters.
2. Graphic imagery – graphics shall use 3D images for all standard and custom graphics. The only allowable exceptions will be photo images, maps, schematic drawings, and selected floor plans.
3. Animation. Graphics shall be able to animate by displaying different Image lies for changed object status.
4. Alarm Indication. Indicate areas or equipment in an alarm condition using color or other visual indicator.
5. Format. Graphics shall be saved in an industry-standard format such as BMP, JPEG, PNG, or GIF. Web-based system graphics shall be viewable on browsers compatible with World Wide Web Consortium browser standards. Web graphic format shall require no plug-in (such as HTML and JavaScript) or shall only require widely available no-cost plug-ins (such as Active-X and Macromedia Flash)

I. Custom Graphics

1. The operator interface shall be capable of displaying custom graphics in order to convey the status of the facility to its operators.
 2. Graphical Navigation. The operator interface shall provide dynamic color graphics of building areas, systems and equipment.
 3. Graphical Data Visualization. The operator interface shall support dynamic points including analog and binary values, dynamic text, static text, and animation files.
 4. Custom background images. Custom background images shall be created with the use of commonly available graphics packages such as Adobe Photoshop. The graphics generation package shall create and modify graphics that are saved in industry standard formats such as GIF and JPEG
- J. Graphics Library. Furnish a library of standard HVAC equipment such as chillers, air handlers, terminals, fan coils, unit ventilators, rooftop units, and VAV boxes, in 3-dimensional graphic depictions. The library shall be furnished in a file format compatible with the graphics generation package program
- K. Manual Control and Override
1. Point Control. Provide a method for a user to view, override, and edit if applicable, the status of any object and property in the system. The point status shall be available by menu, on graphics or through custom programs.
 2. Temporary Overrides. The user shall be able to perform a temporary override wherever an override is allowed, automatically removing the override after a specified period of time.
 3. Override Owners. The system shall convey to the user the owner of each override for all priorities that an override exists.
 4. Provide a specific icon to show timed override or operator override, when a point, unit controller or application has been overridden manually
- L. Engineering Units
1. Allow for selection of the desired engineering units (i.e. Inch pound or SI) in the system.
 2. Unit selection shall be able to be customized by locality to select the desired units for each measurement.
 3. Engineering units on this project shall be IP
- M. Scheduling. A user shall be able to perform the following tasks utilizing the operator interface:
1. Create a new schedule, defining the default values, events and membership.
 2. Create exceptions to a schedule for any given day.
 3. Apply an exception that spans a single day or multiple days.
 4. View a schedule by day, week and month.
 5. Exception schedules and holidays shall be shown clearly on the calendar.
 6. Modify the schedule events, members and exceptions
- N. Trend logs
1. Trend Logs Definition
 - a. The operator interface shall allow a user with the appropriate security permissions to define a trend log for any data in the system.

- b. The operator interface shall allow a user to define any trend log options as described in the Application and Control Software section
- 2. Trend Log Viewer
 - a. The operator interface shall allow Trend Log data to be viewed and printed.
 - b. The operator interface shall allow a user to view trend log data in text-based (time –stamp/value).
 - c. The operator shall be able to view the data collected by a trend log in a graphical chart in the operator interface.
 - d. Trend log viewing capabilities shall include the ability to show a minimum of 5 points on a chart.
 - e. Each data point trend line shall be displayed as a unique color.
 - f. The operator shall be able to specify the duration of historical data to view by scrolling and zooming.
 - g. The system shall provide a graphical trace display of the associated time stamp and value for any selected point along the x-axis
- 3. Export Trend Logs
 - a. The operator interface shall allow a user to export trend log data in CSV or PDF format for use by other industry standard word processing and spreadsheet packages

O. Alarm/Event Notification

- 1. An operator shall be notified of new alarms/events as they occur while navigating through any part of the system via an alarm icon.
- 2. Alarm/Event Log. The operator shall be able to view all logged system alarms/events from any operator interface.
 - a. The operator shall be able to sort and filter alarms from events. Alarms shall be sorted in a minimum of 4 categories based on severity.
 - b. Alarm/event messages shall use full language, easily recognized descriptors.
 - c. An operator with the proper security level may acknowledge and clear alarms/events.
 - d. All alarms/events that have not been cleared by the operator shall be stored by the building controller.
 - e. The alarm/event log shall include a comment field for each alarm/event that allows a user to add specific comments associated with any alarm.
- 3. Alarm Processing.
 - a. The operator shall be able to configure any object in the system to generate an alarm when transitioning in and out of a normal state.
 - b. The operator shall be able to configure the alarm limits, warning limits, states, and reactions for each object in the system

P. Reports and Logs

1. The operator interface shall provide a reporting package that allows the operator to select reports.
2. The operator interface shall provide the ability to schedule reports to run at specified intervals of time.
3. The operator interface shall allow a user to export reports and logs from the building controller in a format that is readily accessible by other standard software applications including spreadsheets and word processing. Acceptable formats include:
 - a. CSV, HTML, XML, PDF
4. Reports and logs shall be readily printed to the system printer.
5. Provide a means to list and access the last 10 reports viewed by the user.
6. The following standard reports shall be available without requiring a user to manually configure the report:
 - a. All Points in Alarm Report: Provide an on-demand report showing all current alarms.
 - b. All Points in Override Report: Provide an on-demand report showing all overrides in effect.
 - c. Commissioning Report: Provide a one-time report that lists all equipment with the unit configuration and present operation.
 - d. Points report: Provide a report that lists the current value of all points.

Q. Provide Mobile App Interface

1. Provide mobile (smart phone or tablet) interfaces to the building automation system, compatible with iOS and Android™ operating systems.
2. Controls manufacturer shall provide a phone/tablet interface with the ability to view/override status and setpoints, view/change schedules, view/acknowledge/comment on alarms, and view graphics for all spaces and equipment.
3. This phone/tablet interface shall resize itself appropriately for the size of the interface (i.e. no "pinching and zooming" required).
4. This phone/tablet interface shall function remotely from the facility while following IT security best practices (e.g. no ports exposed to the internet).
5. The operator interface shall support system access on a mobile device via a mobile app to:
 - a. Alarm log
 - b. System Status
 - c. Equipment status
 - d. Space Status
 - e. Standard Equipment graphics
 - f. Override set points
 - g. Override occupancy
 - h. Acknowledge Alarms
 - i. Add Comment(s) to Alarms

2.9 APPLICATION AND CONTROL SOFTWARE

- A. Provide the following applications software for building and energy management. All software applications shall reside and run in the system controllers. Editing of applications shall occur at the operator interface

1. Scheduling. Provide the capability to schedule each object or group of objects in the system. Each of these schedules shall include the capability for start, stop, optimal start, optimal stop, and night economizer actions. Each schedule may consist of up to [10] events. When a group of objects are scheduled together, provide the capability to define advances and delays for each member. Each schedule shall consist of the following:
 - a. Weekly Schedule. Provide separate schedules for each day of the week.
 - b. Exception Schedules. Provide the ability for the operator to designate any day of the year as an exception schedule. This exception schedule shall override the standard schedule for that day. Exception schedules may be defined up to a year in advance. Once an exception schedule is executed it will be discarded and replaced by the standard schedule for that day of the week.
 - c. Holiday Schedules. Provide the capability for the operator to define up to 99 special or holiday schedules. These schedules may be placed on the scheduling calendar and will be repeated each year. The operator shall be able to define the length of each holiday period.
 - d. Optimal Start. The scheduling application outlined above shall support an optimal start algorithm. This shall calculate the thermal characteristics of a zone and start the equipment prior to occupancy to achieve the desired space temperature at the specified occupancy time. The algorithm shall calculate separate sets of heating and cooling rates for zones that have been unoccupied for less than and greater than 24 hours. Provide the ability to modify the start algorithm based on outdoor air temperature. Provide an early start limit in minutes to prevent the system from starting before an operator determined time limit
2. Trend Log Application
 - a. Trend log data shall be sampled and stored on the System Controller panel and shall capable of being archived to a Workstation for longer term storage
 - 1) Trend logs shall include interval, start-time, and stop-time.
 - 2) Trend log intervals shall be configurable as frequently as 1 minute and as infrequently as 1 year
 - b. Automated Trend Logs
 - 1) The system controller shall automatically create trend logs for defined key measurements for each controlled HVAC device and HVAC application.
 - 2) The automatic trend logs shall monitor these parameters for a minimum of 7 days at 15 minute intervals. The automatic trend logs shall be user adjustable.
 - 3) Coordinate with owner for final automatic trending parameters.
 - c. Alarm/Event logs
 - 1) Any object in the system shall be configurable to generate an alarm when transitioning in and out of a normal or fault state
 - 2) Any object in the system shall allow the alarm limits, warning limits, states, and reactions to be configured for each object in the system

- 3) An alarm/event shall be capable of triggering any of the following actions
 - a) Route the alarm/event to one or more alarm log- The alarm message shall include the name of the alarm location, the device that generated the alarm, and the alarm message itself
 - b) Route an e-mail message to an operator(s)
 - c) Log a data point(s) for a period of time
 - d) Run a custom control program
- 4) Point Control. User shall have the option to set the update interval, minimum on/off time, event notification, custom programming on change of events
- 5) Timed Override. A standard application shall be utilized to enable/disable temperature control when a user selects on/cancel at the zone sensor, operator interface, or the local operator display. The amount of time that the override takes precedence will be selectable from the operator interface
- 6) Anti-Short Cycling. All binary output points shall be protected from short cycling

2.10 SYSTEM CONTROLLERS

- A. There shall be one or more independent, standalone microprocessor-based System Controllers to manage the global strategies described in Application and Control Software section.
 1. The System Controller shall have sufficient memory to support its operating system, database, and programming requirements.
 2. The controller shall provide a USB communications port for connection to a PC
 3. The operating system of the Controller shall manage the input and output communications signals to allow distributed controllers to share real and virtual point information and allow central monitoring and alarms.
 4. All System Controllers shall have a real time clock.
 5. Data shall be shared between networked System Controllers.
 6. The System Controller shall continually check the status of its processor and memory circuits. If an abnormal operation is detected, the controller shall:
 - a. Assume a predetermined failure mode.
 - b. Generate an alarm notification.
 - c. Create a retrievable file of the state of all applicable memory locations at the time of the failure.
 - d. Automatically reset the System Controller to return to a normal operating mode
 7. Environment. Controller hardware shall be suitable for the anticipated ambient conditions. Controller used in conditioned ambient shall be mounted in an enclosure, and shall be rated for operation at -40 F to 122 F
 8. Clock Synchronization
 - a. All System Controllers shall be able to synchronize with a NTP server for automatic time synchronization.
 - b. All System Controllers shall be able to accept a time synchronization command for automatic time synchronization.

- c. All System Controllers shall automatically adjust for daylight savings time if applicable
- 9. Serviceability
 - a. Provide diagnostic LEDs for power, communications, and processor.
 - b. The System Controller shall have a display on the main board that indicates the current operating mode of the controller.
 - c. All wiring connections shall be made to field removable, modular terminal connectors.
 - d. The System controller shall utilize standard DIN mounting methods for installation and replacement
- 10. Memory. The System Controller shall maintain all BIOS and programming information indefinitely without power to the System controller
- 11. Immunity to power and noise. Controller shall be able to operate at 90% to 110% of nominal voltage rating and shall perform an orderly shut-down below 80% nominal voltage
- 12. Test Labs (BTL) Listing. Each System Controller shall be listed as a Building Controller (B-BC) by the Test Labs

2.11 PROGRAMMABLE CONTROLLERS

A. For Stand-Alone Operation the Central Plant and Air Handling Controllers Shall:

- 1. Operate a schedule in a standalone application using a Real Time Clock with a 7 day power backup
 - a. The Controller shall have a built in schedule (assessable with or without a display)\
 - b. Support will be for at least 3 schedules with up to 10 events for each day of the week.
 - c. Each of the 3 schedules can be Analog, Binary or Multi-State
 - d. The controller shall support a minimum of 25 exceptions each with up to 10 events
- 2. For ease of troubleshooting, the Controller shall support data trend logging
 - a. 25,000 samples minimum
 - b. Trends shall be capable of being collected at a minimum sample rate of once every second
 - c. Trends shall be capable of being scheduled or triggered
- 3. To meet the sequence of operation for each application, the Controller shall use library programs provided by the controller manufacturer that are either factory loaded or downloaded with service tool to the Controller
- 4. Environment. Controller hardware shall be suitable for the anticipated ambient conditions
 - a. Storage conditions:

- 1) Temperature: -67°F to 203°F
 - 2) Humidity: Between 5% to 100% RH (non-condensing)
 - b. Operating conditions
 - 1) Temperature: -40°F to 158°F
 - 2) Humidity: Between 5% to 100% RH (non-condensing)
 - c. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum
 - d. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 158 F
5. Input/Output: The Controller shall have on board or through expansion module all I/O capable of performing all functionality needed for the application. Controls provided by the equipment manufacture must supply the required I/O for the equipment. In addition other controls must meet the following requirements:
- a. Shall support flexibility in valve type, the controllers shall be capable of supporting the following valve control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC - 2 position.
 - b. Shall support flexibility in sensor type, the Controller shall be of reading sensor input ranges of 0 to10V, 0 to 20mA, 50ms or longer pulses, 200 to 20Kohm and RTD input.
 - c. Shall support flexibility in sensor type, all Analog Outputs shall have the additional capability of being programmed to operate as Universal Inputs or Pulse Width Modulation Outputs.
 - d. Shall support flexibility in sensor type, the Controller and/or expansion modules shall support dry and wetted (24VAC) binary inputs.
 - e. The controller support pulse accumulator for connecting devices like energy meters.
 - f. In order to support a wide range of devices, the Controller's binary output shall be able to drive at least 10VA each.
 - g. Any I/O that is unused by functionality needed for the equipment shall be available to be used by custom program on the Controller and by any other controller on the network.
 - h. The Controller shall provide 24VAC and 24VDC power terminals sensors and other devices required.
 - i. The Controller shall provide a dedicated static pressure input
6. Input/Output Expandability – The Controller shall provide the following functionality in order to meet current and future application needs
- a. For the application flexibility, the Controller shall be capable of expanding to a total of at least 100 hardware I/O terminations.
 - b. Expansion I/O can be mounted up to 200m from control
 - c. Expansion I/O can be added in as small as 4 point increments.
 - d. To keep MS/TP network traffic to a minimum, expansion I/O must communicate via an internal controller communication bus (point expansion via the MS/TP network is not allowed)

7. Serviceability – The Controller shall provide the following in order to improve serviceability of the Controller.
 - a. Diagnostic LEDs for power/normal operation/status, open protocol communications, sensor bus communications, and binary outputs. All wiring connections shall be clearly labeled and made to be field removable.
 - b. Binary and analog inputs and outputs shall use removable connectors or be connected to terminal strip external to the control box
 - c. Software service tool connection through all of the following methods: direct cable connection to the Controller, connection through another controller on protocol link and through the Controller's zone sensor.
 - d. For configuration, programming, and testing of controller programs must, for safety purposes, be able to be accomplished with the power off to the equipment and the controller.
 - e. The Controller software tool service port shall utilize standard of-the-shelf USB printer cable.
 - f. Capabilities to temporarily override the point values with built-in time expiration in the Controller.
 - g. To aid in service replacement, the Controller shall easily attach to standard DIN rail mounting.
 - h. For future expansion, the Controller shall be capable of adding sequence of operation programming utilizing service tools software with a graphical programming interface (editing or programming in line code is not permissible).
 - i. To aid in service replacement, the Controller shall allow for setting its address must be rotary switches that correspond to a numerical value for the address to allow the setting of the address without the need of a service tool or the control being powered (DIP switch methodologies are not allowed).
 - j. Controller data shall persist through a power failure
8. Software Retention: All Controller operating parameters, set points, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.
9. Transformer for the Controller must be rated at minimum of 115% of ASC power consumption and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads for a maximum of 12 VA for each binary output
10. Controller must meet the following Agency Compliance:
 - a. UL916 PAZX, Open Energy Management Equipment
 - b. UL94-5V, Flammability
 - c. FCC Part 15, Subpart B, Class B Limit
 - d. cUL Marked for international compliance
 - e. CE Marked for international compliance

2.12 APPLICATION SPECIFIC CONTROLLERS

- A. Application Specific Controllers (ASC) shall be microprocessor-based DDC controllers which through hardware or firmware design control specified equipment. They are not user programmable, but are customized for operation within the confines of the equipment they are designed to serve

- B. Zone Controllers are controllers that operate equipment that control the space temperature of single zone
- C. Software
 - 1. To meet the sequence of operation for each zone control, the controller shall use programs developed and tested by the controller manufacturer that are either factory loaded or downloaded with service tool to the controller.
 - 2. Stand-Alone Operation: Each piece of equipment identified on in the drawing schedules to have stand-alone controllers shall be controlled by a single controller and provide stand-alone control in the event of communication failure. In case of communications failure stand-alone operation shall use default values or last values for remote sensors read over the network such as outdoor air temperature.
 - 3. For controlling ancillary devices and for flexibility to change to sequence of operation in the future, the controller shall be capable running custom programs written in a graphical programming language
- D. Environment Controller hardware shall be suitable for the anticipated ambient conditions
 - 1. Storage: -55 to 203 °F and 5 to 95% Rh, non-condensing.
 - 2. Operating: -40 to 158 °F and 5 to 95% Rh, non-condensing.
 - 3. Controllers used indoors shall be mounted in a NEMA 1 enclosure at a minimum
 - 4. Controllers used outdoors and/or in wet ambient shall be mounted within NEMA 4 type waterproof enclosures, and shall be rated for operation at -40 F to 158 F
- E. Input/Output
 - 1. For flexibility in selection and replacement of valves, the controllers shall be capable of supporting all of the following valve control types 0-10VDC, 0-5VDC, 4-20mA, 24VAC floating point, 24VAC - 2 position (Normally Open or Normally Closed).
 - 2. For flexibility in selection and replacement of sensors, the controllers shall be capable of reading sensor input ranges of 0 to 10V, 0 to 20mA, pulse counts, and 200 to 20Kohm.
 - 3. For flexibility in selection and replacement of binary sensors, the controller shall support dry and wetted (24VAC) binary inputs.
 - 4. For flexibility in selection and replacement devices, the controller's shall have binary output which are able to drive at least 12VA each.
 - 5. For flexibility in selection and replacement of motors, the controller shall be capable of outputting 24VAC (binary output), DC voltage (0 to 10VDC minimum range) and PWM (in the 80 to 100 Hz range).
 - 6. For future needs, any I/O that is unused by functionality of equipment control shall be available to be used by custom program on the controller and by another controller on the network.
- F. Serviceability – The controller shall provide the following in order to improve serviceability of the controller
 - 1. Diagnostic LEDs shall indicate correct operation or failures/faults for all of the following: power, sensors, protocol communications, and I/O communications bus.
 - 2. All binary output shall have LED's indicating the output state.
 - 3. All wiring connections shall removable without the use of a tool.

4. Software service tool connection through all of the following methods: direct cable connection to the controller, connection through another controller on protocol link and through the controller's zone sensor.
 5. For safety purposes, the controller shall be capable of being powered by a portable computer for the purposes of configuration, programming, and testing programs so that this work can be accomplished with the power off to the equipment.
 6. Capabilities to temporarily override of point values with built-in time expiration in the controller.
 7. Mack Address shall be set using decimal (0-9) based rotary switches.
 8. Configuration change shall not be made in a programming environment, but rather by a configuration page utilizing dropdown list, check boxes, and numeric boxes.
 9. Trending objects resident on controller
 - a. Minimum of 20,000 trending points total on controller
 - b. Shall be capable of trending all points used by controller
 - c. Shall be capable of 1 second sample rates on all points
- G. Software Retention: All Zone Controller operating parameters, set points, BIOS, and sequence of operation code must be stored in non-volatile memory in order to maintain such information for months without power.
- H. Transformer for the controller must be rated at minimum of 115% of ASC power consumption, and shall be fused or current limiting type. 24 VAC, +/- 15% nominal, 50-60 Hz, 24 VA plus binary output loads, for a maximum of 12 VA for each binary output.
- I. Agency Approval: The controller shall have meet the Agency Compliance:
1. UL916 PAZX, Open Energy Management Equipment
 2. UL94-5V, Flammability
 3. FCC Part 15, Subpart B, Class B Limit

2.13 POWER SUPPLIES

- A. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish overcurrent protection in both primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
1. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in overvoltage and overcurrent protection and shall be able to withstand a 150% current overload for at least three seconds without trip-out or failure.
 - a. Unit shall operate between 0°C and 50°C (32°F and 120°F). EM/RF shall meet FCC Class B and VDE 0871 for Class B and MIL-STD 810C for shock and vibration.
 - b. Line voltage units shall be UL recognized and CSA approved.

2.14 CONTROL DEVICE

A. Control Valve:

1. Control Valves: Factory fabricated, of type, body material, and pressure class based on maximum pressure and temperature rating of piping system, unless otherwise indicated.
2. Sized by temperature control manufacturer and guaranteed to meet the heating and cooling requirements. Water valves shall be sized on the basis of 15% of the total system pressure drop, but not more than 10 ft. of head drop. Pressure drop for valves shall be submitted for review, including all CV values.
3. Valves shall be equal percentage type, equipped with characteristic type throttling plug, #316 stainless steel or Monel stem, removable composition discs, and EDPM seats. Provide with necessary features to operate in sequence with other valves or damper operators and adjustable throttling range as required by the sequence of operations.
4. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:
 - a. Two-way: 150% of total system (pump) head.
 - b. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head whichever is greater.
5. Globe Valves, bronze body, bronze trim, rising stem, renewable composition disc, and screwed ends with backseating capacity repackable under pressure. Valves shall have allowable media temperature of 20°F to 281°F to assure that the valve packing will have a long life (valves will narrower allowable media temperatures have no reserve packing capability for long term watertight seal).
6. Hydronic system globe valves shall have the following characteristics:
 - a. Rating: Class 125 for service at 125 psig. and 250°F operating conditions.
 - b. Internal Construction: Replaceable plugs and seats of stainless steel or brass.
 - 1) Single-Seated Valves: Cage trim provides seating and guiding surfaces for plug on top and bottom of guided plugs.
 - 2) Double-Seated Valves: Balanced plug; cage trim provides seating and guiding surfaces for plugs on top and bottom of guided plugs.
 - c. Flow Characteristics: Two-way valves shall have equal percentage characteristics; three-way valves shall have linear characteristics.
 - d. Water valves shall be sized on the basis of no more than 5 ft. of head drop.

B. Control Dampers:

1. Dampers are available in two mounting types: i.e., "Installed in Duct" or "Flanged to Duct". Dampers over 48 in. in length and height shall be made into multiple sections.
2. Dampers are available with either opposed blade action or parallel blade action. Opposed blade dampers are standard.
3. Dampers are designed for operation in temperatures ranging between -40°F and 212°F.
4. Leakage class 1A at 1" w.g. Static pressure differential. Standard air leakage data is certified under the AMCA Certified Ratings Program.

5. Blades are extruded aluminum profiles. Aluminum end caps are press fitted to blade ends. Blade and frame seals are extruded silicone and are secured in an integral slot within the aluminum extrusions.
 - a. Provide thermally broken frame design where use of standard frame could cause condensation at building envelope.
 - b. Dampers at exterior walls and roof openings shall be insulated blade, thermal break design.
6. Bearings are composed of a Celcon inner bearing fixed to a 7/16" aluminum hexagon blade pin, rotating within a polycarbonate outer bearing inserted in the frame, resulting in no metal-to-metal or metal-to-plastic contact.
7. Linkage hardware is installed in the frame side and constructed of aluminum and corrosion-resistant, zinc-plated steel, complete with cup-point trunnion screws for a slip-proof grip.
8. Two position dampers: Pressure drop of a fully open 48" x 48" damper shall not exceed .02" w.g. At 1000 fpm.
9. Modulating Control Dampers: Shall be sized by the temperature control manufacturer. Maximum velocity shall be 1500 fpm and maximum pressure drop shall be 0.15 in w.g. Dampers shall be of adequate authority and sized and positioned to allow for smooth modulation of controlled air streams.
10. Design make: Tamco 1500 series (standard), Tamco 9000 series (insulated – where specified).
11. Installation:
 - a. Installation of dampers shall be in accordance with current manufacturer's installation instructions.

C. Actuator:

1. The actuator shall have electronic overload or digital rotation sensing circuitry to prevent damage to the actuator throughout the rotation of the actuator.
2. Where shown, for power-failure/safety applications, an internal mechanical, spring return mechanism shall be built into the actuator housing. Floating point actuation allowed only where specifically noted elsewhere in the contract documents.
3. All rotary spring return actuators shall be capable of either clockwise or counter clockwise spring return operation. Linear actuators shall spring return to the retracted position
4. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb. torque capacity shall have a manual crank for this purpose.
5. Actuators shall be provided with a conduit fitting and a minimum 18" electrical cable and shall be pre-wired to eliminate the necessity of opening the actuator housing to make electrical connections.
6. Actuators shall be Underwriters Laboratories Standard 873 listed.
7. Actuators shall be designed for a minimum of 60,000 full stroke cycles at the actuator's rated torque
8. Valve:

- a. Provide modulating 24 VAC control operators that are 0-10 VDC input proportional with spring return as needed by control sequence and designed for water service valve bodies. Operator shall be synchronous motor driven and force sensor safety stop.
- b. Provide two position 24 VAC control operators as needed by control sequence for unitary control such as heat pump control and designed for water service valve bodies. Operator shall be synchronous motor driven and force sensor safety stop.
- c. Run time: 60 seconds or less.
- d. Valve Close-off: Water = 120% of total system (pump) head. Steam = 200% of system operating (inlet) pressure. Valves to be used on this project shall be suitable for complete close-off to the levels stated under modulating duty. If the manufacturer's data provides a separate maximum differential pressure under modulating duty, both criteria shall exceed the above requirements.
- e. Valves shall fail last unless otherwise indicated on the drawings.

9. Damper:

- a. Electronic Damper Actuators: Direct-coupled type non-hydraulic designed for minimum 100,000 full-stroke cycles at rated torque. The actuator shall have rating of not less than twice the thrust needed for actual operation of the damper.
 - 1) Coupling: V-bolt and V-shaped, toothed cradle.
 - 2) Overload Protection: Electronic overload or digital rotation-sensing circuitry.
 - 3) Fail-Safe Operation: Mechanical, spring-return mechanism. Provide external, manual gear release on non-spring-return actuators.
 - 4) Actuators shall have the ability to be tandem mounted.
 - 5) All spring-return actuators shall have a manual override. Complete manual override shall take no more than 10 turns.
 - 6) Power Requirements (Two-Position Spring Return): 24V ac or dc, Maximum 10VA.
 - 7) Power Requirements (Modulating): Maximum 15 VA at 24V ac.
 - 8) Proportional Signal: 2- to 10-V dc or 4 to 20 mA, and 2- to 10-V dc position feedback signal.
 - 9) Housing: Minimum requirement NEMA type 2.
 - 10) Temperature Rating: -22°F to 140°F.
 - 11) Run Time: 200 seconds open, 40 seconds closed
 - 12) Size for running torque calculated as follows, verify with damper manufacturer that damper actuators provide required torque to comply with leakage rate specifications for damper:
 - a) Parallel-Blade Damper with Edge Seals: 7 inch-pounds/sq. ft. of damper.
 - b) Opposed-Blade Damper with Edge Seals: 5 inch-pounds/sq. ft. of damper.
 - c) Parallel-Blade Damper without Edge Seals: 4 inch-pounds/sq. ft. damper.
 - d) Opposed-Blade Damper without Edge Seals: 3 inch-pounds/sq. ft. of damper.

- e) Dampers with 2 to 3 Inches wg. of Pressure Drop or Face Velocities of 1000 to 2500 FPM Multiply the minimum full-stroke cycles above by 1.5.

13) Spring Return Manual Override actuators shall a factory set 5 Degree Damper Preload.

D. Electronic Valve/Damper Position Indication: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

E. Safety/Status Devices:

1. Low Limit Detector: Electric type, with 20' long serpentine element, with manual reset and auxiliary contacts to the DDC, set for 37°F for "freeze" protection and 55°F for fan discharge application. Provide a 20' long element for every 25 sq. ft. of coil face area.
2. High Limit Detector: Electric type, with manual reset and auxiliary contacts to the DDC, UL listed for fire, set for 180°F.
3. Pump status shall be provided through adjustable range current sensing element on pump motor.
4. Fan status shall be provided through adjustable range current sensing element on the fan motor

F. Miscellaneous Devices

1. Provide necessary, relays, transformers, accumulators, three-way air valves, positioners, pneumatic electric switches, air switches, required for a complete and operable system.
2. Locate these devices in a separate panel unless specified otherwise.

2.15 AUXILIARY EQUIPMENT/DEVICES

A. Electronic Temperature Sensors: Vibration and corrosion resistant; for wall, immersion, or duct mounting as required.

1. Resistance Temperature Detectors: Platinum, thermistors, or Balco.
2. Accuracy: +/-1% at calibration point over a range of -30°F - 230°F; +/-0.5% accurate over a range of 40°F - 100°F. Thermistors shall have a maximum 5-year drift of no more than .225°F maximum error of no more than .36°F.
3. Wire: Twisted, shielded-pair cable.
4. Duct Probe Sensor: 8" long, single point, sensing element shall be fully encapsulated in potting material within a stainless-steel probe. Useable in air handling applications where the coil or duct area is less than 4 square feet, or where not affected by temperature stratification. Basis of Design: Veris TD Series.
5. Duct Averaging Sensor: Averaging sensors shall be employed in ducts which are larger 60 inches long (96 inches when duct is greater than 24 inches wide), flexible for use where prone to temperature stratification or where ducts are larger than 4 sq. ft.; 264 inches long, flexible for use where prone to temperature stratification or where ducts are larger than 16 sq. ft; length as required. The averaging sensor tube shall contain at least one thermistor for every 3 feet, with a minimum tube length of 6 feet. The averaging sensor shall be constructed of rigid or flexible copper tubing. Basis of Design: Veris TA Series.

6. Pipe Immersion Sensor: Immersion sensors shall be employed for measurement of temperature in all chilled and hot water applications as well as refrigerant applications. Provide sensor probe length suitable for application. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel for non-corrosive fluids below 250 degrees F and 300 series stainless steel for all other applications. Basis of Design: Veris TI Series.
7. Outside: Provide sensing element on the building's north side. Sensing element shall be fully encapsulated in potting material within a stainless steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure. Operating range -40 to 122 F, Basis of Design: Veris TO Series.
8. Space Temperature Sensors: Space temperature sensors shall be 5000 or 10,000 ohm thermistor type with wall plate adapter and blank cover assembly. Space temperature sensors shall include temperature adjustment and occupancy overrides. Space temperature sensors shall be mounted 60 in. above the finished floor surface.
 - a. Space sensors in public spaces such as corridors, lobbies, etc... shall be provided without local temperature indication, set point adjustment, or setback override.
 - b. Space sensors in private / staff only spaces shall be equipped with set-point adjustment, override switch, display, and/or communication port as shown on the drawings
 - c. The space temperature, set point, and override confirmation will be annunciated by a digital display for each zone sensor. The set point will be selectable utilizing buttons.
 - d. Where space sensors are connected to dedicated terminal unit controllers, they shall be equipped with local communication interface for troubleshooting and balancing purposes. Provide all required wiring from the terminal controllers to the space sensor to allow for interface to a local laptop interface device.
 - e. Room Security Sensors: Stainless steel cover plate with insulated back and security screws.

B. Thermostats:

1. Low-Voltage Space Thermostats. Low-voltage space thermostats shall be 24 V, bimetal-operated, mercury-switch type, with adjustable or fixed anticipation heater, concealed set point adjustment, 55°F-85°F set point range, 2°F maximum differential, and vented ABS plastic cover.
2. Line-Voltage Space Thermostats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed set point adjustment, 55°F-85°F set point range, 2°F maximum differential, and vented ABS plastic cover.

C. Differential Pressure Switch: Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

D. Differential Fluid Pressure Sensor:

1. Pressure range to suit application. Accuracy of 0.25%. Maximum working pressure of 250 psig. Maximum differential and static pressure shall be 250% of rated range. Type

304 stainless steel construction. 100% solid state dual diffused piezoresistive silicon sensing elements compatible with all medusa encountered in HVAC applications. Factory calibrated and tested. Easily accessible adjustments for zero and span. 1/8 in. NPT pressure port connections. Input limiting capability by precisely clipping to transducers output. Adjustable output averaging from 1 to 10 seconds. Provide an external regulated power supply. Transducer shall be complete with 4 to 20 mA output, required mounting brackets, and five-valve manifold.

2. Make: Setra #C230.

E. Humidity Sensors: Accurate at +/- 2 % at full scale. Replaceable sensing element. Thin-film capacitive. Output shall be field selectable 4-20 mA or 0-10 VDC. 12-30 VDC or 24 VAC supply power. Sensor element shall contain multipoint calibration on-board in non-volatile memory. Option of an integrated temperature sensor.

1. Wall:

- a. Operating range shall be 0 - 100% RH noncondensing, 50 to 95 F
- b. Transmitter shall have option of having an LCD display
- c. Basis of Design: Veris HWL Series

2. Duct:

- a. Transmitter shall be fully encapsulated in potting material within a stainless-steel probe.
- b. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
- c. Basis of Design: Veris HD Series

3. Outdoor:

- a. Transmitter shall be fully encapsulated in potting material within a stainless-steel probe. Probe shall be encased in PVC solar radiation shield and mounted in a weatherproof enclosure.
- b. Operating range shall be 0 - 100% RH noncondensing, -40 to 122 F
- c. Basis of Design: Veris HO Series

F. Static-Pressure Transmitter: Nondirectional sensor with suitable range for expected input, and temperature compensated.

1. Accuracy: +/- 1 % of full scale with repeatability of 0.5 %.
2. Output: 4 to 20 mA, 0-5 vDC, 0-10 vDC.
3. Duct Static-Pressure Range: 0 to 1, 0 to 2.5, 0 to 5, 0 to 10 IN WC., jumper adjustable

G. Pressure Transmitters:

1. Pressure transmitters shall be of 2-wire, 4-20 mA output type with a capacitance element having an accuracy of +/- 1% over the entire range. Transmitter shall include protection against reverse polarity and supply voltage transients. Accuracy and zero span adjustment shall be provided with each transmitter to allow for recalibration as necessary.
2. Liquid Pressure:
 - a. The operating range shall be -4.0 to 185.0 F.

- b. Proof pressure shall be 2x max full-scale range. Burst pressure shall be 5x max full-scale range.
- c. Transmitter shall have 4 field selectable ranges.
- d. Transmitter shall be +/-1% accurate over full scale, 2% accurate over full scale in lowest selectable range.
- e. Transmitter shall be stainless steel where it contacts fluid.
- f. Transmitter shall use two independent pressure sensors to measure and calculate differential pressure.
- g. Output shall be field selectable for 4-20 mA or 0-10 VDC.
- h. Transmitter shall have local LCD display.
- i. Transmitter shall accept 12-30 VDC or 24 VAC power supply.
- j. Transmitter shall have ability for field zero of reading and output.
- k. Shall be contained in an aluminum NEMA-4 enclosure.
- l. Sensor warranty shall be 3 years.
- m. Design Make: Veris PW

3. Air Pressure:

- a. The operating range shall be -40.0 to 176.0 F.
- b. Safe overpressure shall be a minimum of 200% of the rated pressure.
- c. Transmitter range to be field selectable between 0.1" and 10" WC.
- d. Transmitter shall be +/-1% accurate in each selectable range.
- e. Transmitter shall be field configurable for wall or duct (w/ static probe) mounting.
- f. Transmitter shall be field selectable for unidirectional or bidirectional.
- g. Output shall be field selectable for 4-20 mA or 0-10 VDC.
- h. Transmitter shall have local LCD display.
- i. Transmitter shall accept 12-30 VDC or 24 VAC power supply.
- j. Transmitter shall have ability for field zero of reading and output.
- k. Shall be contained in an aluminum NEMA-1 enclosure.
- l. Not to be provided when Space Pressure Monitor (SPM) / Room Pressure Monitor (RPM) is specified or called out on the drawings.
- m. Sensor warranty shall be 3 years.
- n. Design Make: Veris model PXU

H. Equipment operation sensors as follows:

- 1. Status Inputs for Fans: Differential-pressure switch with adjustable range of 0 to 5 IN WC.
- 2. Status Inputs for Pumps: Differential-pressure switch piped across pump with adjustable pressure-differential range of 8 to 60 psig.
- 3. Status Inputs for Electric Motors: Current-sensing relay with current transformers, adjustable and set to 175 % of rated motor current.

I. Carbon Dioxide Sensors:

- 1. Duct:
 - a. 0 to 10 VDC or 4-20mA signal output, non-dispersive infrared operation.
 - b. Accuracy shall be +/- 30 ppm or +/-2% of measured value, whichever is less.
 - c. Repeatability shall be +/-20 ppm or +/-1% of measured value whichever is less.
 - d. Response time less than 60 seconds.

- e. 12-30 VDC or 24 VAC power supply to transmitter.
- f. Output range shall be 0-2000 ppm.
- g. Recommended 5-year calibration interval.
- h. Design Make: Veris CDL.

2. Wall:

- a. 0 to 10 VDC or 4-20mA signal output, non-dispersive infrared operation.
- b. Accuracy shall be ± 30 ppm or $\pm 2\%$ of measured value, whichever is less.
- c. Repeatability shall be ± 20 ppm or $\pm 1\%$ of measured value whichever is less.
- d. Response time less than 60 seconds.
- e. 12-30 VDC or 24 VAC power supply to transmitter. LCD display, with faceplate.
- f. Integrated temperature sensor w/ set point slider, integrated humidity sensor.
- g. Output range shall be 0-2000 ppm.
- h. Recommended 5-year calibration interval.
- i. Design Make: Veris CWL.

J. Relays

- 1. Control relays shall be UL listed plug-in type with dust cover. Contact rating, configuration, and coil voltage suitable for application.
- 2. Time delay relays shall be UL listed solid-state plug-in type with adjustable time delay. Delay shall be adjustable plus or minus 200% (minimum) from set-point shown on plans. Contact rating, configuration, and coil voltage suitable for application. Provide NEMA 1 Type enclosure when not installed in local control panel

K. Override Timers: Unless implemented in control software, override timers shall be spring-wound line voltage, UL Listed, with contact rating and configuration required by application. Provide 0-6-hour calibrated dial unless otherwise specified. Flush mount timer on local control panel face or where shown.

L. Current Switches: Current-operated switches shall be self-powered, solid state with adjustable trip current. The switches shall be selected to match the current of the application and output requirements of the DDC system.

M. Current Transmitter: AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and 4-20 mA two-wire output. Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale at 500-ohm maximum burden. Transmitter shall meet or exceed ANSI/ISA S50.1 requirement and shall be UL/CSA recognized. Unit shall be split-core type for clamp-on installation on existing wiring.

N. Current Transducer / Equipment Relay:

- 1. Low Voltage, Single Phase:
 - a. Combined status sensor, command relay, and hand-off-auto switch.
 - b. Sized for monitor and control of small motors.
 - c. Field selectable relay output.
 - d. High and low voltage isolation.
 - e. Industrial grade load switching relay.

- f. Mountable on single or double gang boxes, flush on starter enclosures, or stand-alone.
 - g. Approved for installation in the following environmental conditions:
 - 1) 0-95% relative humidity, non-condensing.
 - 2) 0° to 140°F
 - h. Design equipment: Veris Hawkeye H500.
 - i. Alternative components combining the total functionality of the specified device may be submitted for approval.
- O. Current Transformer: AC current transformers shall be UL/CSA recognized and shall be completely encased (except for terminals) in approved plastic material. Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.
- P. Voltage Transmitter: AC voltage transmitters shall be self-powered single-loop (two-wire) type, 4-20 mA output with zero and span adjustment. Adjustable full-scale unit ranges shall be 100-130 Vac, 200-250 Vac, 250-330 Vac, and 400-600 Vac. Unit accuracy shall be $\pm 1\%$ full-scale at 500-ohm maximum burden. Transmitters shall meet or exceed ANSI/ISA S50.1 requirement and shall be UL/CSA recognized at 600 Vac rating.
- Q. Voltage Transformer: AC voltage transformers shall be UL/CSA recognized, 600 Vac rated, and shall have built-in fuse protection. Transformers shall be suitable for ambient temperatures of 4°C-55°C (40°F-130°F) and shall provide $\pm 0.5\%$ accuracy at 24 Vac and 5 VA load. Windings (except for terminals) shall be completely enclosed with metal or plastic.
- R. Local Control Panels
- 1. All indoor control cabinets shall be fully enclosed NEMA 1 Type construction with hinged door, and removable sub-panels or electrical sub-assemblies.
 - 2. Interconnections between internal and face-mounted devices shall be pre-wired with color-coded stranded conductors neatly installed in plastic troughs and/or tie-wrapped. Terminals for field connections shall be UL listed for 600-volt service, individually identified per control/interlock drawings, with adequate clearance for field wiring. Control terminations for field connection shall be individually identified per control drawings.
 - 3. Provide on/off power switch with over-current protection for control power sources to each local panel
- S. Airflow Measuring Station (AFS):
- 1. Manufacturers: Subject to compliance with requirements, provide a Thermal Dispersion Technology Airflow Measuring Station by one of the following:
 - a. Ebtron
 - b. Ruskin
 - 2. Qualifications:

- a. UL listed and compliant with FCC regulations.
 - b. Third party verification by FCC, UL, AMCA, NIST, and ISO 9001.
3. General:
- a. AFS Accuracy:
 - 1) Airflow (ducted): $\pm 3\%$ of reading when installed in accordance with AMCA figure 5.3.
 - 2) Airflow (non-ducted outdoor air intakes): $\pm 5\%$ of reading when installed in accordance with AMCA figures 5.1 or 5.4.
 - 3) Accuracy is dependent on placement and installed conditions.
 - b. Each AFS shall be provided with the correct number of probes and sensors for the application. Single AFS shall be capable of connecting up to 15 probes and 128 total sensors. Sensor density approximately one (1) sensor per 0.5 sqft or measurement area.
 - 1) Wiring between sensors shall be connected in daisy-chain fashion, with cabling as recommended by the manufacturer.
 - c. Warranty: 36 months parts.
4. Sensors:
- a. Description- Bi-directional airflow and pressure measurement, utilizing thermistors to determine the airflow rate, and temperature at each sensing location.
 - b. Sensor accuracy
 - 1) Airflow: $\pm 2\%$ of reading over the entire calibrated airflow range.
 - 2) Repeatability: $\pm 0.25\%$ repeatability
 - 3) Temp: ± 0.15 -degree F
 - c. Sensor range:
 - 1) Velocity: 0-5000 fpm
 - 2) Temperature: -20°F to 120°F
 - 3) Humidity: 0 to 99% RH, non-condensing
 - d. Sensors shall be factory cabled to the end of the probe.
 - e. Cable assembly (between probe and transmitter when transmitter is remote mounted):
 - 1) Type UL plenum rated PVC jacket, or twisted shielded pair.
 - 2) Length: 50 ft minimum
 - 3) Termination:
 - a) 0.875 in plug [transmitter end], gold plated pins.
 - b) Phoenix type screw terminal connectors.

4) Alternate:

- a) User interface to be factory mounted on the end of the probe, eliminating the need for cabling, or;
- b) User interface shall be remote mounted and connected through wired or wireless technology to the primary probe.

5. Probe:

- a. Construction: Aluminum alloy
- b. Mounting: Insertion or stand-off brackets for face mount on dampers and louvers. Mounting hardware shall be aluminum or stainless steel.
- c. Probe shall not be affected by direct or sustained exposure or moisture.
- d. Internal wiring connections shall be capable of direct exposure to water without affecting instrument operation.
- e. Probe design shall allow replacement of defective or damaged thermistors in the field when necessary.

6. User Interface:

- a. Description: airflow and temperature transmitter capable of direct communication with building management system via analog interface or BACNet MS/TP.
- b. User interface to include 16-character LCD display.
- c. Field configuration and diagnostic to be accomplished through a push button interface on the main circuit board for selection of units of measure, display units, output scaling, dampening filter, diagnostics and instrument status.
- d. Provide an output offset and gain adjustment feature to be engaged for installation where field calibration or adjustment is necessary.
- e. Calibrated airflow range:
 - 1) Velocity: 0-5000 fpm
 - 2) Airflow calibration: To NIST traceable standards
 - 3) Temperature range: -20°F to 120°F
 - 4) Humidity range: 0 to 99% (non-condensing)
 - 5) Power requirements: 24 VAC at 6 to 15 VA
- f. Transmitter enclosure:
 - 1) Transmitter construction: Hinged or sliding cover.
 - 2) Wall mounting kit to include 304 stainless steel face plate with stainless steel screen.
- g. Output interface:
 - 1) Two (2) Analog outputs: Isolated analog 0-5/0-10 VDC or 4-20 mA linear. Each output field configurable to output either average temperature or average airflow.
 - 2) Analog output resolution: 0-10 VDC: 0.10 % of full scale; 0-5VDC: 0.20% of full scale

- 3) 10 Base-T Ethernet output: Field selectable BACnet shall provide average air flow rate, average air temperature, high and low airflow alarm, high and low temperature alarms.
- 4) Programmable alarm: Alarm for user defined hi/low limit with user defined set point and dead band.
- 5) Repeatability: 0.25% of reading
- 6) K factor configuration: Automated 1, 2, or 3-point field adjustment to factory calibration.
- 7) Airflow low limit cutoff: forces output to zero below user-specified value.
- 8) Transmitter capable of identifying sensor malfunction and automatically ignore the sensor in fault mode.

7. Installation:

- a. Inspect the areas to receive flow instrument. Notify the Engineer if conditions that would adversely affect the installation of, or the subsequent utilization of the flow the instrument. Do not proceed with installation until unsatisfactory conditions are corrected.
- b. Refer to manufacturer's publish installation guidelines for positioning within duct system and required equivalent length of straight duct upstream and downstream of flow instrument.
- c. Verify network interface and modification to temperature control system to integrate flow instrument.
- d. Supplier to provide on-site product sizing and placement review, and support for sheet metal installer and field support for commissioning service by TAB.

2.16 SURGE SUPPRESSION (SP) RECEPTACLE

- A. Provide at each DDC panel and operator workstation locations, a surge suppression receptacle with metal oxide varister to dissipate the electrical energy of voltage spikes. 20 ampere, duplex, NEMA 5-20R configuration. Back and side wiring, high impact nylon body.
- B. Acceptable Make: Hubbell 5352-S

PART 3 - EXECUTION

3.1 GENERAL SYSTEM REQUIREMENTS

- A. The control of each system shall be guaranteed to perform as described in the Sequence of Operation Section. Equipment, remote switches, in finished rooms shall be flush-mounted, if possible.
- B. Verify that conditioned power supply is available to control units and operator workstation

3.2 INSTALLATION

- A. The Contract Documents shall be thoroughly examined for coordination of control devices their installation, wiring, and commissioning. Coordinate and review mechanical equipment specifications, locations, and identify any discrepancies, conflicts, or omissions that shall be reported to the Architect/Engineer for resolution before rough-in work is started
- B. The BMS manufacturer shall inspect the jobsite in order to verify that control equipment can be installed as required, and any discrepancies, conflicts, or omissions shall be reported to the Architect/Engineer for resolution before rough-in work is started
- C. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- D. Connect and configure equipment and software to achieve sequence of operation specified.
- E. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation.
- F. Install automatic dampers according to Section 233300 "Air Duct Accessories."
- G. Install damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.
- H. Identification: Identify all control wires with labeling tape or sleeves. Identification shall be easily cross referenced with the as-built drawings. All field enclosures, other than controllers, shall be identified with engraved nameplate, white lettering against a black background, easily cross referenced to the as-built drawings, and matching the nomenclature within the system architecture. Junction boxes marked as part of the BAS system. Field devices, except space sensors, not mounted within FIPs shall be identified with nameplates as described above. All I/O field devices mounted within FIPs shall be labeled. Where applicable, mark IP address on device.
- I. Install hydronic instrument wells, valves, and other accessories according to Section 232113 "Hydronic Piping."
- J. Install duct volume-control dampers according to Section 233113 "Metal Ducts" and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."

3.3 GENERAL WORKMANSHIP

- A. Install equipment, piping, wiring/conduit, parallel to building lines (i.e. horizontal, vertical, and parallel to walls) wherever possible
- B. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment
- C. Install all equipment in readily accessible location as defined by National Electric Code (NEC). Control panels shall be attached to structural walls or properly supported in a free-standing

configuration, unless mounted in equipment enclosure specifically designed for that purpose. Panels shall be mounted to allow for unobstructed access for service

- D. Verify integrity of all control wiring to ensure continuity and freedom from shorts and grounds prior to commencing the startup and commissioning procedures
- E. All control device installation, and wiring shall comply with Contract Documents, acceptable industry specifications, and industry standards for performance, reliability, and compatibility. Installation and wiring shall be executed in strict adherence to local codes and standard practices referenced in Contract Documents

3.4 ELECTRICAL WIRING AND CONNECTION INSTALLATION

- A. Where Class 2 wires are in concealed and accessible locations; including ceiling return air plenums, approved cables outside of electrical raceway can be used provided that the following conditions are met
 - 1. Circuits meet NEC Class 2 (current-limited) requirements. (Low-voltage power circuits shall be sub-fused when required to meet Class 2 current-limit.)
 - 2. All cables shall be UL listed for application (i.e., cables used in ceiling plenums shall be UL listed specifically for that purpose)
- B. Do not install Class 2 wiring in conduits containing Class 1 wiring
- C. Where Class 2 wiring is run exposed, wiring shall be run parallel along a surface or perpendicular to it, and bundled, using approved wire ties at no greater than 10 ft intervals. Such bundled cable shall be fastened to the structure, using industry approved fasteners, at 5 ft intervals or more often to achieve a neat and workmanlike result. Do not affix wires to pipes, conduits, ductwork, etc.
- D. All wire-to-device connections shall be made at a terminal blocks or terminal strip. All wire-to-wire connections shall be at a terminal block, or with a crimped connector. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.
- E. Where different wiring classes terminate within the same enclosure, maintain clearances and install barriers per the National Electric Code.
- F. Maximum allowable voltage for control wiring shall be 120VAC. If only higher voltages are available for use, the BMS system installer shall provide step-down transformers to achieve the desired control voltages.
- G. All control wiring shall be installed as continuous lengths, where possible. Any required splices, equipment terminations, and transitions from EMT to flexible conduit shall be made only within an approved junction box or other approved protective device. Interior dry location J-boxes shall be galvanized pressed steel, nominal four-inch square with blank cover. Exterior and damp location JH-boxes shall be cast alloy FS boxes with threaded hubs and gasketed covers

- H. Where space above the ceiling is a supply or return plenum, the wiring shall be plenum rated. Teflon wiring can be run without conduit above suspended ceilings. EXCEPTION: Any wire run in suspended ceilings that is used to control outside air dampers or to connect the system to the fire management system shall be in conduit. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations in accordance with Contract Documents and National and/or Local Codes.
- I. Conduit and wire sizing shall be determined by the BMS system installer in order to maintain manufacturer's recommendation and must meet National and Local Codes.
- J. Control and status relays are to be located in pre-fabricated enclosures that meet the application. These relays may also be located within packaged equipment control panel enclosures as coordinated. These relays shall not be located within Class 1 starter enclosures.
- K. Follow manufacturer's installation recommendations for all communication and network bus cabling. Network or communication cabling shall be run separately from all control power wiring
- L. BMS system installer shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.
- M. Flexible metal conduits and liquid-tight flexible metal conduits shall not exceed 3' in length and shall be supported at each end. Flexible metal conduit less than 1/2" electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal conduits shall be used.
- N. The 120VAC power wiring to each Ethernet or Remote Site controller shall be a dedicated run, with a separate breaker. Each run will include a separate hot, neutral and ground wire. The ground wire will terminate at the breaker panel ground. This circuit will not feed any other circuit or device.
- O. A true earth ground must be available in the building. Do not use a corroded or galvanized pipe, or structural steel.
- P. Install raceways, boxes, and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."
- Q. Install building wire and cable according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables," and cabinets according to Section 260533 "Raceways and Boxes for Electrical Systems."
- R. Install signal and communication cable:
 - 1. Conceal cable, except in mechanical rooms and areas where other conduit and piping are exposed.
 - 2. Install exposed cable in raceway.
 - 3. Install concealed cable in raceway.
 - 4. Bundle and harness multi-conductor instrument cable in place of single cables where several cables follow a common path.
 - 5. Fasten flexible conductors, bridging cabinets and doors, along hinge side; protect against abrasion. Tie and support conductors.

6. Number-code or color-code conductors for future identification and service of control system, except local individual room control cables.
- S. Connect manual-reset limit controls independent of manual-control switch positions. Automatic duct heater resets may be connected in interlock circuit of power controllers.
- T. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.5 PROGRAMMING

- A. Provide sufficient internal memory for all controllers to ensure specified sequence of operations, alarming, trending, and reporting requirements are achieved. BMS manufacturer shall provide a minimum of 25% spare memory capacity for future use
- B. Software Programming
 1. Provide programming for individual mechanical systems to achieve all aspects of the sequence of operation specified. It is the BMS manufacturer's responsibility to ensure all mechanical equipment functions and operates as specified in sequence of operations. Provide sufficient programming comments in controller application software to clearly describe each section of the program. The comment statements shall reflect the language used in the sequence of operations
- C. BMS Operator's Interface
 1. When Operator Workstation is specified, provide color graphics for each piece of mechanical equipment depicting sufficient I/O to monitor and troubleshoot operation. Additionally, provide individual floor plans of the building allowing an operator to quickly view the overall floor plan area for any out of tolerance conditions that may need addressing. These standard graphics shall depict all points dynamically as specified in the points list and/or indicated in sequence of operation
 2. The BMS manufacturer shall provide all the labor necessary to install, initialize, start-up, and trouble-shoot all operator interface software and their functions as described in this section. This includes any operating system software, the operator interface data base, and any third-party software installation and integration required for successful operation of the operator interface.
 3. As part of this execution phase, the BMS manufacturer shall perform a complete test of the operator interface. Test duration shall be a minimum of (8) hours on-site. Tests shall be made in the presence of the Owner and/or Engineer.
 4. Demonstration: A complete demonstration of the capabilities of the BMS system shall be performed by the BMS manufacturer's field personnel. The BMS manufacturer shall dedicate a minimum of (8) hours on-site with the Owner representatives, and Engineer to demonstrate a complete functional test of all the BMS system requirements, including demonstrating correct sequence of operation. This BMS demonstration shall constitute an acceptance inspection and will represent the process of approving the BMS as designed and specified.

3.6 SYSTEM COMPONENTS

- A. Controllers mounted vertically per manufacturer's installation instructions.
- B. Valves: Union or flanged connected. Locate close to apparatus controlled with pipe reducers and increasers located closest to valve. Locate, arrange, and pipe per installation diagram.
- C. Mounting height for all new room thermostats or sensors shall be 48 in. to the top of the cover or match existing if sensor is being replaced. Refer to mechanical plans.
- D. Locate thermostats or sensors on walls symmetrical with adjacent items. Verify exact room location to avoid doors, fixed and portable equipment. Install to minimize damage. Do not install adjacent to lighting dimmers or other heat generating equipment.
- E. Dampers and Damper Operators: Tag dampers for proper location. Install per manufacturer's printed instruction as to motor size and quantity, linkage arrangement, drive connection point. Adjust to close tightly. Allow for conduit sleeve or blank space for roof fan dampers. Where ducts are insulated, set damper operators at least 2 in. away from side of duct to allow for insulation.
- F. Thermometers: Provide with diagrams indicating exact locations prior to start of Work. Arrange for easy reading.
- G. Well-mounted sensors will include thermal conducting compound within the well to insure good heat transfer to the sensor.
- H. Actuators will be firmly mounted to give positive movement and linkage will be adjusted to give smooth continuous movement throughout 100% of the stroke.
- I. For duct static pressure sensors, the high-pressure port shall be connected to a metal static pressure probe inserted into the duct pointing upstream. The low-pressure port shall be left open to the plenum area at the point that the high-pressure port is tapped into the ductwork.
- J. For building static pressure sensors, the high-pressure port shall be inserted into the space via a metal tube. Pipe the low-pressure port to the outside of the building.

3.7 FIRE/FAN SHUTDOWN

- A. Provided through the fire alarm system.

3.8 LOW LIMIT SAFETY FUNCTIONS

- A. Provide for all supply fan units. Wiring to be directly to the motor starter. Low limit shall be located as shown on drawings. Low limit shall: prevent fan from operating, set heating coils to full heat operate coil pumps, fully close the outside air damper, fully close the relief air dampers, open return air damper, and alarm DDC system until reset.

3.9 SYSTEM TESTING

- A. At the time of installation, systems shall be tested for control device operation prior to the systems acceptance. A report of each systems performance shall be submitted to the Owner's Representative. The report shall include:
 - 1. Field verification and demonstration checklist of analog input calibration, analog output operation, digital input function, and digital output operation.
 - 2. Trend log of inputs and outputs printed every two hours, for one week.
 - 3. Refer to "Instructions and Adjustments"
 - 4. Field verification and demonstration of sequence of operations.

3.10 INTEGRATION WITH EQUIPMENT CONTROL

- A. The DDC system shall fully integrate to provide full monitoring and control functions for equipment shown.

3.11 POINT DESCRIPTION AND PROGRAM LIST

- A. General:
 - 1. Points listed are the minimum number of points to be provided. Provide additional points as required to satisfy the sequence and operational requirements.
 - 2. Provide spare points. After the system has been completed and tested, the following minimum quantity of spare points shall be available for future connection at each DCP:
 - a. Binary inputs: 2
 - b. Binary outputs: 2
 - c. Analog inputs: 1
 - d. Analog outputs: 1
 - 3. Provide proportional-integral-derivative algorithms for all control programs.
 - 4. Determine, through operation of the system, proportional bands, interval time, integral periods, adjustment rates, and any other input information required to provide stable operation of the control programs.
 - 5. The following definitions apply to the letter descriptors used in the point lists:
 - a. RT - Run time of a piece of equipment. This shall be the total operating time since initial start-up of a piece of equipment.
 - b. T - Indicates the point shall be trendable.
 - c. A - Indicates the system shall alarm when the point is outside its range, or upon contact closure or opening.
 - d. CS - Current Sensor
 - 6. All alarms shall be trendable. All equipment start/stops shall be trendable.
 - 7. At a minimum, each sequence and accompanying point list shall be represented by an individual graphic. Each point listed shall appear on the graphic. Where appropriate and approved, multiple sequences and point lists may be combined into a single graphic.

- a. For analog outputs, display on the graphic the percent of full signal (percent open for valves and dampers, percent of speed for variable speed drives, etc.)
 - b. For analog outputs controlled by analog inputs, provide a probe at the graphic to redefine the proportional, integral, and derivative gains.
 - c. Alarm set points and ranges shall be resettable from the graphic. Control set points and ranges shall be resettable from the graphic.
 - d. Where average point values are called for in the sequence, the average value shall be displayed on the graphic. In response to a probe on the graphic, the individual sensor values and sensor locations shall be displayed
8. Where dampers operate in conjunction with fan operation, the damper open signal shall precede the fan start signal by 10 to 15 seconds. The damper close signal shall be delayed 10 to 15 seconds after the fan stop signal.

3.12 FIELD QUALITY CONTROL

A. Perform the following field tests and inspections and prepare test reports:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of electronic controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

B. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check temperature instruments and material and length of sensing elements.
5. Check control valves. Verify that they are in correct direction.
6. Check DDC system as follows:
 - a. Verify that DDC controller power supply is from emergency power supply, if applicable.
 - b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
 - c. Verify that spare I/O capacity has been provided.
 - d. Verify that DDC controllers are protected from power supply surges.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures

3.13 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.
3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:
 - a. Check analog inputs at 0, 50, and 100 % of span.
 - b. Check analog outputs using milliamper meter at 0, 50, and 100 % output.
 - c. Check digital inputs using jumper wire.
 - d. Check digital outputs using ohmmeter to test for contact making or breaking.
 - e. Check resistance temperature inputs at 0, 50, and 100 % of span using a precision-resistant source.
5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 % values with 3-point calibration accomplished at 50, 90, and 100 % of span.
 - b. Manually operate flow switches to verify that they make or break contact.
6. Pressure:
 - a. Calibrate pressure transmitters at 0, 50, and 100 % of span.
 - b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.
7. Temperature:
 - a. Calibrate resistance temperature transmitters at 0, 50, and 100 % of span using a precision-resistance source.
 - b. Calibrate temperature switches to make or break contacts.
8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 % open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 % closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

END OF SECTION

SECTION 230963 – GAS DETECTION AND ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes gas detection instruments and other components necessary for an emergency gas exhaust system.
 - 1. The work to be performed in accordance with these Specifications includes engineering, final system and component configuration design, manufacture, procurement, delivery, storage, installation, equipment calibration, testing, documenting, warranting, maintenance and the placing in service of carbon monoxide and nitrogen dioxide detection system.
 - 2. The work shall include the furnishing and installation of equipment, material, conduit, cables, wiring, mounting hardware, system operating software and all appurtenances required to provide complete, coordinated and compatible operating systems with functional subsystems and elements which meet the requirements described in these Contract documents. All other materials and equipment, including items such as; samples, prototypes, cable termination allowances, packing materials, wastage of material during installation efforts and tests, demonstrations, engineering review documentation, and any other materials or services associated with the prosecution of the work or the administration of the Contract that are not listed, but are otherwise specified or necessary for full and complete operation and performance of each system, shall also be provided by the Contractor. The Contractor is responsible for a complete and operational system.
 - 3. The Gas Detection System to be provided shall be a microprocessor based, distributed control system with industry standard hardware and software to detect the presence of carbon monoxide and nitrogen dioxide in the apparatus bays.
 - 4. The system shall operate over a fault tolerant three-wire communication network loop with built-in diagnostics, programmable logic, non-volatile memory for alarm and calibration logging and accommodate a variety of other fire and gas devices. It shall be designed to ignore opens and shorts that could occur on the network. The loop configuration will ensure a single short or open on the system will not affect system communication between the field devices and the control unit. System communication will provide supervision of all addressable devices on the network and provide fault alarms in the event of system failures
- B. System Performance Requirements:

1. The Gas Detection System shall continuously monitor the carbon monoxide and nitrogen dioxide levels within the spaces in which they are located. Set points for each detector shall be as follows:
 - a. Carbon monoxide: 25 PPM
 - b. Nitrogen Dioxide: 3 PPM
2. The Gas Detection System shall operate satisfactorily in the environment existing in the apparatus bay. With the exception of normal cleaning requirements, the system operation shall not be compromised and false alarms shall not be generated by detectors exposed to normal levels of dust, smoke, moisture, chemicals and fumes from petroleum distillates.
3. System trouble signal initiation shall be by one or more of the following devices or actions:
 - a. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
 - b. Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
 - c. Loss of primary power at the Local Control Unit.
 - d. Ground or a single break in Local Control Unit internal circuits.
 - e. A break in standby battery circuitry.
 - f. Failure of battery charging.
 - g. Abnormal position of any dip switch at the devices so equipped.
4. System Trouble Signal Actions: Ring trouble bell and energize LED or lamp on the graphic annunciator panel. Sound a chime tone and display trouble alarm with description on the computer monitor. Record the event in the system historical log. Trouble alarms shall be cleared only after the system fault has been corrected and a system reset function has been completed

C. Contractor's Total System Responsibility:

1. The Contractor bears total system responsibility for the specified gas detection system (except Contract deliverables not requiring Contractor installation). The Contractor's total system responsibility includes engineering services, construction, testing, installation documentation, warranty, maintenance, and other areas of responsibility, which are subject to periodic review and acceptance by the Authority (as specified elsewhere). The Contractor has the responsibility to integrate the various necessary elements of Contract work so that overall system performance goals are met.
2. The Contractor is required to engage the services of the approved system manufacturer's engineering staff to evaluate the facilities for appropriate applications of gas detection equipment.

D. Related sections:

1. Section 230993 "Sequence of operation of HVAC controls"
2. Section 260533 "Raceways and Boxes for Electrical Systems."

1.3 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's name, model numbers, data sheets, ratings, power requirements, equipment layout, device arrangement, and battery calculation charts. Show the control panel module layouts, remote annunciator panel configurations and wiring terminations.
- B. Wiring Diagrams: Complete detector system wiring point-to-point diagrams, conduit layouts (show penetrations for fire rated walls).
- C. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and corresponding outputs.
- D. Shop Drawings:
 - 1. Complete drawing lists for each system.
 - 2. Complete installation drawings for each system.
 - 3. System riser diagram with device addresses, conduit sizes and cable and wire types and sizes.
 - 4. Floor Plans: Indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
 - 5. Complete test procedures for each system and each item of equipment requiring such procedures.
 - 6. Complete interface control details and procedures.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Contractor shall include the following information in the operations and maintenance manual:
 - 1. As-Built drawings for all equipment items for each system.
 - 2. Complete test data for each system and all equipment for which such data is approved.
 - 3. Other submissions listed elsewhere in these Specifications, as required by the Authority's Representative.

1.5 QUALITY ASSURANCE

- A. The manufacturer of the major components of the Gas Detection System shall have a minimum of 5 years' experience in the manufacturing of gas detection equipment. The satisfactory operation of systems previously provided shall be subject to verification. Manufacturer must be ISO 9002 certified.
- B. All major components of the Gas Detection System, including software, shall be furnished from the same manufacturer.
- C. The equipment supplier shall participate in the applications engineering, set up, testing and commissioning of the system.

- D. Non-dispersed, infrared gas detectors shall be warranted against failure by the manufacturer for a minimum of five years and require calibration only on an annual basis. The gas detectors shall permit calibration to be performed by one person.
- E. The system shall be installed by qualified electricians who have successfully completed a training course provided by the equipment supplier.
- F. Gas Detection System design, clearances, electrical and mechanical installations, and testing shall, as a minimum, be in accordance with the requirements in effect at time of Invitation for Bid for each of the following and shall include addenda and supplements:
 - 1. FMRC NFPA 72 - National Fire Alarm Code
 - 2. Fire Code of the local jurisdiction
 - 3. FM 6310/6320 - Combustible Gas Performance
 - 4. National Electrical Code (NEC).
 - 5. FMRC 6310/6320 Combustible Gas Detectors
 - 6. Building Officials and Code Administrators National Building Code (BOCA).
 - 7. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).
- G. The specifications are not to be construed as supplanting any code requirements.

1.6 WARRANTY

- A. Warranty Period:
 - 1. For Labor: Two years from date of Substantial Completion
 - 2. For Parts: Five years from date of Substantial Completion

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by the following:
 - 1. Honeywell (basis of design).
 - 2. As approved by the Engineer.
- B. All systems to be installed shall be furnished by the same manufacturer.

2.2 MATERIALS AND EQUIPMENT

- A. The system shall be comprised of a control unit, a programmable relay module, addressable infrared gas detectors, initiating device circuits, notification appliance circuits, and analog initiating devices with control unit(s) communicating over a high speed fault tolerant communications link to form an integrated system.

- B. All field devices shall have 3/4 inch NPT cable entry and separate terminals for incoming and outgoing field wiring. Terminals shall be sized to accept 16 to 22 AWG wire.
- C. All detector locations shall permit the separation from the transmitter for a distance up to 50 feet for carbon monoxide and nitrogen dioxide detectors. Transmitters shall have the capability to simulate and adjust the output to compensate for line loss and allow field testing. Conduit and cabling between the detector and remote transmitter shall be rated for installation in hazardous locations. The transmitter shall display Gas Concentration and Alarm Status as a minimum.
- D. Wire and cable shall be UL listed with color coded insulation appropriate for the area of installation. Cable shielding, conductor configuration and sizing shall be as recommended by the system manufacturer. All system wire and cabling installed outside of equipment enclosures and devices shall be installed in rigid galvanized steel conduit.
- E. Provide grounding of system equipment and cable shielding as recommended by the system manufacturer. Grounding shall comply with IEEE 1100.
- F. Local Control Unit:
 - 1. Honeywell model VA301C.
 - 2. Power Requirements: 17-27 Vac, 60 Hz or 24-38 Vdc, 500 mA
 - 3. Operating Temperature Range: -4°F to 122°F
 - 4. Operating Humidity Range: 0 to 95% RH (non-condensing)
 - 5. Outputs: 4 DPDT relays
 - 6. Relay Output Rating: 5A, 30 Vac
 - 7. Network Capacity: Up to 96 transmitters
 - 8. Alarm levels: 3 fully programmable alarm levels
 - 9. Communication Cable: Twisted and shielded 2-24 AWG
 - 10. Length of Communication Lines: 2000ft per channel
 - 11. Battery: 3V Lithium Battery
 - 12. Enclosure: NEMA 4X ABS polycarbonate
 - 13. The control panel must be capable of communicating digitally with the networked transmitters and relay modules through three RS-485 Modbus communication buses. Each communication bus must be capable of accepting a combination of up to 32 addressable transmitters, relay modules, or annunciator panels at a maximum distance of 2,000 feet. The power supply shall be of either 24 Vac or 24 Vdc.
 - 14. The controller will manage four internal DPDT relays at fully programmable alarm levels (and within programmable time delays) and be capable of activating multiple relay modules of eight relays each. The relay rating will be no lower than 5 A, 30 Vdc or 250 Vac (resistive load)
 - 15. The controller to include a self-test function that allows for the activation/deactivation of all the programmed outputs by simulating a continuous 5% increase/decrease value until the maximum/minimum value is reached.
 - 16. The controller to include a real-time clock that enables operation of the outputs for a specific timeframe.
 - 17. The controller must also include an energy saving feature that allows for output operation on alarms set at the max, min or average value of a specific group of transmitters. This feature must also allow for the activation of outputs upon a certain number of a specific group ($\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{4}$) of transmitters reaching their alarm levels. A total of 128 groups can be assigned.
 - 18. The controller will indicate the exact concentration of gas, the gas detected, and the loca-

tion of the sensor by sweeping through the network and displaying the detected levels at each point on a graphic LCD display.

19. Provide required 120V to 24 V by gas detection manufacturer for each controller.
20. Data logging:

- a. Data logging capability to provide long-term data logging to determine trends. The controller must collect data automatically and must store it on a digital Flash media card.

G. Toxic and Combustible Gas Detector- Carbon Monoxide and Nitrogen Dioxide:

1. Honeywell model E³Point
2. Power Requirement: 24 Vac nominal or 24Vdc, 60 Hz, 0.4A
3. Relay Output: 1 DPDT relay, 5A @ 250 Vac; 5A @ 30 Vdc
4. Communications: RS485 Modbus
5. Operating Temperature: -40° to 122°F
6. Display: 8 Character, 2 line backlit LCD
7. Visual Indicator: Green LED: Power; Amber LED 1: Alarm/Fault; Amber LED 2: Alarm/Fault
8. Accuracy: +/- 3% of full scale
9. Gases Detected: Carbon Monoxide (CO), Nitrogen Dioxide (NO₂)
10. Relative humidity range operating range: of 5-95%
11. Operating Temperature: -4° F to 104° F (-20° C to 40° C)
12. Enclosure: Polycarbonate
13. Transmitter to be powered by the control panel power supply rated at 24 Vac or 24 Vdc. Fully addressable gas transmitter must be capable of communicating digitally with controller through an RS-485 communication port. Gas transmitters must be installed in a true daisy chain with an end of the line resistor on the last transmitter. The gas transmitter will incorporate an electrochemical cell for toxic gas monitoring and catalytic bead sensor for combustible gases. Unit sensing cell must compensate for variations in relative humidity and temperature to maintain high levels of accuracy
14. When placed in a network configuration the transmitter to be capable of transmitting gas concentrations through the controller. For local activation of fans or louvers (or other equipment) an on-board DPDT relay 5 A, 30 Vdc or 250 Vac (resistive load) to be activated at programmable set points (and programmable time delays) through the control panel. An LCD display to provide gas concentration readings.
15. Unit will be certified to ANSI/UL 61010-1 label and CAN/CSA-C22.2 No. 61010-1. Transmitter must be manufactured in an ISO 9001-2000 production environment.
16. The transmitter should have a plug-in capability for a gas cartridge with a smart sensor capable of self-testing.
17. Provide splash guard enclosure (Honeywell ECLAB or approved equal) within wash down areas.
18. Provide detector guards (Honeywell E3PT-Guard or approved equal)
 - a. Grid to be made of a 9-gauge steel wire. The guard must be designed to allow calibration without removing the guards.

H. System Relay Module:

1. Honeywell model VA301R8.
2. Fully compatible with the 301C Controller.
3. Capable of 8 additional DPDT relays, 5A, 30Vdc or 250Vac.

4. Easy daisy chain installation (RS-485).
5. LED visual indication of status next to each relay.
6. Connects into a single output of the 301C Controller.
7. Operating Temperature: 32° to 104°F.
8. Humidity Range: 0-95% RH, non-condensing.
9. Power Requirements: 17-27Vac, 24-28Vdc
10. Relay module will be powered by the control panel's power output. Module to be capable of communicating digitally with the controller through an RS-485/MODBUS communication port. Relay module will have eight relays rated at no lower than 5A, 30 Vdc or 250 Vac (resistive load).

PART 3 - EXECUTION

3.1 INSTALLATION

- A. All equipment installation shall comply with applicable codes and shall be performed with a degree of workmanship acceptable to Precision Strip. Final terminations of Gas Detectors, Transmitters, Receivers/Controllers and Supervisory System must be performed by factory authorized and trained service personnel.
- B. Control equipment shall be located at locations shown on contract drawings. Control equipment enclosures and cabinets shall be wall mounted at a height with the top of the enclosure or cabinet not exceeding six feet above the floor. Install all items in accordance with manufacturer's instructions Equipment located within 18 inches below the ceiling shall comply with requirements for areas with hazardous classification per NFPA.
- C. Carbon monoxide detectors shall be located at 12-inches and 60-inches above floor.
- D. Nitrogen dioxide detectors shall be located between 1foot and 3 feet below underside of roof deck.
- E. Install wiring in conduit. Refer to section 260533 "Raceways and Boxes for Electrical Systems."
- F. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace and train conductors to terminal points with no excess. Connect conductors that are terminated or interrupted in any enclosure associated with the gas detection and alarm system to terminal blocks. Label each terminal and wire according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.
- G. Cable Terminations: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- H. Color-Coding: Color-code Gas Detection System conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits.

- I. All wiring used for communication over Ethernet network shall be shielded.

3.2 TESTING

- A. Contractor shall engage a factory-authorized service representative to assist in inspecting, testing, and adjusting components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Component Level Tests and Inspections:
 1. The contractor shall prepare detailed pre-test check sheets, test plans, procedures, data entry forms and test reports for the testing of each component.
 2. The test plans shall provide objectives, approach, pass/fail criteria, requirements and schedule for each test.
 3. Test and adjust all controls and safeties.
 4. Verify each component is installed at the correct height indicated.
 5. Verify each component is installed securely.
 6. Verify electrical connections to each component are correct and secure.
 7. Test all functions within each individual components control.
 8. Test alarms on each component
 9. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. System Level Tests and Inspections:
 1. The contractor shall prepare detailed pre-test check sheets, test plans, procedures, data entry forms and test reports for the testing of the entire gas detection system.
 2. The test plans shall provide objectives, approach, pass/fail criteria, requirements and schedule for each test.
 3. Test and adjust all controls and safeties.
 4. Verify the absence of unwanted voltages between circuit conductors and ground.
 5. Test all conductors for short circuits utilizing an insulation-testing device.
 6. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit.
 7. Verify the control unit is in the normal condition as detailed in the manufacturers operating and maintenance manuals.
 8. Test each detector for operation and proper response at the control unit. Test detectors with actual carbon monoxide and nitrogen dioxide as appropriate for each detector.
 9. Test the system for all specified functions according to the manufacturer's operating and maintenance manual. Systematically initiate specified functional performance items at each station including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.
 10. Verify that all HVAC equipment is functioning properly with the detection control unit.
 11. Verify all relays are performing correctly to start-up HVAC equipment and open garage

doors.

12. Test Reports: Prepare a written report to record the following:

- a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- E. Furnish equipment required to perform all tests. Test each component installation and system in accordance with the approved procedures.
- F. The Contractor shall notify the owner a minimum of two working days prior to commencing any tests that are to be witnessed by the owner.
- G. The Contractor shall furnish personnel, tools and test equipment as required to satisfactorily complete the tests. Test equipment used in performing the tests shall be in current calibration. Factory authorized service personnel shall provide all programming and verification of each Gas Detector, Transmitter, Receiver/Controller, Annunciator Panel and Supervisory System and the Factory authorized service personnel shall provide final test and verification of overall system performance.
- H. Repair or replace malfunctioning units and retest as specified above.
- I. Prepare and submit certified test reports for each equipment installation test indicating the results of all tests and remedial measures implemented to enable equipment to pass the tests.
- J. System Performance Test (30 day): After completion and inspection of all work, and following placement of the gas detection and alarm system in service, the contractor shall perform a 30-day performance test. The performance test shall include an end-to-end test of all function of the system.
1. All detection, alarm and interface functions operate as intended in the event of an actual buildup of carbon monoxide, nitrogen dioxide or the release of compressed natural gas.
 2. No false alarms
 3. No system trouble or fault alarms
 4. If the system, or any part of it, fails to meet any criteria of the performance test, the contractor shall make corrections at no additional cost to the owner. More than three failures during the thirty (30) day test will result in a restart of the test period.

3.3 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas detection devices and equipment. Training shall be a minimum duration of 4 hours and contractor shall provide all training materials and equipment.

END OF SECTION 230963

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Section 230923 "Direct Digital Control System for HVAC" for control equipment and devices and for submittal requirements.

1.3 DEFINITIONS

- A. DDC: Direct digital control.
- B. VAV: Variable air volume.

1.4 AIR HANDLING UNIT CONTROL SEQUENCES

- A. Dedicated Outdoor Air System Unit (DOAS-1):
 - 1. General:
 - a. Variable volume system with supply fan, water-source heat pump, exhaust fan, energy recovery wheel and electric heating.
 - b. Heat pump consists of a digital scroll compressor for capacity control.
 - c. Change over from system heating to system cooling shall be determined by VRF system cooling or heating status.
 - d. All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.
 - 2. Start-up:
 - a. When initiated by manual command through the DDC system, the outside air and exhaust air dampers shall open. Upon proof of open as sensed by the damper end switches, the supply fan and exhaust fan variable speed drives shall be enabled. After proof of operation, the fans shall ramp to set point and the PID

loops for the cooling coil, heat pump, energy recovery wheel, and electric heat shall be enabled.

3. Shutdown:
 - a. When initiated by manual command through the DDC system or triggered by a safety device, the unit shall shut down. Heating/cooling shall be disabled. After a time delay of 180 seconds (adj.), the fan(s) PID loops shall be set to minimum speed and the fan(s) disabled. After a programmable time, delay (initially 30 seconds) the unit's outside air and exhaust air dampers shall close..
4. Heat Pump to be energized and de-energized as required to maintain supply air temperature set point. Unit's controller to modulate compressor as required.
 - a. Cooling Leaving Air Set Point: Based on a reset schedule of 62°F at 55°F outdoor air, 54°F at 80°F outdoor air (adj.)
 - b. Heating Leaving Air Set Point: 65 °F (adj.)
 - 1) Set point
5. Heat pump solenoid valve to open prior to heat pump operating. Heat pump controller to control solenoid valve.
6. Heat Recovery Operation:
 - a. The controller shall modulate the heat recovery wheel for energy recovery as follows:
 - b. Cooling Recovery Mode: The controller shall measure the zone temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) less than the supply air temperature set point. The heat wheel shall run for cool recovery whenever
 - 1) Return air temperature is 5°F (adj.) or more below the outside air temperature.
 - 2) AND the zone temperatures are above cooling setpoint.
 - c. Heating Recovery Mode: The controller shall measure the zone temperature and modulate the heat wheel speed to maintain a setpoint 2°F (adj.) greater than the supply air temperature set point. The heat wheel shall run for heat recovery whenever:
 - 1) Return air temperature is 5°F (adj.) or more above the outside air temperature.
 - 2) AND the zone temperature is below heating setpoint.
 - d. Periodic Self Cleaning
 - 1) The heat wheel shall run at 5% speed (adj.) for 10sec (adj.) every 4hr (adj.) the unit runs.
 - e. Frost Protection:
 - 1) The heat wheel shall run at 5% speed (adj.) whenever
 - a) Outside are temperature drops below 15°F (adj.)
 - b) OR the exhaust air temperature drops below 20°F (adj.).
 - f. The heat wheel bypass dampers will open whenever the heat wheel is disabled.
7. Economizer Operation:
 - a. Unit shall modulate heat recovery bypass damper and face damper to achieve mixed air temperature setpoint (adj.) when cooling is required. Note, bypass

damper is not sized for full bypass, intent is to provide as much free cooling as possible when cooling is required and outdoor conditions allow for free cooling. Bypass damper to close when cooling is not required within the space. When the mixed air temperature falls below setpoint 55 degrees F (adj.) the bypass damper shall close.

8. Electric Heating Coil Operation:

- a. Electric heating coil shall serve as backup to energy recovery wheel and only operate if wheel fails.
- b. During the heating mode, the electric heat shall modulate to maintain the scheduled discharge air temperature of 65°F (adj.)

9. UVC Light Control: The controller shall be enabled whenever the supply fan status is on.

- a. The UVC Light Controller shall turn off whenever:

- 1) On loss of supply fan status.

10. Supply Fan Speed Modulation:

- a. The supply fan shall modulate to maintain duct supply air pressure set point at the remotely located supply air duct pressure sensor.
- b. The DDC system shall poll all connected VAV terminals once every 5 minutes (adj.) for their current damper calculated damper positions.
- c. If any damper is more than 95% open, the duct static pressure set point shall be automatically incremented up by 0.1" w.c. (adj.) each polling interval (up to a maximum determined during air balance to be adequate to serve all terminals at 100% flow)
- d. If all dampers are less than 85% open, the duct static pressure set point shall be automatically incremented down 0.1" w.c. (adj.) each polling interval (down to a minimum determined during air balance to be adequate to serve all terminals at minimum flow).

11. Exhaust Control:

- a. The exhaust fan shall modulate to match the outside air intake air flow rate. Air flow sensors to be provided on outside air and exhaust air intake/relief on unit.

12. Safeties:

- a. All safety devices shall be hard wired in series through the "drive inhibit" (or safety interlock if available) VFD inputs of the supply fan to shut them down immediately on safety trip.
- b. An auxiliary contact on all devices shall be monitored individually to provide specific alarm information at the operator's console.
- c. On trip of any safety device, all PID controlled items shall automatically enter shutdown mode, and the VFD PID loops for the fans shall modulate down to minimum speed. On manual (field) reset of the safety device(s), the fan PID

- loop shall ramp up, followed by the loops controlling the balance of the air handling system in the order described in the startup sequence.
- d. Programming shall preclude the “wind up” of PID loops during shutdown conditions.

B. Gas Detection System: Apparatus Bay

1. Gas detection system shall energize the Apparatus/Sallyport bay exhaust air system when the level of gas reaches the following concentrations.
 - a. Carbon Monoxide: 35 ppm (adj.)
 - b. Nitrogen dioxide: 1 ppm (adj.)
2. Upon detection of gasses above the levels listed above, the following sequence shall be initiated by the gas detection control panel independent of BMS.
 - a. Associated purge exhaust fans motorized dampers to be opened
 - 1) Apparatus Bay: EF-1
 - b. Overhead Apparatus Garage doors shall open 2”
 - c. Associated purge exhaust fans to be energized.
 - 1) Apparatus Bay: EF-1
3. Gas detection system to provide stand-alone control. BMS to monitor.
4. If the gas concentration continues to rise gas detection system to initiate alarm within the BMS system. Alarm to be initiated when the level of gas reaches to following concentrations
 - a. Carbon Monoxide: 225 ppm
 - b. Nitrogen dioxide: 3 ppm
5. System shall automatically reset if levels have dropped below rates listed in section 1 after 15 mins (adj.).

C. Energy Recovery Unit (ERV-1) and Electric Duct Heater (EDH-1):

1. General: Energy recovery unit is a constant volume unit which consists of (1) supply fan, (1) exhaust fan, and a fixed plate total enthalpy air-to-air exchanger.
 - a. The electric duct heater shall have SCR controls. The air handling unit shall operate continuously via the Building Management System (BMS).
2. Occupied (adj.):
 - a. Occupied Schedule: 24/7
 - b. Fan shall be on.
 - c. Discharge air heating set point: 67°F (adj.)

3. Start-up:
 - a. When initiated by manual command through the DDC system, the unit outside and exhaust air dampers shall open. Once the end switches have been proved the supply and exhaust fans shall be enabled.
4. Shutdown:
 - a. When initiated by manual command through the DDC system or triggered by a safety device, the unit shall shut down. Heating shall be disabled where applicable. After a time delay of 180 seconds (adj.), the fan(s) shall be disabled. After a programmable time, delay (initially 30 seconds) the outside air and exhaust air dampers shall close.
5. Heating Operation:
 - a. On call for heat, the electric duct heater shall be enabled. Heating operation shall be modulated to maintain discharge air temperature set point.
6. Alarms
 - a. Fan Failure: If status of a fan, which has been called by the BMS to start, has not been verified as running within a period of 10 seconds (adj.), the BMS shall initiate an alarm signal at the operator's workstation. The fan shall be identified by its designation and shall be tagged as a "FAN FAILURE".
 - b. Filter Maintenance (Qty 2 each unit): A differential pressure switch with sensors on upstream and downstream side of filter shall signal the BMS system when the differential pressure is equal to or greater than the setpoint (adj.). The BMS shall initiate an alarm signal at the operator's workstation indicating a clogged filter and requirement for maintenance.

1.5 HEAT PUMP LOOP CONTROL SEQUENCES

- A. Building Side Heat Pump Distribution System (variable volume heat pump water loop):
 1. This system consists of (2) geothermal heat pump water pumps, (2) heat exchangers, (2) building heat pump water pumps and heat pump water loop.
 2. The heat pump water system shall be enabled and disabled during the occupied/unoccupied modes via the Direct Digital Control system (DDC), through an owner directed time schedule.
- B. Heat Pump System Control (HPP-1 – HPP-4 & HX-1 & HX-2)
 1. System shall be enabled to run 24/7.
 2. Geothermal Side Heat Pump Water Pump (HPP-3 & HPP-4) Lead/Lag Operation: The heat pump water pumps shall operate in a lead/lag fashion.
 - a. The lead pump shall run first.
 - b. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.

3. The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - a. manually through a software switch
 - b. if pump runtime (adj.) is exceeded
 - c. daily
 - d. weekly
 - e. monthly
 4. Alarms shall be provided as follows:
 - a. Heat Pump Water Pump HPP-3
 - 1) Failure: Commanded on, but the status is off.
 - 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) VFD Fault.
 - b. Heat Pump Water Pump HPP-4
 - 1) Failure: Commanded on, but the status is off.
 - 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) VFD Fault.
 5. Geothermal Side Heat Pump Water Pump (HPP-3 & HPP-4): The controller shall monitor building side heat pump water supply temperature and modulate speed to achieve a setpoint. The VFDs minimum speed shall not drop below 20% (adj.).
 - a. Summer Supply Temperature Set Point: 90°F (adj.)
 - b. Winter Supply Temperature Set Point: 50°F (adj.)
- C. Building Side Heat Pump Water Pump (HPP-1 & HPP-2) Lead/Lag Operation: The two heat pump water pumps shall operate in a lead/lag fashion.
1. The lead pump shall run first.
 2. On failure of the lead pump, the lag pump shall run and the lead pump shall turn off.
 3. On decreasing heat pump water differential pressure, the lag pump shall stage on and run in unison with the lead pump to maintain hot water differential pressure setpoint.
 4. The designated lead pump shall rotate upon one of the following conditions (user selectable):
 - a. manually through a software switch
 - b. if pump runtime (adj.) is exceeded
 - c. daily
 - d. weekly
 - e. monthly
 5. Alarms shall be provided as follows:
 - a. Heat Pump Water Pump HPP-1
 - 1) Failure: Commanded on, but the status is off.

- 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) VFD Fault.
- b. Heat Pump Water Pump HPP-2
- 1) Failure: Commanded on, but the status is off.
 - 2) Running in Hand: Commanded off, but the status is on.
 - 3) Runtime Exceeded: Status runtime exceeds a user definable limit.
 - 4) VFD Fault.
6. Building Side Heat Pump Water Differential Pressure Control: The controller shall measure heat pump water differential pressure and modulate the heat pump water pump VFDs in sequence to maintain its heat pump water differential pressure setpoint.
 7. The following setpoints are recommended values. All setpoints shall be field adjusted during the commissioning period to meet the requirements of actual field conditions.
 8. The controller shall modulate heat pump water pump speeds to maintain a heat pump water differential pressure setpoint. The VFDs minimum speed shall not drop below 20% (adj.).
 9. On dropping heat pump differential pressure, the VFDs shall stage on and run to maintain setpoint as follows:
 - a. The controller shall modulate the lead VFD to maintain setpoint.
 - b. If the lead VFD speed is greater than a setpoint of 90% (adj.), the lag VFD shall stage on.
 - c. The lag VFD shall ramp up to match the lead VFD speed and then run in unison with the lead VFD to maintain setpoint.
 10. On rising heat pump differential pressure, the VFDs shall stage off as follows:
 - a. If the VFDs speeds drops back to 60% (adj.) below setpoint, the lag VFD shall stage off.
 - b. The lead VFD shall continue to run to maintain setpoint.
 11. Alarms shall be provided as follows:
 - a. High Heat Pump Differential Pressure: If 25% (adj.) greater than setpoint.
 - b. Low Heat Pump Differential Pressure: If 25% (adj.) less than setpoint.
- D. Alarms shall be provided as follows:
1. High Heat Pump Supply Temp: If greater than 105°F (adj.).
 2. Low Heat Pump Supply Temp: If less than 30°F (adj.).
- E. Plate & Frame HX & Pumps
1. Start/stop command
 2. Common alarm
 3. Speed control
 4. Speed
 5. VFD status
 6. Differential pressure reading at most remote AHU
 7. Differential pressure setpoint
- F. Variable Refrigerant System (VRF) (WSHP-1&2, BCC-1&2, IACU-1-14):
1. General:

- a. Air conditioning systems shall operate from their onboard unit controllers. DDC system shall monitor the status of the systems(s) and report the following points to the to the operator's workstation:
 - 1) System status
 - 2) Operational mode
 - 3) Space temperature
 - 4) Systems status alarm
 - 5) Condensate pan alarm.
- b. The two-way heat pump water solenoid valve shall open when their respective boiler is enabled. Valves shall be interlocked to the boiler control panel via auxiliary contact. If the valve fails to open the respective boiler shall not be allowed to start.

1.6 HOT WATER HEATING CONTROL SEQUENCES

A. Hot Water Distribution System (variable volume hot water loop):

- 1. This system consist of (2) water to water heat pumps, (2) primary hot water pumps, and hot water heating loop.
- 2. The hot water system shall be enabled and disabled during the occupied/unoccupied modes via the Direct Digital Control system (DDC), through an owner directed time schedule.

B. Water to Water Heat Pumps (WWHP-1, WWHP-2 with associated HWP-1 & HWP-2):

- 1. The heat pumps shall be enabled and disabled by the DDC system. Each heat pump shall be controlled by a heat pump microprocessor control system (MCS). The DDC system shall enable the heat pump system whenever the outdoor air temperature is below 60 deg-F (adj.) for a period of 30 minutes (adj.). The DDC system shall monitor an alarm at the MCS for system failure.
- 2. The two-way heat pump water solenoid valve shall open when their respective boiler is enabled. Valves shall be interlocked to the boiler control panel via auxiliary contact. If the valve fails to open the respective heat pump shall not be allowed to start.
- 3. The circulation pumps at each boiler shall run when their respective boiler is enabled. Pumps shall be interlocked to the boiler control panel via auxiliary contact. If the pump fails to start the respective heat pump shall not be allowed to start.
- 4. Once the DDC system has proved operation of the main circulator pumps, the system shall enable the heat pumps and the BMS shall control the starting and stopping of the heat pumps and the MCS shall control compressor modulation.
- 5. The heat pumps shall be enabled/disabled as required to maintain the scheduled hot water return temperature, 130 deg-F (adj.). If after a period of 10 mins (adj.), the lead heat pump cannot maintain the temperature, the lag heat pump shall be enabled.

C. Hot water temperature reset:

- 1. The heating return water temperature set point shall be continuously reset against outdoor air temperature.
- 2. When the outdoor air temperature is 55 deg-F or above, the return water temperature set point shall be 80 deg-F (adj.)

3. When the outdoor air temperature is 15 deg-F or below, the return water temperature set point shall be 110 deg-F (adj.)
4. Return water temperature set point shall be linearly reset between 15 deg-F and 55 deg-F outdoor air conditions.
5. The boiler capacity shall be modulated automatically via its resident control package.
6. Lead and lag water to water heat pumps and their associated primary pumps shall automatically rotate for run time equalization.

D. Pump Control (HWP-3 & HWP-4):

1. Pump Alternation:

- a. Pumps shall operate in a lead/lag arrangement and alternate to equalize equipment run time. Selection of the lead pump and the lag pump is evaluated on a weekly basis. The pump with the least run time is the lead pump. Remaining pump is the lag pump.

2. Pump Failure:

- a. At start-up, if after 2 minutes the lead pump has not proved flow, the lead pump shall disable, the lag pump shall enable, and a building alarm is generated at the operator's workstation. If, after 2 minutes the lag pump has not proved flow, the lag pump shall disable and a critical building alarm shall be generated at the operator's workstation.
- b. If at any point during operation the lead pump fails, a building alarm is generated at the operator's workstation, the lead pump is disabled, and the lag pump is enabled. If both pumps fail a critical building alarm is generated at the operator's workstation and the pumps are disabled.
- c. The DDC system uses current sensors to confirm the pumps are in the desired state (i.e. on or off).

3. Pump Modulation:

- a. The pumps are configured to operate on a variable pressure algorithm. Whenever the secondary pump is in operation the heating system differential pressure control set point shall be reset between pressure P1 and P2.
 - 1) P1 is defined as the minimum differential pressure necessary to circulate minimum flow with all valves closed to heating (only 3-way valve and bypass flow).
 - 2) P2 is defined as the differential pressure necessary to obtain design flow rate with all valves open.
- b. On system shutdown (secondary pumps disabled), the start-up system pressure shall be set to P1.
- c. When the system enters heating mode (secondary pumps enabled), the control system shall continuously monitor the position of the heating valves serving all connected HVAC equipment.

- 1) If any valve is open beyond 95%, the loop pressure differential shall be increased at a rate of 0.5 psi / 3 minutes (up to a maximum level of P2) until such time that no valve is open beyond 95%.
- 2) If all valve close beyond 85% open, the loop pressure differential shall be decreased at a rate of 0.5 psi / 3 minutes (down to a minimum level of P1) until such time that at least one valve is open at least 85%.

d. Pumps shall automatically rotate for run time.

1.7 TERMINAL UNIT OPERATING SEQUENCES

A. VAV, Terminal Air Units:

1. Pressure independent application specific controller with integral differential pressure sensor for connection to manufacturer provided air flow probe. Convert differential pressure to CFM. Calibrate during air balance procedures.
2. Each Terminal Unit shall be an independently adjustable schedule through the building automation systems for days, times, and ventilation set points.
3. Ventilation Control
 - a. VAV-1
 - 1) VAV-1 shall modulate as required to maintain the scheduled outside air flow rate 24/7.
 - b. VAV-2-7
 - 1) VAV-2,3&4 shall modulate as required to maintain the scheduled ventilation rates in each space.
 - 2) VAV-5,6&7 shall modulate to match the airflow rate of their corresponding VAV box.
 - 3) The DDC system shall continuously monitor the space air CO₂ level. If the reading of the sensor is below 800 PPM (adj.), the space's corresponding VAV shall be positioned to supply the Minimum DCV OA Flow Rate (CFM).
 - 4) If the reading of the space CO₂ sensors exceeds 850 PPM (adj.), the VAV shall open from Minimum DCV OA Flow Rate (CFM) to the Maximum OA Flow Rate (CFM) at a rate of 1% damper position per 3 minutes until the CO₂ sensor reads below 900 PPM (adj.).
 - 5) If the reading of the space CO₂ sensor reads below 750 PPM (adj.) and the OA reading is above the Minimum DCV OA Flow Rate (CFM) position, the damper shall close at a rate of 1% damper position per 3 minutes until the CO₂ sensor reads above 800 PPM (adj.).
 - 6) The space sensor shall be provided with an occupancy sensor for the associated spaces. If the space occupancy sensor detects the space is unoccupied, the associated VAVs shall close.
4. Humidity control operation - Controller shall modulate air flow from minimum to maximum per the equipment schedule to maintain the space humidity set point.
5. Provide wall mounted space sensors where indicated.

B. Generator Room

1. General: All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.
2. Upon startup of generator, outside air dampers and exhaust air dampers shall open. If dampers do not open, send critical alarm to the operator's workstation.
3. Generator bypass damper shall modulate to maintain 70°F (adj.) in the generator room as sensed by the space temperature sensor.

C. Cabinet Unit Heaters (CUH):

1. General: All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.
2. The DDC shall monitor the space temperature. If the outside air temperature is below the schedule temperature, the shall be enabled. If the space temperature drops below set point for a period of 30 seconds (adj.) the DDC system shall start the fan and heating control. Once the space temperature has been satisfied for a period of 1 minute (adj.) the unit shall stop.
 - a. CUH-1
 - 1) Outside Air Enable Temperature: 60°F (adj.)
 - 2) Heating Set Point: 65°F (adj.)
 - b. CUH-2
 - 1) Outside Air Enable Temperature: 40°F (adj.)
 - 2) Heating Set Point: 40°F (adj.)
3. Alarms:
 - a. If the BMS system detects a space sensor failure, an alarm shall be sent to the operator's workstation.
 - b. If the space temperature is 5°F (adj.) higher than the set point and the fan is enabled, an alarm will be sent to the operator's workstation.
 - c. If the space temperature is 5°F (adj.) below set point for a period of 5 minutes (adj.) and the outdoor air temperature is below 55°F (adj.), an alarm will be sent to the operator's workstation.

D. In-floor radiant heating zones (RF-1 - 4):

1. General: All control set points noted in this sequence shall be user adjustable and shall be tuned during system start up and commissioning for proper system operation.
2. The DDC shall monitor the space temperature. If the outside air temperature is below 55°F (adj.) the pump shall operate. If the space temperature drops below set point for a period of 30 seconds (adj.) the DDC system shall modulate the control valve open.
 - a. Occupied Space Heating Set Point: 68°F (adj.)
 - b. Apparatus Heating Set Point: 60°F (adj.)
3. Outside air reset schedule:

- a. The hot water loop shall be controlled on a reset schedule. The DDC system shall sense outside air temperature, and shall modulate the hot water 3-way valve to maintain a slab temperature of the following parameters; maximum 80 degrees F (adj.) at outdoor temperature of 0 degrees F (adj.), and minimum 60 degrees F (adj.) at outdoor temperature of 55 degrees F (adj.), with a straight line relationship
4. Alarms:
 - a. If the BMS system detects a space sensor or slab sensor failure, an alarm shall be sent to the operator's workstation.
 - b. If the space temperature is 5°F (adj.) higher than the set point and the pump is enabled, an alarm will be sent to the operator's workstation.
 - c. If the space temperature is 5°F (adj.) below set point for a period of 5 minutes (adj.) and the outdoor air temperature is below 55°F (adj.), an alarm will be sent to the operator's workstation.
- E. Destratification Fans:
 1. The fan shall be controlled during the occupied/unoccupied modes by the BMS, through an owner directed time schedule.
 2. Unoccupied Mode:
 - a. The "Time of Day" program shall cause the fan to go to unoccupied mode settings when called for by the schedule program and the fan shall be disabled.
 3. Heating Season, Occupied Mode:
 - a. The "Time of Day" program shall allow the fans to be energized. Fan control shall be through the BMS to modulate proportionally to differential temperature within the space. The fan shall operate at 100% speed for a differential temperature 15 degrees F (adj.) and greater to 0% speed at differential temperatures 5 degrees F (adj.) with a linear relationship in between.
 4. The destratification fans shall not operate when outdoor air temperature is greater than 60 degrees F (adj.)
- F. Exhaust fans (EF-2):
 1. Exhaust Fan (Mechanical Equipment Rooms): The exhaust fan shall be controlled via the Direct Digital Control system (DDC). The exhaust fans shall be started and shall run as required to maintain the space temperature set point, 85°F (adj.). Any associated dampers shall be open. If status of the fan, which has been started by the DDC System, has not been verified as running within a period of 10 seconds, an alarm shall be sent to the operator's workstation.

1.8 ALARMS

A. Heat Pump System Primary Loop Low Temperature Alarm

1. When the system is in the winter mode, and the primary loop supply temperature falls below 25 degrees F (adj.) for a period of 10 minutes (adj.), an alarm shall be sent to the operator's workstation. The alarm shall be tagged as a "HEAT PUMP WATER LOOP TEMPERATURE LOW LIMIT ALARM".

B. Hot Water System Primary Loop Low Temperature Alarm

1. When the system is in the winter mode, and the primary loop supply temperature falls below 100 degrees F (adj.) for a period of 10 minutes (adj.), an alarm shall be sent to the operator's workstation. The alarm shall be tagged as a "PRIMARY HOT WATER LOOP TEMPERATURE LOW LIMIT ALARM".

C. Fan Failure

1. If status of a fan, which has been called by the DDC system to start, has not been verified as running within a period of 10 seconds (adj.), an alarm shall be sent to the operator's workstation. The fan shall be identified by its designation (AHU-#) or by a description of what it serves. (RTU-# supply fan) and shall be tagged as a "FAN FAILURE".

D. Exhaust Air Fan Failure

1. If status of a fan, which has been called by the DDC systems to start, has not been identified as running within a period of 10 seconds (adj.), an alarm shall be sent to the operator's workstation. The fan shall be identified by its designation (EF-#) or by a description of what it serves and shall be tagged as an "EXHAUST FAN FAILURE".

E. Pump Failure

1. If status of a pump, which has been called by the DDC systems to start, has not been identified as running within a period of 10 seconds (adj.), an alarm shall be sent to the operator's workstation. The pump shall be identified by its designation (P-#) or by a description of what it serves and shall be tagged as a "PUMP FAILURE".

F. High Space Temperature Alarm

1. If the space temperature is offset by more than 5 degrees F (adj.) above setpoint for a period of 5 minutes (adj.) an alarm shall be sent to the operator's workstation. The unit shall be identified by its room location (Room #) and shall be tagged as a "SPACE TEMPERATURE HIGH LIMIT ALARM".

G. Low Space Temperature Alarm

1. If the space temperature is less than 5 degrees F (adj.) below setpoint for a period of 5 minutes (adj.) an alarm shall be sent to the operator's workstation. The unit shall be identified by its room location (Room #) and shall be tagged as a "SPACE TEMPERATURE LOW LIMIT ALARM".

H. High Space Carbon Dioxide (CO2) Alarm

1. If the space CO2 levels reach 10% above setpoint for a period of 5 minutes (adj.) an alarm shall be sent to the operator's workstation. The unit shall be identified by its room location (Room #) and shall be tagged as a "CARBON DIOXIDE HIGH LIMIT ALARM".

I. Mechanical Room Low Space Temperature Alarm

1. If the space temperature drops below 45 degrees F (adj.) for a period of 5 minutes (adj.) an alarm shall be sent to the operator's workstation. The unit shall be identified by its room location (Room #) and shall be tagged as a "MECHANICAL ROOM SPACE TEMPERATURE LOW LIMIT ALARM".

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION (Not Applicable)

END OF SECTION

SECTION 232113 - HYDRONIC 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. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Heat pump piping
 - 3. Makeup-water piping.
 - 4. Condensate-drain piping.
 - 5. Air-vent piping.
 - 6. Safety-valve-inlet and -outlet piping.
- B. Related Sections:
 - 1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.
 - 2. Division 23 Section "General-Duty valves."
 - 3. Division 23 Section "HVAC hydronic piping specialties."

1.3 DEFINITIONS

- A. PTFE: Polytetrafluoroethylene.

1.4 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Hot-Water Heating Piping: 150 psig at 210 deg F.
 - 2. Heat-pump piping: 150 psig at 150 deg F
 - 3. Makeup-Water Piping: 150 psig at 150 deg F.
 - 4. Condensate-Drain Piping: 150 deg F.
 - 5. Blowdown-Drain Piping: 200 deg F.
 - 6. Air-Vent Piping: 200 deg F.
 - 7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Piping
 - 2. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 3. Air control devices.
 - 4. Glycol Make-up Unit including a wiring diagram.
 - 5. Escutcheons and floor plates.
- B. Provide piping schedule indicating type of intended installation and installation location. Refer to piping schedule below.
- C. Coordination Drawings: Plans and other details, drawn to scale, on which components are shown and coordinated with each other, using input from installers of the items involved. Refer to Specification Section 230010 General Mechanical Requirements for further information.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For Installer.
- B. Welding certificates.
- C. Field quality-control test reports.

1.7 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- D. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied from the same manufacturer as the grooved components. Provide training certificate documenting training by manufacturer's field representative per section 3.5.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. DWV Copper Tubing: ASTM B 306, Type DWV.
- C. Fittings (Tees, Elbows, Reducers, etc): Wrought copper or cast bronze as called for in Part 3.1; solder end connections; shall meet applicable ASTM standards F 1974, B16.24 and applicable ASME standards B16.15, B16.18, B16.22, B16.26, and B16.51.
- D. Unions and Flanges: Use unions, solder type, cast bronze, ground joint, 150 lb swp.

2.2 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- C. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- D. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.
 - 3. Facings: Raised face.
- E. Grooved Mechanical-Joint Fittings and Couplings:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic Company
 - b. Anvil International, Inc.
 - c. Central Sprinkler Company; a division of Tyco Fire & Building Products.
 - d. National Fittings, Inc.
 - e. S. P. Fittings; a division of Star Pipe Products.
 - 2. Joint Fittings: ASTM A 536, Grade 65-45-12 ductile iron;; ASTM A 53/A 53M, Type F, E, or S, Grade B fabricated steel; or ASTM A 106, Grade B steel fittings with grooves or shoulders constructed to accept grooved-end couplings; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.
 - 3. Couplings: Ductile-iron housing and synthetic rubber gasket of central cavity pressure-responsive design; with nuts, bolts, locking pin, locking toggle, or lugs to secure grooved pipe and fittings.

- a. Rigid Type: Housings shall be cast with offsetting, angle-pattern bolt pads to provide system rigidity and support and hanging in accordance with ASME B31.1 and B31.9.
 - 1) 2" through 8": "Installation Ready" stab-on design, for direct 'stab' installation onto grooved end pipe without prior field disassembly and no loose parts. Gasket shall be Grade "EHP" EPDM suitable for hot water up to 250 deg F.
 - b. Couplings do not replace the need for flex connections and specialties
- F. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.3 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Welding Filler Metals: Comply with AWS D10.12/D10.12M for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- E. Gasket Material: Thickness, material, and type suitable for fluid to be handled and working temperatures and pressures.

2.4 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.
- B. Dielectric Unions:
 - 1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
 - 2. Description:
 - a. Standard: ASSE 1079.
 - b. Pressure Rating: 125 psig minimum at 180 deg F.
 - c. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Description:
 - a. Standard: ASSE 1079.
 - b. Factory-fabricated, bolted, companion-flange assembly.
 - c. Pressure Rating: 125 psig minimum at 180 deg F.
 - d. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

D. Dielectric-Flange Insulating Kits:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Description:
 - a. Nonconducting materials for field assembly of companion flanges.
 - b. Pressure Rating: 150 psig.
 - c. Gasket: Neoprene or phenolic.
 - d. Bolt Sleeves: Phenolic or polyethylene.
 - e. Washers: Phenolic with steel backing washers.

E. Dielectric Nipples:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Description:
 - a. Standard: IAPMO PS 66
 - b. Electroplated steel nipple, complying with ASTM F 1545.
 - c. Pressure Rating: 300 psig at 230 deg F.
 - d. End Connections: Male threaded or grooved.
 - e. Lining: Inert and noncorrosive, propylene.

2.5 PIPING ACCESSORIES

- A. Escutcheon Plates: Steel type with chrome-plated finish, split hinge type with setscrew, high plates where required for extended sleeves.
- B. Floor plates: Split floor plate, cast iron flange with holes for fasteners.

PART 3 - EXECUTION

3.1 PIPING APPLICATIONS

- A. Hot-water heating piping, aboveground, NPS 2-1/2 and smaller, shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- B. Hot-water heating piping, aboveground, NPS 3 and larger, shall be one of the following:
 - 1. Schedule 40 steel pipe, wrought-steel flanged fittings and joints
 - 2. Schedule 40 steel pipe, welded fittings and joints
 - 3. Schedule 40 steel pipe, grooved mechanical joints couplings and fittings, and grooved mechanical joints. Provide rigid couplings.
- C. Heat pump-water piping, aboveground, NPS 2-1/2 and smaller, shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- D. Heat pump-water piping, aboveground, NPS 3 and larger, shall be the following:
 - 1. Schedule 40 steel pipe, wrought-steel flanged fittings and joints
 - 2. Schedule 40 steel pipe, welded fittings and joints
 - 3. Schedule 40 steel pipe, grooved mechanical joints couplings and fittings, and grooved mechanical joints. Provide rigid couplings
- E. Condensate-Drain piping installed aboveground shall be one of the following:
 - 1. Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
 - 2. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints
- F. Makeup-water piping installed aboveground shall be the following:
 - 1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- G. Blowdown-Drain Piping: Type DWV, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
- H. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed with metal-to-plastic transition fittings for plastic piping systems according to piping manufacturer's written instructions.
- I. Air-Vent Piping:
 - 1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
 - 2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints

3.2 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- E. Install piping to permit valve servicing.
- F. Install piping at indicated slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
 - 1. Provide 45 deg lateral fittings and clean out cap on condensate piping 1-1/4" and larger to accommodate cleanout of piping.
- I. Install piping to allow application of insulation.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- K. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- L. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and short NPS 3/4 threaded nipple with cap, at low points in piping system mains and elsewhere as required for system drainage.
- M. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- N. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- O. Install branch connections to mains using tee fittings in main pipe, with the branch connected to the bottom of the main pipe. For up-feed risers, connect the branch to the top of the main pipe.
- P. Install valves according to Section 230523 "General-Duty Valves for HVAC Piping."
- Q. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- R. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.

- S. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- T. Identify piping as specified in Section 230553 "Identification for HVAC Piping and Equipment."
- U. Install shutoff valve immediately upstream of each dielectric fitting.
- V. Install sleeve seals for piping penetrations of concrete walls and slabs. Comply with requirements for sleeve seals specified in Section 230517 "Sleeves and Sleeve Seals for HVAC Piping."
- W. Install escutcheons and floor plates for exposed piping penetrations of walls, ceilings, and floors. Comply with requirements for escutcheons.
 - 1. Install escutcheons for piping with ID to closely fit around pipe, tube, and insulation pipef and with OD that completely covers the opening.
 - 2. Install floor plates for piping penetrations of equipment room floors. Install floor plates with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers the opening.

3.3 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2-1/2 and Smaller: Use dielectric nipples or unions.
- C. Dielectric Fittings for NPS 3 to NPS 4: Use dielectric flanges.
- D. Dielectric Fittings for larger than NPS 4: Use dielectric flange insulating kits.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal piping less than 20 feet long.
 - 2. Adjustable roller hangers and spring hangers for individual horizontal piping 20 feet or longer.
 - 3. Pipe Roller: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
 - 4. Spring hangers to support vertical runs.
 - 5. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for steel piping with the following maximum spacing and minimum rod sizes:

1. NPS 3/4: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 2. NPS 1: Maximum span, 7 feet; minimum rod size, 1/4 inch.
 3. NPS 1-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 4. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 5. NPS 2-1/2: Maximum span, 11 feet; minimum rod size, 3/8 inch.
 6. NPS 3: Maximum span, 12 feet; minimum rod size, 3/8 inch.
- D. Install hangers for drawn-temper copper piping with the following maximum spacing and minimum rod sizes:
1. NPS 3/4: Maximum span, 5 feet; minimum rod size, 1/4 inch.
 2. NPS 1: Maximum span, 6 feet; minimum rod size, 1/4 inch.
 3. NPS 1-1/2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 4. NPS 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 3/8 inch.
 6. NPS 3: Maximum span, 10 feet; minimum rod size, 3/8 inch.
- E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.5 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel or groove plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- D. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- E. Welded Joints: Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- F. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- G. Grooved Joints: Assemble joints with coupling and gasket, lubricant, and bolts. Cut or roll grooves in ends of pipe based on pipe and coupling manufacturer's written instructions for pipe wall thickness. Use grooved-end fittings and rigid, grooved-end-pipe couplings. Grooved joint piping systems shall be installed in accordance with the manufacturer's guidelines and recommendations. All grooved couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved

components. The gasket style and elastomeric material (grade) shall be verified as suitable for the intended service as specified. Grooved end shall be clean and free from indentations, projections, and roll marks in the area from pipe end to groove for proper gasket sealing. A factory-trained field representative shall provide on-site training for contractor's field personnel in the proper use of grooving tools and installation of grooved piping products. Factory-trained representative shall periodically review the product installation. Contractor shall remove and replace any improperly installed products.

3.6 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections. Provide reducer at unit prior to final connection.
- B. Install control valves in accessible locations close to connected equipment
- C. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Section 230519 "Meters and Gages for HVAC Piping."
- D. Provide Glycol Make-up Unit. Installation in accordance with the manufacturer's recommendations and as per submitted wiring diagrams. Provide pressure gauge on the system side of the pressure reducing valve. Confirm unit operation including low pressure at pump activates and system pressure maintained by unit. Also, confirm operation of low level cutout and alarm interface with building alarm system. Provide all control wiring of equipment as part of division 23 contract. Wiring shall meet the requirements set forth by the equipment suppliers approved wiring diagram.

3.7 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - a. The entire closed loop system shall be cleaned to remove cutting oils, scale deposits, oxides and other fouling as has determined by the water treatment provider. A water meter shall be installed on the supply line as the system is being filled with water so that an accurate system volume can be determined. A non-acid solution of dispersants such as M.I.S of America, Inc. formula 6200NAC or approved equal, shall be added at a rate of one gallon to 500 gallons of system water. This solution shall be circulated for a minimum of 8 hours. This solution shall be tested by a water treatment consultant to insure the proper dispersant level is being maintained. After the solution has been circulated for a minimum of 8 hours the entire system shall be drained and flushed. A second analysis of the flush water shall be made to insure all of the cleaner is removed and that the system is clean.

4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
- B. Using new materials, replace broken and damaged escutcheons and floor plates.
- C. Perform the following tests on hydronic piping:
1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 3. Isolate expansion tanks and determine that hydronic system is full of water.
 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure, but not less than 100 psi for duration of 60 min. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
 5. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing.
- D. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Verify all air has been removed from the system and continuous water flow from each air vent. This includes all equipment associated with the loop that may have been affected by the work performed.
 6. Set temperature controls so all coils are calling for full flow.
 7. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 8. Verify lubrication of motors and bearings.

END OF SECTION 232113

SECTION 232113.33 - GROUND-LOOP HEAT-PUMP PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Ground-coupled heat exchanger and connections to building piping system, serving:
 - 1. Hydronic piping system specified in Section 232113.

1.02 RELATED REQUIREMENTS

- A. Section 232113 - Hydronic Piping: Building heating piping system.
- B. Section 312316.26 - Rock Removal: Procedures for removal of rock during execution of work of this section.

1.03 REFERENCE STANDARDS

- A. APHA (EWWW) - Standard Methods for the Examination of Water and Wastewater.
- B. ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications.
- C. ASTM D92 - Standard Test Method for Flash and Fire Points by Cleveland Open Cup Tester.
- D. ASTM D1177 - Standard Test Method for Freezing Point of Aqueous Engine Coolants.
- E. ASTM D2683 - Standard Specification for Socket-Type Polyethylene Fittings for Outside Diameter-Controlled Polyethylene Pipe and Tubing.
- F. ASTM D2837 - Standard Test Method for Obtaining Hydrostatic Design Basis for Thermoplastic Pipe Materials or Pressure Design Basis for Thermoplastic Pipe Products.
- G. ASTM D3035 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter.
- H. ASTM D3261 - Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing.
- I. ASTM D3350 - Standard Specification for Polyethylene Plastics Pipe and Fittings Material.
- J. ASTM F714 - Standard Specification for Polyethylene (PE) Plastic Pipe (DR-PR) Based on Outside Diameter.
- K. ASTM F1055 - Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene and Crosslinked Polyethylene (PEX) Pipe and Tubing.
- L. ASTM F1105 - Standard Practice for Preparing Aircraft Cleaning Compounds, Liquid-Type, Temperature-Sensitive, or Solvent-Based, for Storage Stability Testing.
- M. EPA 712-C-02-190 - Health Effects Test Guidelines OPPTS 870.1100 Acute Oral Toxicity.
- N. IGSHPA (GROUT) - Grouting Procedures for GHP Systems; International Ground Source Heat Pump Association.

- O. IGSHPA (INSTALL) - Closed-Loop/Geothermal Heat Pump Systems Design and Installation Standards; International Ground Source Heat Pump Association.
- P. NFPA 704 - Standard System for the Identification of the Hazards of Materials for Emergency Response.
- Q. PPI TR-4 - PPI Listing of Hydrostatic Design Basis (HDB), Hydrostatic Design Stress (HDS), Strength Design Basis (SDB), Pressure Design Basis (PDB), and Minimum Required Strength (MRS) Ratings For Thermoplastic Piping Materials or Pipe.
- R. USGS (FMWQ) - National Field Manual for the Collection of Water-Quality Data; United States Geological Survey.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Preinstallation Meeting: Convene one week before starting work of this section. Require attendance by all installers involved with site work and HVAC work.
- C. Product data, design calculations, building energy model, engineering shop drawings and test report shall be signed and stamped by a New York State PE and submitted to the engineer of record.
- D. Product Data, Polyethylene Piping: Provide manufacturer's data for piping and pipe fittings, showing compliance with specified requirements.
 - 1. Provide manufacturer's recommendations for fusion jointing.
 - 2. Include certification of long term hydrostatic basis, or test reports.
- E. Product Data, Heat Exchange Fluid: Provide data showing compliance with specified requirements.
 - 1. Provide manufacturer's Material Data Safety Sheets.
 - 2. Provide results of biodegradability studies conducted in accordance with APHA (EWWW):
 - a. Statement of ecological behavior.
 - b. Total oxygen demand, in pounds of oxygen per pound of fluid.
 - c. Percent of fluid degraded in five days.
- F. Product Data, Grout and Slurry: Provide information on thermal conductivity of proposed materials.
- G. Test well: Perform test well as required to design geothermal well system. Test well to include all drilling, looping, grouting, cuttings & water management. Test well shall be performed for 48 hours. Provide report to engineer of record.
- H. Shop Drawings: Show complete piping layout, water table, water level, depths of excavation, final depths of piping, backfill placement, point of entrance to building, point of connection to equipment, test point locations, and fittings used for all joints and connections.
- I. Design Calculations: Submit all stamped and sealed design calculations along with drawings.
- J. Samples: Provide one 2-inch length of pipe in selected size.
- K. Soil and Rock Samples: Provide one sample from the area of proposed installation.

- L. Test Reports, Soil: Indicate test methods and results for all tests performed on soil samples to determine stability, conductivity, and thermal values.
- M. Test Reports, Piping: Indicate test method and results of hydrostatic pressure tests.
- N. Record Documents: Record actual locations of all underground piping installed relative to Owner's permanent structure on same property.
- O. Operation and Maintenance Data: Provide procedures for pressurizing, charging, and isolation for equipment replacement.

1.05 QUALITY ASSURANCE

- A. Designer Qualifications: NYS Licensed Professional Engineer, regularly engaged in the design of systems of the type and capacity specified in this section, with not less than five years of documented experience, and accredited by IGSHPA.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum 5 years of documented experience and accredited by IGSHPA.
- C. Heat Fusion Technician Certification: Qualified in accordance with 49 CFR 192.285, certified within three years from the date of project commencement.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver piping and fittings to project site in shipping containers with labeling in place.
 - 1. Verify that labels on piping indicate manufacturer's name, pipe or tube size, and PE cell classification.
 - 2. Verify that piping complies with specifications and is undamaged.
- B. Deliver chemicals for heat exchange fluid to project site in unopened shipping containers with labeling in place; comply with local and state regulations.
- C. Protect from weather, humidity and temperature variations, dirt and dust, and other environmental contaminants.
- D. Store piping capped or plugged until time of installation.

PART 2 PRODUCTS

2.01 GROUND LOOP HEAT EXCHANGER SYSTEM

- A. Contractor is responsible for design and execution of the closed-system ground-coupled heat exchanger, to the requirements of and within the limitations of Contract Documents.
 - 1. Design in accordance with methodology in IGSHPA (INSTALL) - Geothermal Heat Pump Systems Design and Installation Standards or ASHRAE (HVACA) - ASHRAE Handbook - HVAC Applications, Geothermal Energy Chapter.
 - 2. Design heat exchanger to comply with heat pump manufacturer's specifications and operating requirements.
 - 3. Circulator pumps, plate and frame water to water heat exchangers, utilization equipment, gauges, and sensors are specified elsewhere and are the responsibility of this designer.

- a. Plate and Frame heat exchangers design and specification shall be the responsibility of this designer. Building load side allowance of 10 psi pressure drop used for sizing pumps serving the heat pumps.
 - b. Allowance for geothermal circulator pumps of 7.5 HP, 208/3, provided. Notify engineer of record of any differences.
- 4. Provide an IGSHPA registered system, with certificate and label.
- B. Heat Exchanger Configuration: Closed system; polyethylene piping in vertical boreholes located adjacent to building, as indicated on drawings.
 - 1. Borehole Dimensions and Spacing: As required to achieve specified performance.
- C. Heat Exchanger Performance:
 - 1. Peak Heat Transfer Capacity for Heating: 378k Btuh.
 - 2. Peak Heat Transfer Capacity for Cooling: 253k Btuh
 - 3. Peak Heat Transfer Capacity for Domestic Water Heating: 171k Btuh.
 - 4. Minimum Winter Temperature of Fluid (Winter Inlet Temperature): 40 degrees F.
 - 5. Maximum Summer Temperature of Fluid (Summer Inlet Temperature): 85 degrees F.
 - 6. System shall be designed to not drift outside of the minimum and maximum operating temperatures for a 30 year period.

2.02 MATERIALS

- A. Pipe: High density polyethylene pipe, type PE3408, PE3608, or PE4710, with minimum ASTM D3350 cell classification of PE345364C.
 - 1. Pipe Used in Vertical Bore Applications: Comply with ASTM D3035 with minimum working pressure rating of 160 psi.
 - 2. Other Pipe of 3 Inches Diameter and Larger: Comply with ASTM D3035 or ASTM F714, with minimum working pressure rating of 100 psi.
 - 3. Other Pipe 1.25 Inches But Less Than 3 Inches In Diameter (Nominal): Comply with ASTM D3035 with minimum working pressure rating of 110 psi.
 - 4. Other Pipe Less Than 1.25 Inches in Diameter (Nominal): Comply with ASTM D3035 with minimum working pressure rating of 160 psi.
 - 5. Long Term Hydrostatic Design Basis: 1600 psi at 73 degrees F, when tested in accordance with ASTM D2837; appropriate listing in current edition of PPI TR-4 will constitute evidence of compliance with this requirement; otherwise, submit independent test results.
 - 6. Joints and Fittings: Polyethylene of same type as pipe, of sizes and types suitable for the pipe being used; use only heat fusion or stab-type mechanical fittings that are quality controlled to provide a leak-free union between piping ends that is stronger than the piping itself. Do not use other barbed fittings or hose clamps.
 - a. Electrofusion Type Fittings: Comply with ASTM F1055.
 - b. Butt Fusion Fittings: Comply with ASTM D3261.
 - c. Socket Type Fittings: Comply with ASTM D2683.
 - d. Where threaded fittings must be used for connection to equipment or dissimilar piping, use fittings and thread sealant compatible and effective with antifreeze used.
- B. Heat Exchange Fluid: Any type that meets the following criteria and complies with requirements of authorities having jurisdiction.
 - 1. Compatible with heat pump equipment.
 - 2. Biodegradability: Minimum 90 percent.
 - 3. Flash Point: 194 degrees F, when determined in accordance with ASTM D92, minimum.

4. Biological Oxygen Demand: 0.2 gram oxygen per gram, maximum; 0.1 gram oxygen per gram, minimum; when tested for five days at 50 degrees F in accordance with USGS (FMWQ).
 5. Freezing Point: 8 degrees F, as determined in accordance with ASTM D1177, maximum.
 6. Toxicity: LD 50 (oral-rats) of 5 g/kg, maximum, when tested in accordance with EPA 712-C-02-190.
 7. Toxicity, Hazardous Material Rating: 1, maximum, as determined in accordance with NFPA 704.
 8. Storage Stability: No separation from exposure to heat or cold, and no increase in turbidity, when tested in accordance with ASTM F1105.
- C. Detectable Underground Tape: Magnetic detectable conductor in 2 inch wide rot-resistant plastic tape or mesh, brightly colored, imprinted with "Water Line" in large letters.
- D. Backfill for Vertical Boreholes: Bentonite.

PART 3 EXECUTION

3.01 EXAMINATION AND PREPARATION

- A. Verify location of existing structures and utilities prior to excavation.
- B. Verify soil composition and rock depth, if any, before beginning excavation.
- C. Protect adjacent structures from the effects of excavation.
- D. Verify that layout dimensions are correct and that available land is sufficient for design.
- E. Notify Engineer of Record of unsatisfactory conditions.
- F. Do not proceed with installation until unsatisfactory conditions have been corrected.
- G. Coordinate work with site grading, site backfilling, and foundation construction.

3.02 EXCAVATION

- A. Excavate in accordance with requirements of authorities having jurisdiction.
- B. Remove rock; see Section 312316.26.
- C. Vertical Boreholes: Drill to depths required.
 1. Minimize over-drilling; fill over-drilled areas with backfill or excavated materials.
 2. Piping: Assemble heat exchanger piping and test before installation.
- D. Trenches: Excavate trenches for piping to lines and grades as required.
 1. Minimize over-excavation; fill over-excavated areas with backfill or excavated materials.
 2. Excavate to accommodate grade changes.
 3. Maintain trenches free of debris, material, and obstructions that may damage pipe.
 4. Piping: Assemble heat exchanger piping and test before backfilling.
 5. All piping shall be at minimum 5ft below grade.

3.03 POLYETHYLENE PIPING

- A. Join piping and fittings using heat fusion or electrofusion; do not use solvents, adhesives, or mechanical fittings.
- B. Provide flanges or unions to connect heat exchanger piping to equipment or piping of different type; locate all transitions between piping of different types inside the building or otherwise accessible (i.e. above grade).
- C. Keep dirt, water, and debris out of pipe assemblies; cap or plug open ends until connected to adjacent piping.
- D. Do not bend piping to shorter radius than recommended by pipe manufacturer; do not kink piping; use elbow or other fittings for sharp bends.
- E. Partially backfill radius bends in narrow trenches by hand to ensure that piping is properly supported and to prevent kinking.
- F. Test piping to be installed in boreholes after assembly but before installation in boreholes; re-cap tested assemblies before installation.
- G. Test piping to be installed in trenches after installation but before backfilling.
- H. Testing: Perform hydrostatic test on all piping; portions of assembled piping may be tested separately.
 - 1. Prior to testing, isolate piping from all connections to building systems.
 - 2. Flush all dirt and debris using potable water flowing at twice the normal operating flow rate for a minimum of four hours or until no dirt or debris is visible, whichever is longer.
 - 3. Plug or cap piping.
 - 4. Pressurize piping to 150 psi for 30 minutes and monitor.
 - 5. If there is any pressure loss or visible leakage, identify leak and repair in accordance with manufacturer's recommendations.
 - 6. Repeat test until there is no loss of pressure for the duration of the test.
- I. Where piping passes through foundation walls, provide sleeves sealed with non-hardening, waterproof material.
- J. After connection of piping to building systems and installation of equipment served by heat exchanger, fill piping with heat exchange fluid and pressurize.
 - 1. Water Temperature of 70 to 90 degrees F: Pressurize to 20 to 30 psi, minimum.
 - 2. Water Temperature of 40 to 50 degrees F: Pressurize to 40 to 50 psi, minimum.
 - 3. If adequate flooding of circulating pump can be accomplished without pressurization and pump manufacturer approves, pressurization is not required.
 - 4. After pressurization, remove charging valve handles, or plug ports, whichever is applicable, and deliver handles to Owner.
 - 5. Install system label at charging valves, indicating:
 - a. Heat exchange fluid, including antifreeze type and concentration.
 - b. Service date.
 - c. Company name.
 - d. Company phone number and responsible person.

3.04 BACKFILLING

- A. Install in compliance with local authorities having jurisdiction.

B. Vertical Boreholes: Backfill after pipe installation in accordance with IGSHPA (GROUT) - IGSHPA Grouting Procedures for GHP Systems.

C. Trenches:

1. Provide minimum 60 inch cover over piping.
2. Backfill trenches after pipe has been installed and tested, using suitable backfill per piping manufacturer's installation guidelines.
3. Install detectable tape with integral tracer wire continuously 6 inches above top of all buried pipe.
4. Backfill and compact using the procedures specified in Section 312316.13.
5. Backfill to original grades with sufficient overfill to allow for settlement.

D. Protect piping from displacement.

3.05 CLEANING

A. Leave adjacent paved areas broom clean.

B. Clear debris, including excess backfill and excavated dirt and rock, from heat exchanger area.

3.06 PROTECTION

A. Protect area during excavation from excess runoff and erosion.

B. Protect pipe protrusions from damage until connections to building systems are installed.

1. Initial test well shall be protected against damage during construction and site excavation.

END OF SECTION 232113.33

SECTION 232114 - HYDRONIC PIPING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes special-duty valves and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Heat pump piping
 - 3. Makeup-water piping.
 - 4. Condensate-drain piping.
 - 5. Blowdown-drain piping.
 - 6. Air-vent piping.
- B. Safety-valve-inlet and -outlet piping Related sections
 - 1. Section 230553 "Identification for HVAC Piping and Equipment" for valve tags and schedules.
 - 2. Division 23 Section "General-Duty valves."

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of the following:
 - 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 - 2. Air control devices.
 - 3. Hydronic specialties.
- B. Provide valve and hydronic specialties schedule indicating type of intended installation and installation location. Refer to schedule below.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.5 MAINTENANCE MATERIAL SUBMITTALS

- A. Differential Pressure Meter: For each type of balancing valve and automatic flow control valve, include flowmeter, probes, hoses, flow charts, and carrying case.

1.6 QUALITY ASSURANCE

- A. Pipe Welding: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 - 1. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- B. To assure uniformity and compatibility of piping components in grooved piping systems, all grooved products utilized shall be supplied by a single manufacturer. Grooving tools shall be supplied from the same manufacturer as the grooved components.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and operating temperature:
 - 1. Hot-Water Heating Piping: 150 psig at 210 deg F.
 - 2. Heat-pump piping: 150 psig at 150 deg F
 - 3. Makeup-Water Piping: 150 psig at 150 deg F.
 - 4. Condensate-Drain Piping: 150 deg F.
 - 5. Blowdown-Drain Piping: 200 deg F.
 - 6. Air-Vent Piping: 200 deg F.
 - 7. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

2.2 VALVES

- A. Gate, Check, and Ball valves: Comply with requirements specified in Section 230523 "General-Duty Valves" for HVAC Piping.
- B. Automatic Temperature-Control Valves, Actuators, and Sensors: Comply with requirements specified in Section 230900 "Instrumentation and Control for HVAC.
- C. Automatic Flow-Control Balancing Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Flow Design Inc.
 - b. Griswold Controls.
 - c. Nexus Valve, Inc.
2. Description: Balancing valve to consist of a spring loaded cartridge that dynamically absorbs pressure fluctuations resulting from changing flow conditions due to varying heating/cooling loads. These fluctuations in pressure do not change the flow through the valve. Flow is to be controlled within a +/- 5% of the design flow. Additional balancing is not required.
3. Body: Brass or ferrous metal.
4. Piston and Spring Assembly: 304 Stainless steel, tamper proof, self cleaning, and removable.
5. Identification Tag: Marked with zone identification, valve number, and flow rate.
6. Size: Same as pipe in which installed.
7. Performance: Maintain constant flow, plus or minus 5 percent over system pressure fluctuations.
8. Minimum CWP Rating: 175 psig.
9. Maximum Operating Temperature: 200 deg F.
10. Body tapings: 1/4" NPT with P/T test valves

D. Bronze, Calibrated-Orifice, Balancing Valves:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Body: Bronze, ball or plug type with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Plug: Resin.
5. Seat: PTFE.
6. End Connections: Threaded or socket.
7. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
8. Handle Style: Lever, with memory stop to retain set position.
9. CWP Rating: Minimum 125 psig.
10. Maximum Operating Temperature: 250 deg F.

E. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:

1. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following:
2. Body: Cast-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
3. Ball: Brass or stainless steel.
4. Stem Seals: EPDM O-rings.
5. Disc: Glass and carbon-filled PTFE.
6. Seat: PTFE.
7. End Connections: Flanged or grooved.
8. Pressure Gauge Connections: Integral seals for portable differential pressure meter.
9. Handle Style: Lever, with memory stop to retain set position.
10. CWP Rating: Minimum 125 psig.

11. Maximum Operating Temperature: 250 deg F.

2.3 AIR-CONTROL DEVICES

- A. Performance: Subject to compliance with requirements and related documents, provide products meeting a minimum performance of the following
- B. Manual Air Vents:
 1. Body: Bronze.
 2. Internal Parts: Nonferrous.
 3. Operator: Screwdriver or thumbscrew.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/8.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 225 deg F.
- C. Automatic Air Vents:
 1. Body: Bronze or cast iron.
 2. Internal Parts: Nonferrous.
 3. Operator: Noncorrosive metal float.
 4. Inlet Connection: NPS 1/2.
 5. Discharge Connection: NPS 1/4.
 6. CWP Rating: 150 psig.
 7. Maximum Operating Temperature: 240 deg F.
- D. Diaphragm Type Expansion Tanks:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Taco, Inc.
 - b. Armstrong Pumps, Inc.
 - c. Bell & Gossett Domestic Pump.
 2. Shell: Fabricated steel designed and constructed per ASME Section VIII, Div 1
 3. Diaphragm- Heavy Duty Butyl
 4. Working pressure- 120 psig
 5. Operating temperature- 240 deg F
 6. Diaphragm: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
 7. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.
 8. Provide with stand and California sight glass
- E. Air and Dirt Separators:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Taco, Inc.
 - b. Armstrong Pumps, Inc.

c. Spirotherm

2. Air and dirt removal device shall be constructed of carbon steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 psi at 270°F. Manufacturer shall be holder of ASME U stamp.
3. Provide with flanged system connections as standard. Inlet and outlet connections to be inline with piping system. Both inlet and outlet to be in the same horizontal and vertical planes
4. Each air and dirt removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill
5. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator
6. A blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning. The valve and all openings shall be 2".
7. The air and dirt removal device shall remove air down to 18 microns and shall remove dirt/debris down to 35 microns. The unit shall be 100% efficient at removing dirt down to 90 microns in 100 passes or less.
8. Provide third party independent test data certifying that the unit performs to the above standards.
9. Provide 304 stainless steel coalescence pall ring basket and cage or equivalent technology and performance constructed of stainless steel to achieve optimal separation of air and dirt with minimal pressure drop.
10. Provide base ring stand
11. The unit shall be manufactured with a removable cover to facilitate removal, inspection, and cleaning of the pall ring basket. The entire pall ring basket shall be constructed of stainless steel. For safety and ease of service the unit shall be accessed from the top and the pall ring basket shall be accessed as one complete assembly housed in a stainless steel cage.
12. Provide units in sizes for full-system flow capacity

2.4 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

B. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.

5. Maximum Operating Temperature: 250 deg F

PART 3 - EXECUTION

3.1 VALVE APPLICATIONS

- A. Install shutoff-duty valves at each branch connection to supply mains and at supply connection to each piece of equipment.
- B. Install calibrated orifice balancing valves at each branch connection to return mains.
- C. Install automatic flow control balancing valves in the return pipe of each heating or cooling terminal.
- D. Install balancing valves as required to achieve flow tolerances required by Section 230593 Testing, Adjusting, and Balancing for HVAC.
- E. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- F. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1, for installation requirements.
- G. Install pressure-reducing valves at makeup-water connection to regulate system fill pressure.

3.2 HYDRONIC SPECIALTIES INSTALLATION

- A. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Install manual vents at heat-transfer coils and elsewhere as required for air venting.
- B. Install piping from heat pump outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- C. Install air and dirt separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.
- D. Install expansion tanks as indicated on drawings. Vent and purge air from hydronic system, and ensure that tank is properly charged with air to suit system Project requirements.
- E. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.

END OF SECTION 232116

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Close-coupled, in-line centrifugal pumps.
 - 2. Wet-rotor pumps.

1.3 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.6 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Mechanical Seals: One mechanical seal for each pump.

PART 2 - PRODUCTS

2.1 CLOSE-COUPLED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong.
 - 2. Bell & Gossett. (Basis of Design)
 - 3. Grundfos.
- B. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, close-coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally or vertically.
- C. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet and threaded companion-flange connections.
 - 2. Impeller: ASTM B584, cast bronze; statically and dynamically balanced, keyed to shaft, and secured with a locking cap screw. For constant-speed pumps, trim impeller to match specified performance.
 - 3. Pump Shaft: Steel, with copper-alloy shaft sleeve.
 - 4. Seal: Mechanical seal consisting of carbon rotating ring against a ceramic seat held by a stainless-steel spring, and EPT bellows and gasket. Include water slinger on shaft between motor and seal.
- D. Motor: Single speed and rigidly mounted to pump casing.
 - 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - a. Efficiency: Premium efficient.
- E. Accessories:
 - 1. Variable Frequency Drive: Refer to Section 232923 for requirements.

2.2 WET-ROTOR PUMPS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Armstrong.
 - 2. Bell & Gossett. (Basis of Design)

3. Grundfos.
- B. Description: Factory-assembled and -tested, wet-rotor pump with integral electronically commutated motor (ECM).
- C. Pump Construction:
1. The pumps shall be single stage, canned-rotor type, in-line design. Pump casing shall be constructed of cast iron. The pump casing / volute shall be rated for 175psi working pressure. The pump flanges shall be ANSI Class 125 flanges.
 2. All casings shall be flanged connections.
 3. The impeller and shaft shall be Class 304 stainless steel.
 4. The pump and motor form an integral unit without a mechanical seal. The bearings are lubricated by the pumped liquid.
- D. Motor:
1. The pumps shall be able to operate as single or parallel variable speed pumps, where the speed is regulated by an integrated ECM motor. The integrated electronics shall allow these pumps to run in parallel, standby or alternating modes.
 - a. Parallel pump communication via Ethernet cabling
 - b. 24 hour run time automatic operation
 - c. Main/standby operation in the event of failure
 - d. Simultaneous parallel operation as required by system demand
 2. The commissioning and set up of the pump shall be accessed via:
 - a. A web interface (data exchange) and use HTML 1.1 web language. The pump shall provide a port for a RJ-45 cable connection.
 - b. A user interface located on the face of the speed controller.
 - c. The user interface:
 - 1) Adjusts modes and mode values.
 - 2) LED display reads real time mode set values, flow, head, speed and power.
 - 3) Lockouts unauthorized adjustment of the pump.
 3. The electronics shall provide "Auto" as factory default whereas the slope of the proportional curve will automatically match the required system curve, constant pressure control (Δp -c), variable differential pressure control (Δp -v), and constant curve duty (uncontrolled pump), RPM regulation. RPM (speed) regulation can be accomplished by:
 - a. Manual (via user interface or HTML)
 - b. Remote via 0-10Vdc
 - c. Modbus RTU data protocol
 4. The pump electronics shall come standard with multiple digital inputs and one external digital output to be available for additional mechanical room control and pump status monitoring.
 5. The wiring / electronics enclosure shall be class 2, IP44.

6. Pumps shall meet UL 778, 1004-1, 508C,.
7. The pumps shall be electronically protected, be rated for continuous duty and have a built-in startup circuit. The pump electronics shall provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
8. The pump shall be capable of being monitored 24/7 via integrated internet link.
9. The pump must be driven by an electrically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets shall be time stable, non-toxic ceramic magnet. The electrically commuted electrical motor shall be driven by a frequency converter with an integrated PFC filter.

2.3 PUMP SPECIALTY FITTINGS

A. Suction Diffuser:

1. Angle pattern.
2. 175-psig pressure rating, ductile-iron body and end cap, pump-inlet fitting.
3. Bronze startup and bronze or stainless-steel permanent strainers.
4. Bronze or stainless-steel straightening vanes.
5. Drain plug.
6. Factory-fabricated support.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps to provide access for periodic maintenance including removing motors, impellers, couplings, and accessories.
- C. Independently support pumps and piping so weight of piping is not supported by pumps and weight of pumps is not supported by piping.
- D. Equipment Mounting:

- E. Equipment Mounting: Install in-line pumps with continuous-thread hanger rods and elastomeric hangers of size required to support weight of in-line pumps.
 - 1. Comply with requirements for hangers and supports specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."

3.3 CONNECTIONS

- A. Where installing piping adjacent to pump, allow space for service and maintenance.
- B. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- C. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- D. Install check, and shutoff on discharge side of pumps.
- E. Install Y-type strainer shutoff valve on suction side of pumps.
- F. Install suction diffuser on suction side close-coupled, inline pumps where pump manufacturer's inlet straight length requirements are not met.
- G. Install pressure gages on pump suction and discharge or at integral pressure-gage tapping, or install single gage with multiple-input selector valve.
- H. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.4 STARTUP SERVICE

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

3.5 DEMONSTRATION

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

END OF SECTION

SECTION 232300 - REFRIGERANT PIPING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Piping.
- B. Refrigerant.
- C. Moisture and liquid indicators.
- D. Valves.
- E. Strainers.
- F. Filter-driers.
- G. Expansion valves.
- H. Flexible connections.

1.02 RELATED REQUIREMENTS

1.03 REFERENCE STANDARDS

- A. AHRI 750 - Thermostatic Refrigerant Expansion Valves.
- B. ASHRAE Std 15 - Safety Standard for Refrigeration Systems.
- C. ASHRAE Std 34 - Designation and Safety Classification of Refrigerants.
- D. ASME B16.22 - Wrought Copper and Copper Alloy Solder-Joint Pressure Fittings.
- E. ASME B31.5 - Refrigeration Piping and Heat Transfer Components.
- F. ASTM B280 - Standard Specification for Seamless Copper Tube for Air Conditioning and Refrigeration Field Service.
- G. AWS A5.8M/A5.8 - Specification for Filler Metals for Brazing and Braze Welding.
- H. MSS SP-58 - Pipe Hangers and Supports - Materials, Design, Manufacture, Selection, Application, and Installation.

1.04 SYSTEM DESCRIPTION

- A. This Section includes refrigerant piping used for air-conditioning applications

1.05 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-410A:
 - 1. Suction Lines for Heat-Pump Applications: 535 psig.

2. Hot-Gas and Liquid Lines: 535 psig.

1.06 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide general assembly of specialties, including manufacturers catalogue information. Provide manufacturers catalog data including load capacity.
- C. Manufacturer's Installation Instructions: Indicate support, connection requirements, and isolation for servicing.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. Extra Filter-Dryer Cartridges: Two extra filter cores per filter provided.
- E. Delegated-Design Submittal: Provide refrigerant size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment. Provide design of required piping specialties as required to make a complete and operable system. Provide analysis and data signed and sealed by the qualified professional engineer responsible for their preparation.
 1. Design Calculations: Calculate requirements based on equipment capacities and equipment characteristics. It is the contractors responsibility to provide an operational system in compliance with equipment manufacturers recommendations and printed data

1.07 QUALITY ASSURANCE

- A. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of experience.

1.08 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 REGULATORY REQUIREMENTS

2.02 PIPING

- A. Copper Tube: ASTM B280, H58 hard drawn.
 1. Fittings: ASME B16.22 wrought copper.
 2. Joints: Braze, AWS A5.8M/A5.8 BCuP silver/phosphorus/copper alloy.
- B. 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. Multiple or Trapeze Hangers: MSS SP-58, Type 44 for multiple horizontal piping 20 feet or longer, supported on a trapeze.
4. Wall Support for Pipe Sizes to 3 Inches: Cast iron hook.
5. Vertical Support: Steel riser clamp.
6. Copper Pipe Support: Carbon steel ring, adjustable, copper plated.
7. Hanger Rods: Mild steel threaded both ends, threaded one end, or continuous threaded.
8. 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.

2.03 REFRIGERANT

- A. Refrigerant: R-410A, Pentafluoroethane/Difluoromethane as defined in ASHRAE Std 34.

2.04 MOISTURE AND LIQUID INDICATORS

- A. Indicators: Single port type, UL listed, forged brass body, flared or solder ends, sight glass, color coded paper moisture indicator to indicate above 60 ppm and plastic cap; for maximum temperature of 240 degrees F and maximum working pressure of 500 psi.

2.05 VALVES

- A. Service Valves:
 1. Forged brass body with copper stubs, brass caps, removable valve core with stainless-steel spring, polytetrafluoroethylene seal, integral ball check valve, copper spring end connections, hand-wheel or quarter turn lever, for maximum pressure of 500 psi.

2.06 STRAINERS

- A. Straight Line or Angle Line Type:
 1. Welded steel with corrosion resistant coating, steel cap and flange, and replaceable cartridge, with screen of 100-mesh stainless steel wire; for maximum working pressure of 500 psi and maximum operating temperature of 275 deg F. Socket or flared ends.

2.07 FILTER-DRIERS

- A. Performance:
 1. Pressure Drop: 2 psi, maximum, when operating at full connected evaporator capacity.
 2. Design Working Pressure: 500 psi, minimum.
- B. Cores: Molded or loose-fill molecular sieve desiccant compatible with refrigerant, activated alumina, and filtration to 10 microns; of construction that will not pass into refrigerant lines.
- C. Construction: UL listed.
 1. Connections: Socket.

2.08 EXPANSION VALVES

- A. Angle or Straight Through Type: AHRI 750; design suitable for refrigerant, brass or steel body, internal or external equalizer, bleed hole, adjustable superheat setting, replaceable inlet strainer, with non-replaceable capillary tube and remote sensing bulb; for maximum working pressure of 450 psi and suction temperature of 40 deg F .
- B. Selection: Evaluate refrigerant pressure drop through system to determine available pressure drop across valve. Select valve for maximum load at design operating pressure and minimum 10 degrees F superheat. Select to avoid being undersized at full load and excessively oversized at part load.

2.09 FLEXIBLE CONNECTORS

- A. Corrugated bronze hose with single layer of tinned-bronze-wire-reinforced exterior braiding, minimum 7 inches long, capable of 3/4-inch misalignment with socket copper tube ends; for maximum working pressure of 500 psi and maximum operating temperature of 250 deg-F.

PART 3 EXECUTION

3.01 PREPARATION

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

3.02 INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor systems; indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings and Delegated-Design.
- B. Install refrigerant piping according to ASHRAE 15.
- C. Install fittings for changes in direction and branch connections.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. Provide clearance for installation of insulation and access to valves and fittings.
 - 1. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings. Route piping in orderly manner, with plumbing parallel to building structure, and maintain gradient. Install piping free of sags and bends.
- G. Install piping to conserve building space and avoid interference with use of space.
- H. Group piping whenever practical at common elevations and locations.

- I. Slope piping as follows:
 - 1. Install horizontal hot-gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- J. Install piping to allow for expansion and contraction without stressing pipe, joints, or connected equipment.
- K. Provide replaceable cartridge filter-driers, with isolation valves and valved bypass.
- L. Locate expansion valve sensing bulb immediately downstream of evaporator on suction line.
- M. Provide external equalizer piping on expansion valves with refrigerant distributor connected to evaporator.
- N. Install flexible connectors at right angles to axial movement of compressor, parallel to crankshaft.

3.03 Pipe Joint Construction

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 - 2. Use Type BAg, cadmium-free silver alloy for joining copper with bronze or steel.

3.04 Pipe Hangers and Supports

- A. Install in accordance with ASME B31.5.
- B. Support horizontal piping as indicated.
- C. Install hangers to provide minimum 1/2 inch space between finished covering and adjacent work.
- D. Place hangers within 12 inches of each horizontal elbow.
- E. Support vertical piping at every floor. Support riser piping independently of connected horizontal piping.
- F. Where several pipes can be installed in parallel and at same elevation, provide multiple or trapeze hangers.
- G. Provide copper plated hangers and supports for copper piping.

- H. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/8 and smaller: Maximum span, 24 inches; minimum rod size, 1/4 inch
 - 2. NPS 1/2: Maximum span, 36 inches; minimum rod size, 1/4 inch.
 - 3. NPS 5/8: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 4. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch .
- I. 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.
 - 1. Provide clearance for installation of insulation and access to valves and fittings.
 - 2. Provide access to concealed valves and fittings..

3.05 FIELD QUALITY CONTROL

- A. Test refrigeration system in accordance with ASME B31.5.
- B. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
- C. Test high-, low-pressure, and hot gas reheat side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" Article.
 - 1. Pressure Test: Test refrigerant piping using dry, oil-free nitrogen, and prove tight at 300psi on the high side, 300 psi on the hot gas reheat side, and 150 psi on the low side. Maintain pressure for 2 hours with no leakage or reduction in pressure.
 - 2. System shall maintain test pressure at the manifold gage throughout duration of test.
 - 3. Test joints and fittings with by brushing a small amount of soap and glycerin solution over joints and electronic leak detector.
 - 4. Remake leaking joints using new materials, and retest until satisfactory results are achieved.'
 - 5. Include Test and Inspection certificate in Operation and Maintenance submittal. Certificate to give the name of the refrigerant and the field test pressure applied to the high side and the low side of the system. The certification of test shall be signed by the installer and shall be made part of the public record.
- D. Fully charge completed system with refrigerant after testing. Follow ASHRAE Std 15 procedures for charging and purging of systems and for disposal of refrigerant.
 - 1. Install core in filter dryers after leak test but before evacuation.
 - 2. Evacuation: Using high vacuum pump and certified micron gage, reduce absolute pressure on both sides of system simultaneously to 500 microns and 500 microns. After reaching this point charge system with refrigerant until pressure of 0psi is obtained. Repeat evacuation procedure for 2 more cycles, totaling three evacuation-charging cycles. On final evacuation, secure pump and maintain 500 microns and 500 microns for 12 hours before charging with required final refrigerant. If vacuum holds for 12 hours, system is ready for charging.
 - 3. Break vacuum with refrigerant gas, allowing pressure to build up to 2 psig.
 - 4. Charge system with a new filter-dryer core in charging line.

3.06 ADJUSTING

- A. Perform adjustments before operating the refrigeration system, according to manufacturer's written instructions.

- B. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 232300

SECTION 232500 - HVAC WATER TREATMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes water-treatment systems for the following:

1. Hot water piping (closed-loop system)
2. Heat pump piping (closed-loop system)

1.3 PERFORMANCE REQUIREMENTS

- A. Maintain water quality for HVAC systems that controls corrosion and build-up of scale and biological growth for maximum efficiency of connected equipment without posing a hazard to operating personnel or the environment. The water treatment consultant shall coordinate with equipment manufacturers to determine the required pH level and chemical treatment required to accommodate the connected equipment water treatment requirements.
- B. Base chemical treatment performance requirements on quality of water available at Project site, HVAC system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.
 1. Closed System: Maintain system essentially free of scale, corrosion, and fouling to sustain the water characteristics recommended by the connected equipment manufacture.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities; water-pressure drops; shipping, installed, and operating weights; and furnished products listed below:
 1. Bypass filter feeder
 2. Glycol feeder.
 3. Test equipment.
 4. Glycol solution and chemicals.

1.5 INFORMATIONAL SUBMITTALS

- A. Field quality-control test reports
- B. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site prior and post system drainage

1.6 CLOSEOUT SUBMITTALS

- A. Maintenance Data: For pumps, feeders, filters, system controls, and accessories to include in maintenance manuals.
- B. Include vendor contact information for service and warranty.

1.7 QUALITY ASSURANCE

- A. Installer Qualifications: Provide all equipment and chemicals through an experienced installer who is an authorized representative of the chemical treatment manufacturer for both installation and maintenance of chemical treatment equipment required for this Project. The installer shall be a member in good standing of the Association of Water Technologies and the water program shall be supervised by a Certified Water Technologist. The representative shall reside within 100 miles of the job site and maintain a laboratory for water testing.

1.8 MAINTENANCE AND SERVICE

- A. Provide chemicals and service program for maintaining optimum conditions in the circulating water for inhibiting corrosion, scale, and organic growths. Services, glycol, and chemicals shall be provided for a period of one year from date of Substantial Completion, and shall include the following:
 - 1. Initial water analysis and HVAC water-treatment recommendations.
 - 2. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation.
 - 3. Periodic field service and consultation.
 - 4. Customer report charts and log sheets.
 - 5. Laboratory technical analysis.
 - 6. Analyses and reports of all chemical items concerning safety and compliance with government regulations.

- B. Service

The water treatment consultant shall perform monthly on site tests of the system for one year from project substantial completion. These tests shall include, but not be limited to, the following:

PH
Hardness
T- Alkalinity
Inhibitor Level

% Glycol
Freeze point
Oxides matching the metallurgy of the system

- C. Provide a one-year supply of 10 micron filter bags associated with bag filter feeder.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

1. HVAC Water-Treatment Products:

- a. M.I.S of America, Inc.
- b. Buffalo industrial chemical

2.2 HOT WATER and HEAT PUMP WATER, (CLOSED-LOOP SYSTEM)

A. System cleaning

1. The entire closed loop system shall be cleaned to remove cutting oils, scale deposits, oxides and other fouling as has determined by the water treatment consultant. A water meter shall be installed on the supply line as the system is being filled with water so that an accurate system volume can be determined. A non-acid solution of dispersants M.I.S of America, Inc. formula 6200NAC or approved equal shall be added at a rate of one gallon to 500 gallons of system water. This solution shall be circulated for a minimum of 8 hours. This solution shall be tested by the water treatment consultant to insure the proper dispersant level is being maintained. After the solution has been circulated for a minimum of 8 hours the entire system shall be drained and flushed. A second analysis of the flush water shall be made to insure all of the cleaner is removed and that the system is clean.

B. Glycol and water treatment

1. The system shall immediately be refilled with a 30% solution of Propylene glycol containing a blend of corrosion inhibitors, which have been selected to match the metallurgy of the system. Coordinate with equipment manufacturers for required pH level and chemical treatment required. The water treatment consultant shall analyze a sample of the solution after it has circulated for a minimum of 24 hours. This analysis shall include the glycol level; freeze point, inhibitor levels and oxides of the metals in the system. The following conditions shall be maintained and minimum:
- a. pH greater than 7 but less than 9

C. Equipment

1. Automatic glycol feeder
 - a. An automatic glycol feeder shall be installed to feed a 36% premixed solution of inhibited Propylene glycol to the water system should makeup be required. The glycol feeder shall contain the following features:
 - 1) Low pressure activation switch
 - 2) Audible Alarm
 - 3) Single dry contact
 - 4) LED indicators
 - 5) Steel stand
 - 6) Heavy Duty Gear pump with mechanical seal and replaceable wear plates and bearings- 115 V – 1.5 GPM@1 PSI
 - 7) A controller mounted in a Nema 4X enclosure.
 - 8) HOA control of the pump
 - 9) Fully piped and wired including suction and discharge assemblies.
2. Bypass Filter Style Feeder
 - a. Capacity- 7 gallon
 - b. Rated for high flow applications
 - c. Construction- 10 gauge carbon steel
 - d. Operating pressure- 200 psi at 200 deg F
 - e. Adjustable legs
 - f. Perforated stainless steel basket
 - g. Finish- Gray epoxy
 - h. Provide two sets of 20 and 5 micron filter bags
 - i. Provide a one-year supply of 10 micron filter bags

PART 3 - EXECUTION

3.1 WATER ANALYSIS

- A. The water treatment supplier is required to perform an initial water supply analysis to determine the specific program and the quantities of chemical to be supplied to match existing conditions. A copy of the analysis shall be submitted to the engineer.

3.2 INSTALLATION

- A. Installation by the contractor with supervision of the supplier.
 1. Installing the contractor to coordinate with the chemical equipment and product supplier.
 2. Install equipment plumb and level.
 3. Add cleaning chemicals as recommended by the supplier.
- B. Fill system with 30% propylene glycol solution and provide corrosion inhibitors, which have been selected to match the metallurgy of the system.

- C. Fill glycol feeder with 30% propylene glycol solution matching system conditions
- D. Test system mixture and provide report to engineer for approval

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Inspect field-assembled components and equipment installation, including piping and electrical connections. Report results in writing.
 - 2. Inspect piping and equipment to determine that systems and equipment have been cleaned, flushed, and filled with water, and are fully operational before introducing chemicals for water-treatment system.
 - 3. Place HVAC water-treatment system into operation and calibrate controls during the preliminary phase of HVAC systems' startup procedures.
 - 4. Test system mixture
 - 5. Startup assistance for Contractor to flush the systems, clean with detergents, and initially fill systems with required chemical treatment prior to operation
- B. Test chemical feed piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it is tested and satisfactory test results are achieved.
 - 2. Test for leaks and defects. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 3. Leave uncovered and unconcealed new, altered, extended, and replaced water piping until it has been tested and approved. Expose work that has been covered or concealed before it has been tested and approved.
 - 4. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow test pressure to stand for four hours. Leaks and loss in test pressure constitute defects.
 - 5. Repair leaks and defects with new materials and retest piping until satisfactory results are obtained.
 - 6. Prepare test reports, including required corrective action.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC water- treatment systems and equipment.
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining equipment and schedules.

- B. Review manufacturer's safety data sheets for handling of chemicals.
- C. Review data in maintenance manuals, especially data on recommended parts inventory and supply sources and on availability of parts and service.
- D. Schedule at least 2 hours training with Owner, with at least seven days' advance notice.

END OF SECTION 232500

SECTION 232923 - VARIABLE-FREQUENCY MOTOR CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes separately enclosed, preassembled, combination VFCs, rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.3 DEFINITIONS

- A. BAS: Building automation system.
- B. CE: Conformance Europeene (European Compliance).
- C. CPT: Control power transformer.
- D. EMI: Electromagnetic interference.
- E. LED: Light-emitting diode.
- F. NC: Normally closed.
- G. NO: Normally open.
- H. OCPD: Overcurrent protective device.
- I. PID: Control action, proportional plus integral plus derivative.
- J. RFI: Radio-frequency interference.
- K. VFC: Variable-frequency motor controller.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated.
 - 1. Include dimensions and finishes for VFCs.
 - 2. Include rated capacities, wiring diagrams, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For each VFC indicated.

1. Include mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

1.5 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Required working clearances and required area above and around VFCs.
2. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements.
3. Show support locations, type of support, and weight on each support.
4. Indicate field measurements.

B. Qualification Data: For testing agency.

C. Product Certificates: For each VFC from manufacturer.

D. Harmonic Analysis Report: Provide Project-specific calculations and manufacturer's statement of compliance with IEEE 519.

E. Source quality-control reports.

F. Field quality-control reports.

G. Sample Warranty: For special warranty.

1.6 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For VFCs to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 017823 "Operation and Maintenance Data," include the following:
 - a. Manufacturer's written instructions for testing and adjusting thermal-magnetic circuit breaker and motor-circuit protector trip settings.
 - b. Manufacturer's written instructions for setting field-adjustable overload relays.
 - c. Manufacturer's written instructions for testing, adjusting, and reprogramming microprocessor control modules.
 - d. Manufacturer's written instructions for setting field-adjustable timers, controls, and status and alarm points.

- e. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate, full-load currents.
- f. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor-running overload protection suit actual motors to be protected.

1.7 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3. Indicating Lights: Two of each type and color installed.
 - 4. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 - 5. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

1.8 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. If stored in space that is not permanently enclosed and air conditioned, remove loose packing and flammable materials from inside.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.10 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: An 18-month warranty shall be provided on materials and workmanship from the date of shipment.

PART 2 - PRODUCTS

2.1 SUMMARY

- A. This section provides specification requirements for solid-state, pulse-width modulated (PWM) Adjustable Frequency Drives, herein referred to as AC Drives, for use with NEMA® design NEMA B AC motors, or standard IEC motors.
- B. The AC Drive supplier shall furnish, field test, adjust and certify all installed AC Drives for satisfactory operation.
- C. Any exceptions/deviations to this specification shall be indicated in writing and submitted no less than one week prior to bid date.

2.2 REFERENCES

- A. ANSI®/NFPA® 70 - National Electrical Code® (NEC®).
- B. UL 508 - UL Standard for Safety Industrial Control Equipment.
- C. UL 508C - UL Standard for Safety Power Conversion Equipment.
- D. NEMA ICS7 : Industrial Control and Systems Variable Speed Drives.
- E. CSA C22.2 No. 14-M91 : Industrial Control Equipment
- F. IEC 1800 : Adjustable speed Electrical power drive systems
- G. SEMI-F47: Voltage Ride Thru

2.3 GENERAL DESCRIPTION

- A. The AC Drive shall convert the input AC mains power to an adjustable frequency and voltage
- B. The input power section shall utilize a full wave bridge design incorporating diode rectifiers. The diode rectifiers shall convert fixed voltage and frequency, AC line power to fixed DC voltage.
- C. The output power section shall change fixed DC voltage to adjustable frequency AC voltage.
- D. The adjustable frequency drive package shall include input EMI/RFI filtering.
- E. The AC drive shall have a user interface (keypad) that presents information in plain English / Spanish / French text. The user interface shall include a Local / Remote button to switch between control at the terminal strip and the user interface (keypad). This button shall also switch between network control and the user interface (keypad). The keypad shall have Run and Stop keys and a manual speed potentiometer function.

2.4 MANUFACTURERS

- A. Manufacturers: Subject to compliance with the requirements, provide products by one of the following:
 - 1. Schneider Electric USA, Inc Square D.
 - 2. ABB
 - 3. Eaton Electrical Inc: Cutler Hammer business unit

2.5 ENCLOSURES

- A. VFC Enclosures: NEMA 250, to comply with environmental conditions at installed location.
 - 1. Dry and Clean Indoor Locations: Type 1.
 - 2. Outdoor Locations: Type 3R.
 - 3. Other Wet or Damp Indoor Locations: Type 4.
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: Type 12.

2.6 CONSTRUCTION

- A. The AC Drive power converter shall be UL Plenum rated.
 - 1. Plenum Rating: UL 1995; NRTL certification label on enclosure, clearly identifying VFC as "Plenum Rated."
- B. All heat sink fans shall be accessible from the front and shall not require the removal of the AC drive power converter for fan replacement.
- C. All heat sink fans shall be cycled on only when required to cool the drive to maximize the life of the fan
- D. When a Type 12 conduit entrance kit is required. The kit shall attach and be ground to the bottom of the AC drive and provide conduit landing for incoming line power cables, motor lead cable, control wiring, and network cabling.

2.7 APPLICATION DATA

- A. The AC Drive shall be sized to operate a variable torque load.
- B. The speed range shall be from a minimum speed of 1.0 Hz to a maximum speed of 72 Hz.

2.8 ENVIRONMENTAL RATINGS

- A. The AC Drive shall meet IEC 60664-1 Annex A and NEMA ICS 1, UL, and CSA standards.
- B. The AC Drive shall be designed to operate in an ambient temperature from -10 to 50 °C (14 to 122 °F).

- C. AC Drives in Type 12 enclosures shall be designed to operate in an ambient temperature from -10 to 40 °C (14 to 104 °F).
- D. Provide internal heaters as required to provide operation down to 0 degrees F.
- E. The storage temperature range shall be -25 to 65 °C (-13 to 149 °F).
- F. The maximum relative humidity shall be 95%, non-condensing.
- G. The AC Drive shall be rated to operate at altitudes less than or equal to 3300 ft (1000 m).
- H. For altitudes above 3300 ft (1000 m), the AC Drive should be de-rated per drive specifications.
- I. The AC Drive shall meet the IEC 60721-3-3-3M3 operational vibration specification.

2.9 RATINGS

- A. The AC Drive shall be designed to operate at the input line voltage indicated on the equipment schedule.
- B. The AC Drive shall operate from an input frequency range of 60 Hz (±) 5%.
- C. The displacement power factor shall not be less than .98 lagging under any speed or load condition.
- D. The efficiency of the AC Drive at 100% speed and load shall not be less than 97%.
- E. The variable torque rated AC Drive over current capacity shall be not less than 110% for 1 minute.
- F. The output carrier frequency shall be randomly modulated about the selected frequency. The output carrier frequency of the AC Drive shall be selectable from 1 to 16 kHz, 12kHz nominal rating for 1-60 hp @ 200/240 V, 1-100 hp @ 380/480 V. Selectable: 2.5 to 8 kHz, 2.5kHz nominal rating for 75-125 hp @ 200/240 V, 125-900 hp @ 380/480 V.

2.10 PROTECTION

- A. Upon power-up, the AC Drive shall automatically test for valid operation of memory, loss of analog reference input, loss of communication, DC-to-DC power supply, control power and pre-charge circuit.
- B. The AC drive shall be rated for UL minimum short circuit currents per given horsepower rating.
- C. The AC Drive shall be protected against short circuits, between output phases and to ground.
- D. The AC Drive shall have under-voltage power-loss ride through performance per the SEMI F-47 voltage ride through standard and certified by a third party.
- E. The AC drive shall have a programmable ride-through function, which will allow the logic to maintain control for a minimum of one-second (60 cycles) without faulting.

- F. An auto restart function will provide selectable time for restart attempts after the fault has disappeared and other operating conditions permit the restart. The restart shall be performed by a series of automatic attempts separated by increasingly longer periods of time. This period of time shall be selectable.
- G. Upon loss of the analog process follower reference signal, the AC Drive shall be programmable to display a fault.
- H. The AC Drive shall have a solid-state UL 508C listed overload protective device and meet IEC 60947.
- I. The output frequency shall be software enabled to fold back when the motor is overloaded.
- J. There shall be three skip frequency ranges that can be programmed to a bandwidth of ± 2.5 Hz.

2.11 ADJUSTMENTS & CONFIGURATIONS

- A. The AC Drive shall be capable of storing the configuration in the keypad.
- B. The acceleration and deceleration ramp times shall be adjustable from 0.05 to 999.9 seconds.
- C. The memory shall retain and record run status and fault type of the past eight faults.
- D. The software shall have an energy economy function that, when selected, will reduce the voltage to the motor when selected for variable torque loads. A constant volts/Hz ratio will be maintained during acceleration. The output voltage will then automatically adjust to meet the torque requirement of the load. Selectable volts/Hz ratio patterns does not meet specification, the function must be automatically optimized.
- E. The AC Drive shall have macro configurations for HVAC and pump applications, PID regulator set-up and network set-up.

2.12 KEYPAD DISPLAY INTERFACE

- A. A keypad display interface shall offer the modification of AC Drive adjustments through a touch keypad. All electrical values, configuration parameters, I/O assignments, application and activity function access, faults, local control, and adjustment storage, and diagnostics shall be accessible.
- B. The AC Drive model number, torque type, software revision number, horsepower, output current, motor frequency and motor voltage shall be listed on the drive identification portion of the LCD display.
- C. The keypad display shall have password protection that allows the keypad to be locked out from unauthorized personnel.
- D. The keypad shall be capable of displaying I/O assignment and status.

2.13 CONTROL CONNECTIONS

- A. The control power for the digital inputs and outputs shall be 24Vdc.
- B. The internal power supply shall incorporate automatic current fold-back that protects the internal power supply if incorrectly connected or shorted. The transistor logic outputs will be current limited and will not be damaged if shorted.
- C. Removable terminal strips shall be used on all logic and analog signal connections in the power converter.
- D. Two voltage-free relay output contacts will be provided. One of the contacts will indicate AC Drive fault status. The other contact shall indicate a drive run status. These relays shall be configurable for other status indicators.
- E. The AC drive shall have a power removal logic input. The drive shall not allow the motor to operate until this input is closed. If this input is opened while the connected motor is running, the AC drive shall stop applying power to the motor. This power removal function shall be certified by an independent agency.
- F. The control section of AC drive shall be supplied separately if necessary with 24V DC, to keep the network communication always available even if the power supply is OFF.
- G. The drive shall include a damper solenoid end switch. Switch closure to be made prior to fan being energized.
- H. Provide with preset speed input to accommodate high speed operation from auxiliary 24 V signal

2.14 SERIAL COMMUNICATION

- A. The AC Drive shall have an integrated RJ45 port, selectable for Modbus or CanOpen.
- B. The AC drive shall have the capability for internal mounted communication card. The following protocols shall be the minimum available :

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2.15 HARMONIC MITIGATION

- A. Each drive shall include a combination of integrated filters and DC link reactors to provide effective harmonic mitigation equivalent to 3% impedance without requiring additional panel space.

PART 3 - EXECUTION

3.1 INSPECTION

- A. Verify that the location is ready to receive work and the dimensions are as indicated.

3.2 PROTECTION

- A. Before and during the installation, the AC Drive equipment shall be protected from water and site contaminants.

3.3 INSTALLATION

- A. Wall-Mounting Controllers: Install with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor, unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not on walls, provide freestanding racks complying with Section 260529 "Hangers and Supports for Electrical Systems."
- B. Roof-Mounting Controllers: Install VFC on roofs with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished roof surface unless otherwise indicated, and by bolting units to curbs or mounting on freestanding, lightweight, structural-steel channels bolted to curbs. Seal roof penetrations after raceways are installed.
 - 1. Curbs and roof penetrations are specified in Section 077200 "Roof Accessories."
 - 2. Structural-steel channels are specified in Section 260529 "Hangers and Supports for Electrical Systems."
- C. Comply with NECA 1.
- D. Installation shall be the responsibility of the mechanical contractor. The contractor shall install the drive in accordance with the recommendations of the VFD manufacturer as outlined in the VFD installation manual.
- E. Power wiring shall be completed by the electrical contractor, to NEC code 430.122 wiring requirements based on the VFD input current. Caution: VFDs supplied without internal reactors have substantially higher input current ratings, which may require larger input power wiring and branch circuit protection. The contractor shall complete all wiring in accordance with the recommendations of the VFD manufacturer as outlined in the installation manual.
- F. Installation shall be in compliance with manufacturer's instructions, drawings and recommendations.
- G. The AC Drive supplier shall provide a representative to inspect the contractor's installation, test and start-up the AC Drive(s) furnished under this specification.

3.4 DOCUMENTATION

- A. The AC Drive supplier shall supply a comprehensive bound instruction and installation manual that includes wiring diagrams, layout diagrams, and outline dimensions. This manual must be insertion in a shop manual supplied by the installing contract.

3.5 SYSTEM DESCRIPTION

- A. General Requirements for VFCs:
 - 1. VFCs and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 - 2. Comply with NEMA ICS 7, NEMA ICS 61800-2, and UL 508C.
- B. VFC Description: Variable-frequency motor controller, consisting of power converter that employs pulse-width-modulated inverter, factory built and tested in an enclosure, with integral disconnecting means and overcurrent and overload protection; listed and labeled by an NRTL as a complete unit; arranged to provide self-protection, protection, and variable-speed control of one or more three-phase induction motors by adjusting output voltage and frequency.
 - 1. Units suitable for operation of NEMA MG 1, Design A and Design B motors, as defined by NEMA MG 1, Section IV, Part 30, "Application Considerations for Constant Speed Motors Used on a Sinusoidal Bus with Harmonic Content and General Purpose Motors Used with Adjustable-Voltage or Adjustable-Frequency Controls or Both."
 - 2. Units suitable for operation of inverter-duty motors as defined by NEMA MG 1, Section IV, Part 31, "Definite-Purpose Inverter-Fed Polyphase Motors."
 - 3. Listed and labeled for integrated short-circuit current (withstand) rating by an NRTL acceptable to authorities having jurisdiction.
- C. Design and Rating: Match load type, such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Output Rating: Three phase; 10 to 60 Hz, with voltage proportional to frequency throughout voltage range] [66 Hz, with torque constant as speed changes; maximum voltage equals input voltage.
- E. Isolated Control Interface: Allows VFCs to follow remote-control signal over a minimum 40:1 speed range.
 - 1. Signal: Electrical.
- F. Internal Adjustability Capabilities:
 - 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 - 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 - 3. Acceleration: 0.1 to 999.9 seconds.
 - 4. Deceleration: 0.1 to 999.9 seconds.
 - 5. Current Limit: 30 to minimum of 150 percent of maximum rating.
- G. Self-Protection and Reliability Features:

1. Surge Suppression: Factory installed as an integral part of the VFC, complying with UL 1449 SPD, Type 1 or Type 2.
 2. Surge Suppression: Field-mounted surge suppressors complying with Section 264313 "Surge Protection for Low-Voltage Electrical Power Circuits," UL 1449 SPD, Type 2.
 3. Loss of Input Signal Protection: Selectable response strategy, including speed default to a percent of the most recent speed, a preset speed, or stop; with alarm.
 4. Under- and overvoltage trips.
 5. Inverter overcurrent trips.
 6. VFC and Motor-Overload/Overtemperature Protection: Microprocessor-based thermal protection system for monitoring VFCs and motor thermal characteristics, and for providing VFC overtemperature and motor-overload alarm and trip; settings selectable via the keypad.
 7. Critical frequency rejection, with three selectable, adjustable deadbands.
 8. Instantaneous line-to-line and line-to-ground overcurrent trips.
 9. Loss-of-phase protection.
 10. Reverse-phase protection.
 11. Short-circuit protection.
 12. Motor-overtemperature fault.
- H. Automatic Reset/Restart: Attempt three restarts after drive fault or on return of power after an interruption and before shutting down for manual reset or fault correction; adjustable delay time between restart attempts.
- I. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped, unless "Bidirectional Autospeed Search" feature is available and engaged.
- J. Bidirectional Autospeed Search: Capable of starting VFC into rotating loads spinning in either direction and returning motor to set speed in proper direction, without causing damage to drive, motor, or load.
- K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.

3.6 CONTROLS AND INDICATION

- A. Status Lights: Door-mounted LED indicators displaying the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.

- B. Panel-Mounted Operator Station: Manufacturer's standard front-accessible, sealed keypad and plain-English-language digital display; allows complete programming, program copying, operating, monitoring, and diagnostic capability.
1. Keypad: In addition to required programming and control keys, include keys for HAND, OFF, and AUTO modes.
 2. Security Access: Provide electronic security access to controls through identification and password with at least three levels of access: View only; view and operate; and view, operate, and service.
 - a. Control Authority: Supports at least four conditions: Off, local manual control at VFC, local automatic control at VFC, and automatic control through a remote source.
- C. Historical Logging Information and Displays:
1. Real-time clock with current time and date.
 2. Running log of total power versus time.
 3. Total run time.
 4. Fault log, maintaining last four faults with time and date stamp for each.
- D. Indicating Devices: Digital display and additional readout devices as required, mounted flush in VFC door and connected to display VFC parameters including, but not limited to:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (V dc).
 9. Set point frequency (Hz).
 10. Motor output voltage (V ac).
- E. Control Signal Interfaces:
1. Signal Inputs: Capability to accept any of the following speed-setting input signals from the BAS or other control systems:
 - a. 0- to 10-V dc.
 - b. 4- to 20-mA dc.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 2. Output Signal Interface: A minimum of one programmable analog output signal(s) 4- to 20-mA dc, which can be configured for any of the following:
 - a. Output frequency (Hz).
 - b. Output current (load).
 - c. DC-link voltage (V dc).

- d. Motor torque (percent).
 - e. Motor speed (rpm).
 - f. Set point frequency (Hz).
- 3. Remote Indication Interface: A minimum of two programmable dry-circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- F. BAS Interface: Factory-installed hardware and software shall interface with BAS to monitor, control, display, and record data for use in processing reports. VFC settings shall be retained within VFC's nonvolatile memory.
 - 1. Hardwired Points:
 - a. Monitoring: On-off status.
 - b. Control: On-off operation.

3.7 SOURCE QUALITY CONTROL

- A. Testing: Test and inspect VFCs according to requirements in NEMA ICS 61800-2.
 - 1. Test each VFC while connected to a motor that is comparable to that for which the VFC is rated.
 - 2. Verification of Performance: Rate VFCs according to operation of functions and features specified.
- B. VFCs will be considered defective if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.8 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs, with Installer present, for compliance with requirements for installation tolerances, and other conditions affecting performance of the Work.
- B. Examine VFC before installation. Reject VFCs that are wet, moisture damaged, or mold damaged.
- C. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFC installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.9 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's central-control system. Comply with requirements in Section 260523 "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only those manual- and automatic-control devices that have no safety functions when switches are in manual-control position.
 - 2. Connect selector switches with control circuit in both manual and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high-temperature cutouts, and motor-overload protectors.

3.10 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure-mounted control and pilot device.
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.11 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Perform tests and inspections with the assistance of a factory-authorized service representative.
- D. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each VFC element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- E. Tests and Inspections:
 - 1. Inspect VFC, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Test insulation resistance for each VFC element, component, connecting motor supply, feeder, and control circuits.

3. Test continuity of each circuit.
4. Verify that voltages at VFC locations are within 10 percent of motor nameplate rated voltages. If outside this range for any motor, notify Engineer before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform tests according to the Inspection and Test Procedures for Adjustable Speed Drives stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
8. Perform the following infrared (thermographic) scan tests and inspections, and prepare reports:
 - a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each VFC. Remove front panels so joints and connections are accessible to portable scanner.
 - b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each VFC 11 months after date of Substantial Completion.
 - c. Instruments and Equipment: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
9. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

F. VFCs will be considered defective if they do not pass tests and inspections.

G. Prepare test and inspection reports, including a certified report that identifies the VFC and describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations made after remedial action.

3.12 STARTUP SERVICE

A. Perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.

3.13 ADJUSTING

- A. Program microprocessors for required operational sequences, status indications, alarms, event recording, and display features. Clear events memory after final acceptance testing and prior to Substantial Completion.
- B. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- C. Adjust the trip settings of instantaneous-only circuit breakers and thermal-magnetic circuit breakers with adjustable, instantaneous trip elements. Initially adjust to 6 times the motor nameplate full-load amperes and attempt to start motors several times, allowing for motor cool-down between starts. If tripping occurs on motor inrush, adjust settings in increments until

motors start without tripping. Do not exceed 8 times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor, notify Engineer before increasing settings.

- D. Set the taps on reduced-voltage autotransformer controllers.
- E. Set field-adjustable pressure switches.

3.14 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until controllers are ready to be energized and placed into service.
- B. Replace VFCs whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.15 DEMONSTRATION

- A. Train owner's maintenance personnel to adjust, operate, reprogram, and maintain VFCs.

END OF SECTION 232923

SECTION 233100 - HVAC DUCTS AND CASINGS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Metal ductwork.

1.02 RELATED REQUIREMENTS

- A. Section 230593 - Testing, Adjusting, and Balancing for HVAC.
- B. Section 233300 - Air Duct Accessories.

1.03 REFERENCE STANDARDS

- A. ASHRAE (FUND) - ASHRAE Handbook - Fundamentals.
- B. ASHRAE Std 90.1 I-P-2016 - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. ASTM A480/A480M - Standard Specification for General Requirements for Flat-Rolled Stainless and Heat-Resisting Steel Plate, Sheet, and Strip.
- D. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- E. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- F. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
- G. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- H. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- I. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- J. SMACNA (LEAK) - HVAC Air Duct Leakage Test Manual.
- K. UL 181 - Standard for Factory-Made Air Ducts and Air Connectors.

1.04 SUBMITTALS

- A. Product Data: Provide data for duct materials, duct liner, and sealants and gaskets.
- B. Shop Drawings: Indicate duct fittings, particulars such as gauges, sizes, welds, and configuration prior to start of work for all systems.
- C. Test Reports: Indicate pressure tests performed. Include date, section tested, test pressure, and leakage rate, following SMACNA (LEAK).

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Company specializing in manufacturing the type of products specified in this section, with minimum three years of experience.
- B. Installer Qualifications: Company specializing in performing the type of work specified in this section, with minimum 5 years of documented experience.
- C. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.4.4 - "HVAC System Construction and Insulation."

1.06 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. Unless otherwise indicated:
 - 1. Pressure class: positive 3 inches w.g., negative 2 inches w.g.
 - 2. Seal class: A.
 - 3. Leakage class: 4 for rectangular, 2 for round.
- C. Low Pressure supply, return, relief and general exhaust: galvanized steel.
 - 1. Exhaust ductwork within wet environment: 3 inch wg pressure class, seal class 3 , aluminum sheets with bright finish where exposed and mill finish where concealed.
- D. Domestic Clothes dryer exhaust duct: galvanized steel with smooth interior finish.
 - 1. Exhaust duct shall be a minimum of 4 inches (102mm) in diameter.
 - 2. The entire exhaust system shall be supported and secured in place.
 - 3. The male end of the duct at overlapped duct joints shall extend in the direction of airflow.
 - 4. Clothes dryer transition ducts used to connect the appliance to the exhaust duct system shall be limited to single lengths not to exceed 8 feet (2438 mm) and shall be listed and labeled for the application.
 - 5. Transition ducts shall not be concealed within construction.
- E. Domestic kitchen exhaust duct: galvanized steel with smooth interior finish.
 - 1. Exhaust duct shall be a minimum of 4 inches (102mm) in diameter.
 - 2. The entire exhaust system shall be supported and secured in place.
 - 3. Transition ducts shall not be concealed within construction.

2.02 MATERIALS

- A. Galvanized Steel for Ducts: Hot-dipped galvanized steel sheet, ASTM A653/A653M FS Type B, with G90/Z275 coating.
 - 1. Finishes for surfaces exposed to view: Mill Phosphatized.
- B. Aluminum for Ducts: ASTM B209 (ASTM B209M); aluminum sheet, alloy 3003-H14. Aluminum Connectors and Bar Stock: Alloy 6061-T651 or of equivalent strength.
- C. 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 75 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.
- D. Gasket Tape: Provide butyl rubber gasket tape for a flexible seal between transfer duct connector (TDC), transverse duct flange (TDF), applied flange connections, and angle rings connections.
- E. Hanger Rod: ASTM A36/A36M; steel, cadmium-plated; threaded both ends, threaded one end, or continuously threaded.
- F. Hanger Fasteners: Attach hangers to structure using appropriate fasteners.

2.03 DUCTWORK FABRICATION

- A. Fabricate and support in accordance with SMACNA (DCS) and as indicated.
- B. No variation of duct configuration or size permitted except by written permission. Size round duct installed in place of rectangular ducts in accordance with ASHRAE (FUND) Handbook - Fundamentals.
- C. Provide duct material, gauges, reinforcing, and sealing for operating pressures indicated.
- D. Elbow Configuration:
 - 1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-2, "Rectangular Elbows."
 - a. Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-3, "Vanes and Vane Runners," and Figure 4-4, "Vane Support in Elbows."
 - 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity up to 1500 fpm: 1.5 radius-to-diameter ratio and four segments for 90-degree elbow.
 - b. Round Elbows, 8 Inches and Smaller in Diameter: Stamped.
 - c. Round Elbows, 10 Inches and Larger in Diameter: 5 Gore, Welded.
- E. Branch Configuration:

1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 4-6, "Branch Connection."
 - a. Rectangular Main to Rectangular Branch: 45-degree lateral or 90-degree with 45-degree entry.
 2. Rectangular Main to Round Tap: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees." Saddle taps are permitted in existing duct.
 - a. 45-degree lateral or 90-degree with 45-degree entry.
- F. Increase duct sizes gradually, not exceeding 15 degrees divergence wherever possible; maximum 30 degrees divergence upstream of equipment and 45 degrees convergence downstream.
- G. Fabricate continuously welded round and oval duct fittings in accordance with SMACNA (DCS).

2.04 MANUFACTURED DUCTWORK AND FITTINGS

- A. Round Ducts: Round lockseam duct with galvanized steel outer wall.
1. Manufacture in accordance with SMACNA (DCS).
 2. Manufacturers:
 - a. Linday Inc.
 - b. McGill AirFlow LLC.
 - c. SEMCO Inc.
 - d. Sheet Metal Connectors, Inc.
- B. Flexible Ducts:
1. UL 181, Class 1 labeled . Black polymer film supported by helically wound spring steel wire.
 2. Insulation: Fiberglass insulation with polyethylene vapor barrier film. Comply with ASHRAE Std 90.1 I-P-2016.
 3. Pressure Rating: 4 inches wg positive and 0.5 inches wg negative.
 4. Maximum Velocity: 4000 fpm.
 5. Temperature Range: Minus 20 degrees F to 175 degrees F.
 6. Connectors: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 inches through 18 inches, to suit duct size.
 7. Flexible ducts to be provided for supply air ductwork only or as otherwise shown on drawings.

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. Flexible Ducts: Connect to metal ducts with steel band clamps with hex screw draw bands.

- E. Duct sizes indicated are inside clear dimensions. For lined ducts, maintain sizes inside lining.
- F. 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.
- G. Locate ducts with sufficient space around equipment to allow normal operating and maintenance activities.
- H. Use crimp joints with or without bead for joining round duct sizes 8 inch and smaller with crimp in direction of air flow.
- I. Use double nuts and lock washers on threaded rod supports.
- J. Connect terminal units to supply ducts directly.
- K. Connect air devices to low pressure ducts directly or with 48" maximum length of flexible duct held in place with strap or clamp. Maximum one 90 degree bend.

END OF SECTION 233100

SECTION 233300 - AIR DUCT ACCESSORIES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Turning Vanes
- B. Duct access doors.
- C. Duct test holes.
- D. Fire dampers.
- E. Flexible duct connectors.
- F. Volume control dampers.
- G. Miscellaneous products:
 - 1. Flange connectors.

1.02 RELATED REQUIREMENTS

- A. Section 233100 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

- A. ASTM A653/A653M - Standard Specification for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by the Hot-Dip Process.
- B. ASTM B209 - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate.
- C. ASTM B209M - Standard Specification for Aluminum and Aluminum-Alloy Sheet and Plate (Metric).
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- E. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- F. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- G. UL 33 - Safety Heat Responsive Links for Fire-Protection Service.
- H. UL 555 - Standard for Fire Dampers.
- I. UL 555C - Standard for Safety Ceiling Dampers.

1.04 SUBMITTALS

- A. Product Data
- B. Shop Drawings: Indicate for shop fabricated assemblies including volume control dampers.

- C. Project Record Drawings: Record actual locations of access doors, test holes, and volume dampers.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. See Section 016000 - Product Requirements, for additional provisions.
 - 2. Extra Fusible Links: One for each damper requiring fusible link installed.

1.05 MATERIALS Qualifications

- A. Galvanized sheet steel shall comply with ASTM A653/A653M. Galvanized coating equal to G90. Exposed surface finish shall be mill phosphatized.
- B. Aluminum sheets shall comply with ASTM B209, alloy 3003, temper H14; with mill finish for concealed and standard 1-side bright finish for exposed components.
- C. Reinforcement Shapes and Plates: Galvanized-steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless-steel ducts.
- D. Tie Rods: Galvanized steel, 1/4 inch minimum diameter for lengths 36 inch or less; 3/8 inch minimum diameter for lengths longer than 36 inch.

1.06 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 TURNING VANES

- A. Comply with SMACNA (DCS); Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- B. Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. Vane construction: Single Wall for ducts up to 36 inches wide and double wall for larger dimensions.
- D. Vane spacing: 1.5 inches
- E. Vane radius: 2 inches

2.02 DUCT ACCESS DOORS

- A. Fabricate in accordance with SMACNA (DCS); Figures 7-2, "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
- B. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 1. Less Than 18 inch Square: Two hinges and two sash locks.
 - 2. Up to 24 by 48 inches: Three hinges and two compression latches.
 - 3. Larger than 24 by 48 inches: : Four hinges and two compression latches with outside and inside handles.

- C. Door:
1. Double-wall, rectangular, with 1 inch thick board insulation with minimum R-6
 2. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 3. Fabricate doors airtight and suitable for duct pressure class.
 4. Compression Latch: Cam style
 5. Hinge: 1-by-1-inch piano hinge.

2.03 DUCT TEST HOLES

- A. Permanent Test Holes: Factory fabricated, air tight flanged fittings with screw cap. Provide extended neck fittings to clear insulation.

2.04 FIRE DAMPERS

- A. Manufacturers:
1. Air Balance, a division of MESTEK; _____: www.airbalance.com/#sle.
 2. Greenheck Fan Corporation; _____: www.greenheck.com/#sle.
 3. Ruskin Company; _____: www.ruskin.com/#sle.
- B. Static damper, rated and labeled according to NFPA 90A and UL 555.
- C. Closure rating in ducts up to 4 inch w.g. and a minimum of 2000 fpm velocity.
- D. Rated for one and a half hour service in compliance with UL 555C.
- E. Mounting: vertical or horizontal as indicated on the drawings.
- F. Fusible Links: UL 33, separate at 165 degrees F with adjustable link straps for combination fire/balancing dampers.

2.05 FLEXIBLE DUCT CONNECTORS

- A. Fabricate in accordance with SMACNA (DCS) and as indicated.
- B. Flexible Duct Connections: Fabric crimped into metal edging strip.
1. Fabric: UL listed fire-retardant neoprene coated woven glass fiber fabric to NFPA 90A, minimum density 30 oz per sq yd.
 - a. Net Fabric Width: Approximately 2 inches wide.
- C. Maximum Installed Length: 14 inch.

2.06 VOLUME CONTROL DAMPERS

- A. Manufacturers:
1. Greenheck Fan Corporation; _____
 2. Nailor Industries, Inc; _____
 3. Ruskin Company; _____
- B. Fabricate in accordance with SMACNA (DCS) and as indicated.
- C. Standard, Manual Volume Dampers:

1. Standard leakage rating, with linkage outside airstream.
2. Suitable for horizontal or vertical applications.
3. Frames: Hat-shaped 16 gauge, 0.0568 inch, 5 inch deep, galvanized sheet steel. Mitered and welded corners. Flanges for attaching to walls, and flangeless for installing in ducts.
4. Blade: Single blade up to 12 inch high, multi blade over 12 inch high. Stiffened damper blades for stability. Hat-shaped 16 gauge, 0.0568 inch, 5 inch deep, galvanized sheet steel. Fabricate of single thickness sheet metal to streamline shape, secured with continuous hinge or rod.
5. Bearings: Type 316 stainless steel sleeve. Dampers in ducts with pressure classes of 2 inch w.g. or more and on all dampers over 12 inch diameter shall have continuous rod axles full length of damper blades and bearings at both ends of operating shaft.
6. Blade axles, tie bars, and brackets same material as damper.
7. Operator: Minimum 1/4 inch diameter rod in self aligning, universal joint action, flanged bushing with set screw. Heavy stamped, locking handle. Include elevated platform for mounting on insulated duct.

2.07 MISCELLANEOUS PRODUCTS

- A. Flange Connectors (Interior):
 1. Description: roll-formed, factory-fabricated, slide-on transverse flange connectors, gaskets, and components.
 2. Material: Match connecting ductwork.
 3. Gauge and Shape: Match connecting ductwork.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install accessories in accordance with manufacturer's instructions, NFPA 90A, and follow SMACNA (DCS). Refer to Section 233100 for duct construction and pressure class.
- B. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel and fibrous-glass ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.
- C. Access doors shall be provided with swing against duct static pressure. Provide duct access doors for inspection and cleaning before and after filters, coils, fans, control devices requiring access, at fire dampers, and elsewhere as indicated.
- D. Provide duct test holes at fan inlets and outlets and where required for testing and balancing purposes.
- E. Install flexible connectors to connect ducts to equipment.
- F. Provide fire dampers at locations indicated according to their UL listing, where ducts and outlets pass through rated components. Install with required perimeter mounting angles, sleeves, breakaway duct connections, corrosion resistant springs, bearings, bushings and hinges.
- G. Demonstrate re-setting of fire dampers to Owner's representative.
- H. Provide balancing dampers at points on supply, return, and exhaust systems where branches are taken from larger ducts as required for air balancing. Dampers shall be provided as necessary to achieve a NEBB certified air balance.

1. Install steel volume dampers in steel ducts.
2. Install stainless steel volume dampers in stainless steel ducts.
3. Provide balancing dampers on duct take-off to diffusers, grilles, and registers, unless the dampers specifically shown on the contract documents without a damper and dampers to be installed are specified as part of the diffuser, grille, or register assembly.
4. Set dampers to fully open position before testing, adjusting, and balancing.

3.02 FIELD QUALITY CONTROL

A. Tests and Inspections:

1. Operate dampers to verify full range of movement.
2. Inspect locations of access doors and verify that purpose of access door can be performed.
3. Operate fire dampers to verify full range of movement and verify that proper heat-response device is installed.
4. Inspect turning vanes for proper and secure installation.
5. Verify all dampers are secured and handles can be correctly fastened to hold damper in place.

END OF SECTION 233300

SECTION 233413 - AXIAL HVAC FANS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Propeller fans.

1.02 RELATED REQUIREMENTS

- A. Section 233300 - Air Duct Accessories: Backdraft dampers - metal.

1.03 REFERENCE STANDARDS

- A. 29 CFR 1910 - Occupational Safety and Health Standards.

1.04 SUBMITTALS

- A. Product Data: Provide data on axial fans and accessories, including fan curves with specified operating point plotted, power, RPM, sound power levels for both fan inlet and outlet at rated capacity, and electrical characteristics and connection requirements.
- B. Manufacturer's Instructions: Indicate installation instructions.
- C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Protect motors, shafts, and bearings from weather and construction dust.

PART 2 PRODUCTS

2.01 PROPELLER FANS

- A. Manufacturers:
 - 1. Twin City Fan & Blower; _____: www.tcf.com/#sle.
 - 2. Greenheck.
- B. Impeller: Aluminum blade with heavy hubs, statically and dynamically balanced, keyed and locked to shaft, directly connected to motor.
- C. Frame: One-piece, square galvanized steel with die-formed venturi orifice, mounting flanges, and supports, with baked enamel finish.
- D. Accessories:
 - 1. Backdraft Damper: Multiple blades with offset hinge pin, blades linked; see Section 233300.

2. Safety Screens: Expanded galvanized metal over inlet, motor, drive; to comply with 29 CFR 1910.
3. Wall housing with flush exterior and OSHA Guard.
4. Controller: Dial for balancing.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Provide safety screen where inlet or outlet is exposed.
- C. Provide backdraft dampers on discharge of exhaust fans and as indicated.

END OF SECTION 233413

SECTION 233423 - HVAC POWER VENTILATORS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Roof exhausters.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.

1.03 REFERENCE STANDARDS

- A. AMCA (DIR) - (Directory of) Products Licensed Under AMCA International Certified Ratings Program.
- B. AMCA 99 - Standards Handbook.
- C. AMCA 204 - Balance Quality and Vibration Levels for Fans.
- D. AMCA 210 - Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating.
- E. AMCA 300 - Reverberant Room Method for Sound Testing of Fans.
- F. AMCA 301 - Methods for Calculating Fan Sound Ratings from Laboratory Test Data.
- G. NFPA 96 - Standard for Ventilation Control and Fire Protection of Commercial Cooking Operations.
- H. UL 762 - Outline of Investigation for Power Roof Ventilators for Restaurant Exhaust Appliances.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data on fans and accessories, including fan curves with specified operating point plotted, power, rpm, sound power levels at rated capacity, and electrical characteristics and connection requirements.
- C. Maintenance Data: Include instructions for lubrication, motor and drive replacement, spare parts list, and wiring diagrams.

PART 2 PRODUCTS

2.01 POWER VENTILATORS - GENERAL

- A. Static and Dynamically Balanced: Comply with AMCA 204.
- B. Performance Ratings: Comply with AMCA 210, bearing certified rating seal.
- C. Sound Ratings: Comply with AMCA 301, tested to AMCA 300, bearing certified sound ratings seal.
- D. Fabrication: Comply with AMCA 99.
- E. Electrical Components: Listed and classified by Underwriters Laboratories Inc. as suitable for the purpose specified and indicated.
- F. Kitchen Hood Exhaust Fans: Comply with requirements of NFPA 96 and UL 762.

2.02 ROOF EXHAUSTERS

- A. Manufacturers:
 - 1. Carnes, a division of Carnes Company Inc; _____ : www.carnes.com/#sle.
 - 2. Greenheck Fan Corporation; _____ : www.greenheck.com/#sle.
 - 3. Twin City Fan & Blower; BCRD: www.tcf.com/#sle.
- B. Basis of Design: Greenheck Fan Corporation.
 - 1. Direct Drive, Down-Blast Discharge: G-140-VG.
- C. Fan Unit: Direct driven, with spun aluminum housing; resilient mounted motor; 1/2 inch mesh, 0.62 inch thick aluminum wire birdscreen; square base to suit roof curb with continuous curb gaskets.
 - 1. Wheel:
 - a. Constructed of aluminum.
 - b. Non-overloading, backward inclined centrifugal.
 - c. Statically and dynamically balanced in accordance to AMCA Standard 204-05
 - d. The wheel cone and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency.
 - 2. Motors:
 - a. Motor enclosures: Totally enclosed
 - b. Motor to be a DC electronic commutation type motor (ECM) specifically designed for fan applications. AC induction type motors are not acceptable. Examples of unacceptable motors are: Shaded Pole, Permanent Split Capacitor (PSC), Split Phase, Capacitor Start and 3 phase induction type motors.
 - c. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase.
 - d. Internal motor circuitry to convert AC power supplied to the fan to DC power to operate the motor.
 - e. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal.
 - f. Motor shall be a minimum of 85% efficient at all speeds.
 - 3. Housing:
 - a. Motor cover, shroud, curb cap, and lower windband shall be constructed of heavy gauge aluminum
 - b. Shroud shall have an integral rolled bead for extra strength
 - c. Shroud shall be drawn from a disc and direct air downward

- d. Lower windband shall have a formed edge for added strength
 - e. All housing components shall have final thicknesses equal to or greater than preformed thickness.
 - f. Leak Proof
- D. Roof Curb: 20 inch high self-flashing of galvanized steel with continuously welded seams, built-in cant strips and insulation and curb bottom.
- E. Disconnect Switch: Factory wired, nonfusible, in housing for thermal overload protected motor NEMA-1 rated.
- F. Backdraft Damper: Gravity actuated, aluminum multiple blade construction, felt edged with offset hinge pin, nylon bearings, blades linked.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Secure roof exhausters with zinc-plated hardware to roof curb. See section 077200 "Roof Curb Accessories" for installation of roof curbs.
- C. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- D. Install roof exhausters level and plumb.
- E. Comply with requirements for vibration isolation and seismic-control devices specified in Section 230548 "Vibration and Seismic Controls for HVAC."
- F. Label units according to requirements specified in Section 230553 "Identification for HVAC Piping and Equipment."

3.02 DUCTWORK CONNECTIONS

- A. Extend ducts to roof exhausters into roof curb. Counterflash duct to roof opening.
- B. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Section 233300 "Air Duct Accessories."

3.03 ELECTRICAL CONNECTIONS

- A. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, according to NFPA 70 and NECA 1.

3.04 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring according to Section 260523 "Control-Voltage Electrical Power Cables."

3.05 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- D. Perform tests and inspections with the assistance of a factory-authorized service representative.
- E. Tests and Inspections:
 - 1. Verify that shipping, blocking, and bracing are removed.
 - 2. Verify that unit is secure on mountings and supporting devices and that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
 - 3. Verify that there is adequate maintenance and access space.
 - 4. Verify that cleaning and adjusting are complete.
 - 5. Adjust damper linkages for proper damper operation.
 - 6. Verify lubrication for bearings and other moving parts.
 - 7. Disable automatic temperature-control operators, energize motor, and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 - 8. Shut unit down and reconnect automatic temperature-control operators.
 - 9. Remove and replace malfunctioning units and retest as specified above.
- F. Test and adjust controls and safeties. Controls and equipment will be considered defective if they do not pass tests and inspections.
- G. Prepare test and inspection reports.

3.06 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- C. Lubricate bearings.

3.07 DEMONSTRATION

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

END OF SECTION 233423

SECTION 233449 - DESTRATIFICATION FANS

PART 1 GENERAL

- 1.01 section includes
 - A. De-stratification fans
- 1.02 related requirements
 - A. 260519 - Low-Voltage Electrical Power Conductors and Cables
 - B. 260526 - Grounding and Bonding for Electrical Systems
- 1.03 REFERENCES
 - A. AMCA 211 - Certified Ratings Program Product Rating Manual for Fan Air Performance.
 - B. ANSI/AMCA 230 - Laboratory Methods Of Testing Air Circulating Fans For Rating And Certification.
 - C. NFPA 70 - National Electric Code.
 - D. UL 94 - Tests for Flammability of Plastic Materials for Parts in Devices and Appliances
 - E. UL 507 - Electric Fans.
 - F. ETL: Listed in US and Canada in Intertek Directory of List Products
- 1.04 SUBMITTALS
 - A. Product Data:
 - 1. Preparation instructions and recommendations.
 - 2. Power requirements, wiring diagrams and mounting recommendations.
 - B. Manufacturer's Instructions: Provide manufacturer's "Installation and Operation Guide".
 - C. Operation and Maintenance Data: For centrifugal fans to include in emergency, operation, and maintenance manuals.
- 1.05 DELIVERY, STORAGE, AND HANDLING
 - A. Deliver products and materials to project site in manufacturer's unopened packaging.
 - B. Store products in manufacturer's unopened packaging until ready for installation.
- 1.06 WARRANTY
 - A. 1 year parts and labor.

- B. 30-day money-back customer satisfaction guarantee. Refer to warranty information contained in the “Installation, Operation & Maintenance Guide”.
- C. Factory Refurbish Program: Discounted replacement motors available outside of standard warranty period.

PART 2 PRODUCTS

2.01 Manufacturers

- A. Airius; Air Pear.
- B. Approved Equal.

2.02 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Listed and label in compliance with UL 507 and UL 94.
- C. AMCA Compliance:
 - 1. Test fans according to ANSI/AMCA 230.
 - 2. Certify fan performance according to AMCA 211.
- D. Performance Data: Comply with ANSI 230 test procedure standard, based on five rating points: 20-, 40-, 60-, 80-, and 100-percent of maximum speed. Comply with AMCA 211 for publication of performance data.

2.03 DE-STRATIFICATION FANS

- A. Performance: Coordinated design of housing, stator and motor shall provide columnar laminar airflow to produce a minimum of 100 fpm at center of column at grade level when installed within 24 inches of ceiling:.
- B. Housing: The fan housing shall be made of PC/ABS resin, rated 5VA for flame resistance.
 - 1. Housing color: Selected by Architect.
- C. Safety Cable: Fan supplied with 6 ft steel cable .
- D. Motor Mounting: Enclosed in housing, above stator.
 - 1. Stator: The fan shall be equipped with a multiple-vane stator coordinated with fan design for maximizing columnar laminar flow.
 - 2. EC motor shall be controlled by wall mounted potentiometer. Uses low voltage control circuit. See wiring diagram.
- E. Identification: Permanently affixed manufacturer’s nameplate including the following: Model Number, Serial Number, Motor Power Specifications, Country of Manufacture and Safety Marks: ETL (US & CA) & CE (EU).
- F. Power Cord: 6 ft, 300-volt AC, UL rated. Motors within the voltage range of 100-130VAC are provided with a standard 3-prong plug.

- G. Steel blades welded to steel hub. Ball bearings shall be permanently lubricated and shielded. Thermally protected motor with an operating range of -13 deg F to 140 deg F.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Do not begin installation until supporting structure and interior work have been properly completed.
- B. Check location and availability of utility services to ensure proper voltage and installation preparation.
- C. Installation of miscellaneous support, if required, electrical wire and wiring, conduit, fuses, and disconnect switches other than those provided by fan manufacturer are specified in other sections.
- D. Examine the substrate and conditions under which the Fan is to be installed. Notify the Architect in writing of any conditions detrimental to the proper and timely completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected

3.02 INSTALLATION

- A. Install de-stratification fan according to manufacturer's written recommendations.
- B. Fan to be mounted at a maximum of 24 inches from ceiling deck to ensure thermal/humidity equalization from ceiling to floor.
- C. Adjust unit as required for proper operation in accordance with manufacturer's installation instructions. Contractor shall adjust fan speed to deliver 125 FPM at the floor.
- D. Install wall mounted potentiometer.

3.03 connections

- A. Ground equipment according to Section 260526.
- B. Connect power and controls wiring according to Section 260519. Terminate power connection with duplex receptacle within 72 inches of the unit.

3.04 PROTECTION

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

3.05 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain fans.

END OF SECTION 233449

SECTION 233600 - AIR TERMINAL UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single-duct terminal units.
 - 1. Single-duct, variable-volume units.

1.02 RELATED REQUIREMENTS

- A. Section 233100 - HVAC Ducts and Casings.

1.03 REFERENCE STANDARDS

- A. AHRI 880 (I-P) - Performance Rating of Air Terminals.
- B. ASHRAE Std 130 - Methods of Testing Air Terminal Units.
- C. ASTM A492 - Standard Specification for Stainless Steel Rope Wire.
- D. ASTM A603 - Standard Specification for Metallic-Coated Steel Structural Wire Rope.
- E. ASTM C1071 - Standard Specification for Fibrous Glass Duct Lining Insulation (Thermal and Sound Absorbing Material).
- F. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- G. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.
- H. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems.

1.04 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. Manufacturer's Installation Instructions: Indicate support and hanging details, installation instructions, recommendations, and service clearances required.
- C. Warranty: Submit manufacturer warranty and ensure forms have been completed in Owner's name and registered with manufacturer.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project. O&M information shall include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.05 QUALITY ASSURANCE

- A. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-Up."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Insulation shall meet NFPA 90A requirements for flame spread and smoke generation and UL 181 requirements for anti-erosion, corrosion and fungus properties. Any sealant used shall also conform to NFPA 90A and be approved for duct use.
- D. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."
- E. Sound power levels shall be AHRI certified in accordance with the requirements of AHRI 880.

1.06 WARRANTY

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

PART 2 PRODUCTS

2.01 SINGLE-DUCT, VARIABLE-VOLUME UNITS

- A. Manufacturers:
 - 1. Nailor Industries, Inc.; _____
 - 2. Price Industries, Inc.; _____
 - 3. Titus; _____
 - 4. Trane _____
- B. Performance Requirements
 - 1. Structural Performance: Hangers and supports shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"
- C. General:
 - 1. Factory-assembled, AHRI 880 (I-P) rated and bearing the AHRI seal, air volume control terminal with damper assembly, flow sensor, externally mounted volume controller, duct collars, and all required features.
 - 2. Control box bearing identification, including but not necessarily limited to nominal cfm, maximum and minimum factory-set airflow limits
- D. Unit Casing:
 - 1. Minimum 20 gauge, 0.0359 inch galvanized steel, single wall.
 - a. Assembled with longitudinal lock seam construction.
 - b. Casing leakage shall be less than 1% of the maximum rated airflow at 3" w.c. static pressure, when tested in accordance with ASHRAE Std 130.
 - 2. Connection products and materials shall be appropriate for the metal gauges being joined, the maximum pressure, and SMACNA (DCS) recommendations, to result in a rigid, leak-free duct connection.
 - 3. Air Inlet Collar: Provide round, suitable for standard duct sizes.

4. Unit Discharge: Rectangular, with slip-and-drive connections.
 5. Acceptable Liners:
 - a. 1 inch (min. R-4.2) thick, rigid duct board insulation with nylon reinforced foil material covering the insulation fibers. Insulation shall meet UL 181 and NFPA 90A. The lining shall be attached to the terminal unit casing by insulation adhesive and full seam length steel Z-strips which enclose and seal the insulation cut edges. Taped edges shall not be accepted.
 - b. Liner not to contain pentabrominated diphenyl ether (CAS #32534-81-9) or octabrominated diphenyl ether.
 6. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket. Access door located on the bottom of the terminal
- E. Damper Assembly:
1. Heavy-gauge, galvanized steel or extruded aluminum construction with solid steel, nickel-plated shaft pivoting on HDPE, self-lubricating bearings.
 2. Provide integral position indicator or alternative method for indicating damper position over full range of 90 degrees.
 3. The damper blade shall be mechanically attached to the die-cast metal damper shaft with through the shaft machine-applied rivets. The low leakage damper shall be constructed of a gasket material sandwiched between two 22-gauge zinc coated steel plates. The damper gasket material shall be securely fastened between the two damper plates using machine applied rivets. The damper assembly shall rotate freely in self-lubricating bearings.
 4. Air Leakage Past Closed Damper: AHRI 88- rated, maximum two percent of unit maximum airflow at 3 inch wg inlet static pressure, tested in accordance with ASHRAE Std 130.
- F. Control :
1. Electronic:
 - a. Damper Actuator: 24 volt, powered open, spring return
 - b. Velocity Controller:
 - 1) Settings for minimum/maximum air volumes, factory-calibrated, and field adjustable at thermostat.
 - 2) Maintain constant airflow dictated by thermostat to within 5 percent of set point while compensating for inlet static-pressure variations up to 4 inch wg, when tested in accordance with ASHRAE Std 130.
 2. DDC (Direct-Digital Controls):
 - a. Terminal Unit Controller: Pressure-independent, variable-air-volume (VAV) controller with electronic airflow transducer with multipoint velocity sensor at air inlet, factory calibrated to minimum and maximum air volumes, and having the following features:
 - 1) Occupied and unoccupied operating mode.
 - 2) Remote reset of airflow or temperature set points.
 - 3) Adjusting and monitoring with portable terminal.
 - 4) Communication with temperature-control system specified in Section 230923 "Direct Digital Control (DDC) System for HVAC."
 - b. Room Sensor:
 - 1) Compatible with temperature controls specified.
 - 2) Wall-mounted, system powered, with temperature set-point adjustment including connection access for portable operator terminal.
 - c. See Section 23 0923.
 3. Controls:

- a. Suitable for operation with duct pressures between 0.25- and 3.0-inch wg inlet static pressure.

2.02 SOURCE QUALITY CONTROL

- A. Factory Tests: Test assembled air terminal units according to ARI 880.
 - 1. Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions and NFPA 90A.
- B. Install air terminal unit(s) level and plumb. Maintain ready accessibility for routine service and maintenance. Unit shall be accessible within the reach of an 8-foot step ladder. Access shall not be hindered by building components. No maintainable parts of the unit, reheat coil, or appurtenance shall be crossed by a wall
- C. Install the inlets of air terminal units and air flow sensors a minimum of four duct diameters from elbows, transitions, and duct takeoffs.
- 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).
 - 1. Hangers exposed to view: Threaded rod and angle or channel support.
- F. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
- G. Do not support from ductwork.
- H. Connect to ductwork in accordance with Section 233100. All connections shall be sealed using appropriate duct sealant method _____.

3.02 IDENTIFICATION

- A. Label each air terminal unit with plan number, nominal airflow, and maximum and minimum factory-set airflows. Comply with requirements in Section 230553 "Identification for HVAC Piping and Equipment" for equipment labels and above ceiling location indicators.

3.03 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:.
 - 1. 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.

- B. Air terminal unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.04 STARTUP SERVICE

- A. Perform startup service:
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that the building management system display accurately reflects the as-built condition and that the building management system responds and causes the terminal unit to respond as specified.
 - 7. Verify that the identified terminal unit serves the area specified on the final drawings.

3.05 DEMONSTRATION

- A. Train owner's maintenance personnel to adjust, operate, and maintain air terminal units.

END OF SECTION 233600

SECTION 233700 - AIR OUTLETS AND INLETS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Diffusers:
 - 1. Square ceiling diffusers.
- B. Registers/grilles:
 - 1. Egg crate exhaust and return register/grilles.
 - 2. Exhaust and return register/grilles.
 - 3. Supply register/grilles.
 - 4. Wall-mounted, supply register/grilles.
- C. Louvers

1.02 RELATED REQUIREMENTS

- A. Division 23 Section "Air Duct Accessories" for dampers not integral to diffusers, registers, and grilles.

1.03 REFERENCE STANDARDS

- A. AMCA 500-L - Laboratory Methods of Testing Louvers for Rating.
- B. ASHRAE Std 70 - Method of Testing the Performance of Air Outlets and Inlets.
- C. ASTM D610 - Standard Practice for Evaluating Degree of Rusting on Painted Steel Surfaces.
- D. ASTM D714 - Standard Test Method for Evaluating Degree of Blistering of Paints.
- E. ASTM D1654 - Standard Test Method for Evaluation of Painted or Coated Specimens Subjected to Corrosive Environments.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide data for equipment required for this project. Review outlets and inlets as to size, finish, and type of mounting prior to submission. Submit schedule of outlets and inlets showing type, size, accessories, location, application, throw and drop, static-pressure drop and noise level.
- C. Color Chart: Provide color chart separately from Product Data, addressed to the Architect of Record.

1.05 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.
- C. All paint finishes shall pass 500 hours of salt spray exposure with no measurable creep in accordance with ASTM D1654 and 1000 hours with no rusting or blistering per ASTM D610 and ASTM D714.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Carnes, a division of Carnes Company Inc; _____
- B. Nailor Industries; _____
- C. Price Industries; _____
- D. Titus, a brand of Air Distribution Technologies; _____

2.02 SQUARE CEILING DIFFUSERS

- A. Basis of Design: Price Model SPD.
- B. Type: Provide square, plaque style, diffuser to discharge air in 360 degree pattern.
 - 1. Precision formed back cone of one-piece seamless construction that incorporates a round Intel collar of sufficient length for connecting rigid or flexible duct.
 - 2. An inner plaque assembly shall be incorporated and shall drop no more than a ¼ inch below the ceiling plane to assure proper air distribution performance.
 - 3. The inner plaque assembly shall be completely removable from the diffuser face to allow for full access to any dampers or other ductwork components located near the diffuser neck.
- C. Connections: As indicated on drawings.
- D. Frame: Provide inverted T-bar type. In plaster ceilings, provide plaster frame and ceiling frame.
- E. Fabrication: Steel with powder coat finish.
- F. Color: As selected by Engineer of Record from manufacturer's standard range.
- G. Accessories: Provide radial opposed blade volume control damper, equalizing grid with damper adjustable from diffuser face.

2.03 SUPPLY REGISTERS/GRILLES

- A. Manufacturers:
 - 1. Price Industries; 520.
- B. Type: Streamlined and individually adjustable curved blades to discharge air along face of grille, spaced at 3/4 inch, double deflection. Front blades parallel to the long dimension.
- C. Frame: 1-1/4 inch margin with countersunk screw mounting and gasket.
- D. Construction: Made of steel with factory powder-coated finish.

- E. Color: As selected by Engineer of Record from manufacturer's standard range.

2.04 EXHAUST, TRANSFER AND RETURN REGISTERS/GRILLES

- A. Manufacturers:
 - 1. Price Industries; 535.
- B. Type: Streamlined blades, 3/4 inch minimum depth, 1/2 inch maximum spacing, with blades set at 45 degrees, parallel to the long dimension.
- C. Frame: 1-1/4 inch wide, welded with precision mitered corners and countersunk screw mounting.
- D. Construction: Made of steel with factory powder-coated finish.
- E. Color: To be selected by Engineer of Record from manufacturer's standard range.

2.05 SHOWER/BATHROOM EXHAUST REGISTERS/GRILLES

- A. Manufacturers:
 - 1. Price Industries; 635.
- B. Type: Streamlined blades, 3/4 inch minimum depth, 1/2 inch maximum spacing, with blades set at 45 degrees, parallel to the long dimension.
- C. Frame: 1-1/4 inch wide, welded with precision mitered corners and countersunk screw mounting.
- D. Construction: Made of aluminum with factory powder-coated finish.
- E. Color: To be selected by Engineer of Record from manufacturer's standard range.

2.06 EGGCRATE EXHAUST AND RETURN GRILLES

- A. Manufacturers:
 - 1. Price Industries; 85.
- B. Type: Egg crate style face consisting of 1/2 by 1/2 by 1/2 inch grid core. Grid to be on 45 degree angle for sight-resistance.
- C. Fabrication: Grid core consists of aluminum with powder coat finish.
- D. Color: To be selected by Engineer of Record from manufacturer's standard range.
- E. Frame: 1-1/4 inch wide, welded with precision mitered corner with countersunk screw mounting.
- F. Frame: Channel lay-in frame for suspended grid ceilings.
- G. Accessories: Where indicated on drawings, provide integrated plenum equal to Price model 80SR.

2.07 LOUVERS

- A. Type: 4 inch deep frame with drainable head, heavy channel frame, .75 inch square mesh screen over intake or exhaust end.
- B. Fabrication: 16 gauge, 0.0598 inch (1.52 mm) thick galvanized steel thick galvanized steel welded assembly, with factory baked enamel finish.
- C. Color: To be selected by Architect from manufacturer's standard range.
- D. Mounting: Furnish with channel for installation.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb in accordance with manufacturer's instructions.
- B. Ceiling-Mounted Outlets and Inlets: Drawings indicate general arrangement of ducts, fittings, and accessories. Air outlet and inlet locations have been indicated to achieve design requirements for air volume, noise criteria, airflow pattern, throw, and pressure drop. Make final locations where indicated, as much as practical. For units installed in lay-in ceiling panels, locate units in the center of panel. Where architectural features or other items conflict with installation, notify Architect for a determination of final location.
- C. Install diffusers to ductwork with air tight connection to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers..
- D. 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.

3.03 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

END OF SECTION 233700

SECTION 237200 - ROOF ACCESSORIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Roof curbs.
2. Equipment supports.
3. Gravity ventilators.
4. Pipe supports.
5. Pipe hoods.

- B. Related Requirements:

1. Section 233423 "HVAC Power Ventilators" for power roof-mounted ventilators.
2. Section 237413 "Packaged, Outdoor, Central-Station Air-Handling Units" for standard curbs specified with rooftop units.

1.3 COORDINATION

- A. Coordinate layout and installation of roof accessories with roofing membrane and base flashing and interfacing and adjoining construction to provide a leakproof, weathertight, secure, and noncorrosive installation.
- B. Coordinate dimensions with rough-in information or Shop Drawings of equipment to be supported.

1.4 ACTION SUBMITTALS

- A. Delegated Design: Design roof accessories and associated anchors including comprehensive engineering analysis signed and sealed by a qualified professional engineer, licensed in the project location state, responsible for their preparation. Wind pressures are to be determined by delegated design engineer based on site specific wind criteria indicated below. All building attachments to be coordinated with structural conditions.
 1. Detail fabrication and assembly of rooftop unit and roof curb.
 2. Wind Design Loads:

- a. Basic wind speed: 122.5 MPH
- b. Risk Category: IV
- c. Exposure Category: B

1) Refer to structural drawing S001 for additional structural design data.

B. Product Data: For each type of roof accessory.

- 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. General Performance: Roof accessories shall withstand exposure to weather and resist thermally induced movement without failure, rattling, leaking, or fastener disengagement due to defective manufacture, fabrication, installation, or other defects in construction.
- B. Structural Performance: Equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7.
- C. Detail mounting, securing, and flashing of roof curb to roof structure and unit to roof curb. Indicate coordinating requirements with roof membrane system

2.2 ROOF CURBS

- A. Roof Curbs: Internally reinforced roof-curb units capable of supporting superimposed live and dead loads, including equipment loads and other construction indicated on Drawings, bearing continuously on roof structure, and capable of meeting performance requirements; with welded or mechanically fastened and sealed corner joints, straight sides and integrally formed deck-mounting flange at perimeter bottom.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Greenheck Fan Corporation.
 - b. Pate Company.
 - c. Thybar Corporation (Basis of Design).
- B. Size: Coordinate dimensions with roughing-in information or Shop Drawings of equipment to be supported.
- C. Supported Load Capacity: Coordinate load capacity with information on Shop Drawings of equipment to be supported.
- D. Material: Zinc-coated (galvanized) steel sheet, 18-gauge thick.

E. Construction:

1. Curb Profile: compatible with roofing system.
2. On ribbed or fluted metal roofs, form deck-mounting flange at perimeter bottom to conform to roof profile.
3. Fabricate curbs to minimum height of 18 inches above roofing surface unless otherwise indicated.
4. Top Surface: Level top of curb, with roof slope accommodated by sloped deck-mounting flange.
5. Sloping Roofs: Where roof slope exceeds 1:48, fabricate curb with perimeter curb height tapered to accommodate roof slope so that top surface of perimeter curb is level. Equip unit with water diverter or cricket on side that obstructs water flow.
6. Insulation: Factory insulated with 1-1/2-inch-thick glass-fiber board insulation.
7. Liner: Same material as curb, of manufacturer's standard thickness and finish.
8. Nailer: Factory-installed wood nailer under top flange on side of curb, continuous around curb perimeter.
9. Wind Restraint Straps and Base Flange Attachment: Provide wind restraint straps, welded strap connectors, and base flange attachment to roof structure at perimeter of curb, of size and spacing required to meet wind uplift requirements.
10. Platform Cap: Where portion of roof curb is not covered by equipment, provide weathertight platform cap formed from 3/4-inch-thick plywood covered with metal sheet of same type, thickness, and finish as required for curb.
11. Metal Counterflashing: Manufacturer's standard, removable, fabricated of same metal and finish as curb.

2.3 PIPE HOODS

- A. Curb-Mounted Pipe Hood: Insulated roof-curb units with welded or mechanically fastened and sealed corner joints, straight sides, and integrally formed deck-mounting flange at perimeter bottom; with weathertight curb cover with single or multiple collared openings and pressure-sealed conically shaped EPDM protective rubber caps sized for piping indicated, with stainless steel snaplock swivel clamps.
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Pate Company. (Basis of Design)
 - b. Roof Penetration Housings
 - c. Approved Equal.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, to verify actual locations, dimensions, and other conditions affecting performance of the Work.

- B. Verify that substrate is sound, dry, smooth, clean, sloped for drainage, and securely anchored.
- C. Verify dimensions of roof openings for roof accessories.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install roof accessories according to manufacturer's written instructions.
 - 1. Install roof accessories level; plumb; true to line and elevation; and without warping, jogs in alignment, buckling, or tool marks.
 - 2. Anchor roof accessories securely in place so they are capable of resisting indicated loads.
 - 3. Use fasteners, separators, sealants, and other miscellaneous items as required to complete installation of roof accessories and fit them to substrates.
 - 4. Install roof accessories to resist exposure to weather without failing, rattling, leaking, or loosening of fasteners and seals.
- B. Metal Protection: Protect metals against galvanic action by separating dissimilar metals from contact with each other or with corrosive substrates by painting contact surfaces with bituminous coating or by other permanent separation as recommended by manufacturer.
 - 1. Coat concealed side of uncoated aluminum roof accessories with bituminous coating where in contact with wood, ferrous metal, or cementitious construction.
 - 2. Underlayment: Where installing roof accessories directly on cementitious or wood substrates, install a course of underlayment and cover with manufacturer's recommended slip sheet.
 - 3. Bed flanges in thick coat of asphalt roofing cement where required by manufacturers of roof accessories for waterproof performance.
- C. Roof Curb Installation: Install each roof curb so top surface is level.

3.3 REPAIR AND CLEANING

- A. Galvanized Surfaces: Clean field welds, bolted connections, and abraded areas and repair galvanizing according to ASTM A780/A780M.
- B. Clean exposed surfaces according to manufacturer's written instructions.
- C. Clean off excess sealants.
- D. Replace roof accessories that have been damaged or that cannot be successfully repaired by finish touchup or similar minor repair procedures.

END OF SECTION

SECTION 237210 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Energy recovery ventilators.

1.02 RELATED REQUIREMENTS

- A. Section 237200 - Roof Accessories: Equipment roof curb.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.
- C. Section 230923 - Direct-Digital Control System for HVAC.
- D. Section 260583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.

1.04 SUBMITTALS

- A. Product Data: Manufacturer's installation instructions, product data, and operating characteristics, furnished specialties, and accessories. Fan performance curves, sound power, construction and electrical information.
- B. Closeout Submittals: Submit manufacturer's operation and maintenance instructions.
- C. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 - 1. Extra Stock Materials: Two sets of each type of filter specified.

1.05 WARRANTY

- A. See Section 017800 - Closeout Submittals for additional warranty requirements.
- B. Manufacturer Warranty: Provide 2-year manufacturer warranty for equipment including parts, materials, workmanship, and operation commencing on date of Substantial Completion. Complete forms in Owner's name and register with manufacturer.
- C. Fixed Plate Heat Exchanger Warranty: Provide 10-year manufacturer warranty against material and workmanship defects including issues arising from reduced performance under circumstances of normal use from listed design figures.

PART 2 PRODUCTS

2.01 ENERGY RECOVERY VENTILATOR

- A. Manufacturers:

1. Greenheck
 2. RenewAire
 3. Innovent.
- B. ERV Performance Requirements
1. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
 2. ASHRAE Compliance:
 - a. Applicable requirements in ASHRAE 62.1.
 - b. Capacity ratings for fixed-plate energy-recovery units shall comply with ASHRAE 84.
 3. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1.
 4. UL Compliance:
 - a. Packaged heat-recovery ventilators shall comply with requirements in UL 1815 or UL 1812.
 5. Comply with ASTM E84 or UL 723.
- C. Packaged, Enthalpy Core, Energy-Recovery Units
1. Source Limitations: Obtain packaged, outdoor, enthalpy core, energy-recovery units from single manufacturer.
 2. Surfaces in Contact with Airstream: Comply with requirements in ASHRAE 62.1.
 3. Housing: Manufacturer's standard construction with corrosion-protection coating and exterior finish, gasketed, hinged access doors with neoprene gaskets for inspection and access to internal parts, minimum 2-inch thick, thermal insulation with a minimum R-value of 4.3/in (hr-ft²-°F/BTU), knockouts for electrical and piping connections, exterior drain connection, and lifting lugs.
 4. Fixed-Plate, Total Enthalpy Heat Exchanger:
 - a. Casing: 20-gauge galvanized metal double wall construction.
 - b. Energy recovery core shall be of the total enthalpy type, capable of transferring both sensible and latent energy between airstreams. Latent energy transfer shall be accomplished by direct water vapor transfer from one airstream to the other, without exposing transfer media in succeeding cycles directly to the exhaust air and then to the fresh air. No condensate drains shall be allowed. The energy recovery core shall be designed and constructed to permit cleaning and removal for servicing.
 5. Supply and Exhaust Fans: Forward-curved centrifugal fan.
 - a. Motors and Drives: Direct driven.
 - 1) Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230513 "Common Motor Requirements for HVAC Equipment."
 - 2) Motor Sizes: Minimum size as indicated. If size is not indicated, provide motor large enough so driven load will not require motor to operate in service factor range above 1.0.
 6. Filters:
 - a. Description: MERV 13 (Supply) & Merv 8 (Exhaust) pleated factory-fabricated, self-supported, disposable air filters with holding frames.
 - b. UL Compliance: Comply with UL 900.
 - c. Media: Interlaced glass fibers sprayed with nonflammable adhesive and antimicrobial agent.
 - d. Filter-Mounting Frames: Arranged with access doors or panels on both sides of unit. Filters shall be removable from one side or lift out from access plenum.

7. Wiring: Fabricate units with space within housing for electrical conduits. Wire motors and controls so only external connections are required during installation.
 - a. NEMA 250, Type 3R enclosure contains relays, starters, and terminal strip.
 - b. Include non-fused disconnect switches.
- D. Controls
 1. Control Panel: Solid-state, programmable, microprocessor-based control unit. Integrate to BACnet, as specified in Section 230923 "Direct Digital Control (DDC) System for HVAC".
 2. Starting relay, factory mounted and wired, and manual motor starter for field wiring.
 3. Frost Control: Passive.
 4. Dry-bulb temperature sensor.
 5. Dirty filter switch.
 6. Low-Voltage Transformer: Integral transformer to provide control voltage to unit from primary incoming electrical service.
- E. Source Quality Control
 1. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by NRTL, and marked for intended location and application.
 2. AHRI Compliance: Capacity ratings for air-to-air energy-recovery equipment certified as complying with AHRI 1060 (IP).
 3. Fan Performance Rating: Comply with AMCA 211, and label fans with AMCA-certified rating seal. Factory test fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210 and ASHRAE 51.
 4. Fan Sound Ratings: Comply with AMCA 301 or AHRI 260 (IP).

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that structure is ready for installation including openings, ductwork, mechanical utilities, and electrical utilities.
- B. Rooftop Installation: Verify that equipment supplied roof curbs are installed and ready to receive intended unit otherwise provide equipment matched roof curbs; see Section 237200.

3.02 INSTALLATION

- A. Install equipment in accordance with manufacturer's written installation instructions.
- B. Do not obstruct maintenance access to equipment piping, electrical conduit, or any other utility.
- C. Vibration Isolation: Provide corrosion-resistant equipment isolation products; see Section 230548.
- D. Electrical: Provide equipment raceway, wiring, and cables; see Section 260583.
- E. Coordinate installation and fire alarm system interface of system compatible duct-mounted smoke detectors and other appurtenances following NFPA 90A guidelines.
- F. Start system and adjust controls and equipment for satisfactory operation.

- G. Coordinate hardwired or software interfacing links to enable coordinate as minimum start-stop, occupied, unoccupied functions as well as specific schedules and setpoints functions with other DDC controls onboard airside systems serving common spaces; see Section 230923.
- H. Do not operate equipment fans until temporary or permanent filters are in place. Replace filters used during construction and testing with new, clean filters prior to final inspection.

3.03 DUCTWORK CONNECTIONS

- A. Comply with requirements for ductwork in accordance with Section 233113 "Metal Ducts."
- B. Connect duct to units with flexible connections. Comply with requirements in Section 233300 "Air Duct Accessories."

3.04 ELECTRICAL CONNECTIONS

- A. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- B. Connect wiring in accordance with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Ground equipment in accordance with Section 260526 "Grounding and Bonding for Electrical Systems."
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate shall be laminated acrylic or melamine plastic signs, as specified in Section 260553 "Identification for Electrical Systems."
 - 2. Nameplate shall be laminated acrylic or melamine plastic signs with a black background and engraved white letters at least 1/2 inch high.\

3.05 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 260523 "Control-Voltage Electrical Power Cables."

3.06 SYSTEM STARTUP

- A. Provide services of manufacturer's authorized representative to provide start up of unit.

3.07 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with assistance of factory-authorized service representative.
- C. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Packaged, outdoor, enthalpy core, energy-recovery units will be considered defective if it does not pass tests and inspections.
- E. Prepare tests and inspections report.
- 3.08 DEMONSTRATION
- A. Engage factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy-recovery units.

END OF SECTION 237210

SECTION 237433 - DEDICATED OUTDOOR AIR UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Packaged outdoor air unit
- B. Heat Exchanger
- C. Refrigeration Components
- D. Unit operating controls
- E. Electrical power connections
- F. Operation and maintenance service

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.
- C. Section 233300 - Air Duct Accessories: Flexible duct connections.
- D. Section 237200 - Roof Accessories

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment.
- B. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- C. NFPA 70 - National Electrical Code.
- D. NFPA 90A - Standard for the Installation of Air-Conditioning and Ventilating Systems.
- E. UL (DIR) - Online Certifications Directory.

1.04 SUBMITTALS

- A. Product Data: Provide data with dimensions, perform duct and service connections, accessories, controls, electrical nameplate data, and wiring diagrams.
- B. Operation And Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listing.
- C. Warranty: Submit manufacturers warranty and ensure forms have been filled out in Owner's name and registered with manufacturer.
- D. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. Extra Filters: One set of each type and size.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Comply with manufacturer's installation instructions for rigging, unloading, and transporting units.
- B. Protect units from physical damage. Leave factory shipping covers in place until installation.

1.06 WARRANTY

- A. Provide five year parts and labor warranty from date of shipment.
- B. Provide twenty-five year heat exchanger limited warranty from date of shipment.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Trane
- B. Addison
- C. LC-Systems

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 MANUFACTURED UNITS

- A. Unit shall consist of insulated weather-tight casing with compressor(s), air-cooled condenser coil, condenser fans, evaporator coil, electric coil, air filters, supply motors and unit controls.
 1. Construction and Ratings: In accordance with AHRI 210/240 and UL 207. Testing: ASHRAE Std 23.1.
 2. Performance Ratings: Energy Efficiency Rating (EER)/Coefficient of Performance (COP) not less than requirements of ASHRAE Std 90.1.
- B. Before shipment, each unit(s) shall be leak tested, dehydrated, charged with refrigerant (R-410A) and compressor oil, and factory run tested for proper control operation.
- C. The condenser coils must be aluminum fin, mechanically bonded to copper tubing.
- D. Direct-drive, vertical discharge condenser fans must be provided with built-in thermal overload protection.
- E. Unit(s) shall have labels, decals, and/or tags to aid in the service of the unit and indicate caution areas.
- F. Unit(s) shall be dedicated downflow or dedicated, thru curb horizontal airflow as manufactured.

- G. Wiring internal to the unit shall be colored and numbered for identification.

2.04 FABRICATION

- A. Cabinet: Zinc-coated, heavy gauge, galvanized steel. Exterior surfaces shall be cleaned, phosphatized, and finished with a weather-resistant baked enamel finish. Unit's surface shall be tested 672 hours in a salt spray test in compliance with ASTM B45. Structural members shall be a minimum of 16 gauge with access doors and removable panels of minimum 20 gauge.
- B. Panels: 2" double-wall foamed panel construction throughout the indoor section of unit to provide nonporous, cleanable interior surfaces. All interior seams exposed to airflow shall be sealed.
- C. Insulation: 2" polyisocyanurate Foam metal encapsulated with no exposed edges. Initial R value of 6.6 per inch of thickness.
- D. Cabinet construction shall provide access panels for all parts requiring service.
- E. Cabinet top cover shall be one piece construction or where seams exist, it shall be double-hemmed and gasket-sealed.
- F. Panels: Water- and air-tight hinged panels with handles shall provide access to filters, heating section; optional ERV and power exhaust fan section, supply air fan section, evaporator coil section, and unit control section. Door hardware shall be oriented to allow the door swing to be reversed.
 - 1. Latches with hold down hooks will be factory installed on hinged access doors.
- G. Unit shall include a motor operated outside air damper and optional return air damper assembly constructed of galvanized steel, and air foil blades with rubber edge seals. Damper blades shall be designed to have no more than 4 cfm of leakage per sq ft of damper area and shall exceed ASHRAE 90.1 requirements. Linkage shall be concealed out of airstream, within the damper frame to reduce pressure and noise. Damper assembly shall be controlled by a spring return two position or fully modulating actuator. Dampers shall not be sized for air velocities exceeding 2000 fpm.
- H. Type 430 Stainless steel drain pan sloped in two directions to ensure positive drainage. Pan shall have a minimum depth of 2". Seams exposed to standing water shall be welded liquid tight. Base of pan shall be insulated with 1" thick foam insulation.
- I. Provide openings either on side of unit or thru the base for power and control connections.
- J. Pipe portal shall be provided on side of unit for water connections to come from below.
- K. The base of the unit shall have provisions for forklift and crane lifting

2.05 FILTERS

- A. Filter: MERV 13 (Supply) and MERV 8(Exhaust) removable 2 inches thick high velocity permanent filters in metal frames.

2.06 POWER WIRING

- A. Field wiring access to be provided thru unit base into isolated enclosure with removable cover.

- B. Power wiring to be single point connection.
- C. Unit shall be factory wired to field wiring terminal block mounted in isolated enclosure.
- D. Factory wired main power disconnect device, overcurrent and SCCA rated for total unit power connection.
- E. Factory installed safety barrier shall isolate all high voltage components, mounted inside electrical compartment, to protect service personnel from incidental contact.
- F. Factory wired Phase monitor shall be included as standard.
- G. Factory to mount and wire 120 volt convenience outlet. Field wiring of convenience outlet not acceptable.

2.07 LOW VOLTAGE CONTROLS

- A. Factory wired 24 volt control system complete with required transformers and fusing.
- B. Main Control Module (MCM) shall prevent simultaneous operation of any modes and shall enable operation in Dehumidification, Cooling, Heating or Economizer mode based on programmed settings for
 - 1. Outdoor air conditions and discharge air temperature
- C. MCM shall accept separate setpoints for Occupied and Unoccupied states.
- D. MCM shall control based on dew point design settings for Dehumidification and Economizer modes, and sensible temperature settings for heating and cooling modes.
- E. MCM shall have onboard clock and scheduling function for occupancy.
- F. MCM shall include non-volatile memory to retain all programmed values without the use of a battery, in the event of a power failure.
- G. Factory installed and wired sensors shall monitor Outdoor Air (OA) temperature, humidity and evaporator leaving air temperature. If an Energy Recovery Ventilator (ERV) is chosen, factory installed and wired sensors shall monitor the exhaust ERV leaving air temperature for defrost control.
- H. Supply air sensor shall be furnished with unit. Installing contractor shall install remote mounted supply air sensor in supply air duct and field wire to the unit.
- I. Space temp and humidity sensor shall be furnished and field wired to unit by the installing contractor.
- J. Fully modulating hot-gas reheat shall be enabled in dehumidification mode and cooling mode with modulation controlled by MCM to maintain (supply air temperature / space temperature).
- K. System controls shall include anti-cycle timing and minimum compressor run/off-times.
- L. Systems controls shall be digital, programmable type with access via factory installed and wired touchscreen, or through portable computer connection. All setpoints, unit functions, and status shall be accessible via the touchscreen or portable computer.
- M. Factory wired (return air / supply air) smoke detector(s)

- N. All low voltage field wiring connections shall be made at factory installed low voltage terminal strip.

2.08 FANS AND MOTORS

- A. Indoor fan shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive and shall be equipped with slide out service access.
- B. All fan motors shall be premium efficiency ODP and meet the U.S. Energy Policy Act of 2005/10 (EPACT).
- C. All fan motors shall either be permanently lubricated and/ or have internal thermal overload protection.
- D. Provide shafts constructed of solid hot rolled steel, ground and polished, with key-way, and protectively coated with lubricating oil.

2.09 MODULATING ELECTRIC HEAT SECTION

- A. The unit may have fully modulating, SCR controlled, electric heat.

2.10 EVAPORATOR CONDENSOR AND REHEAT COILS

- A. Evaporator and hot gas reheat coils shall be constructed of copper tubes mechanically bonded to a configured aluminum plate fin.
- B. Coils shall be leak tested at the factory to ensure pressure integrity. The evaporator coil, reheat coil and condenser coil shall be leak tested to 500 psig and pressure tested to 500 psig.
- C. Evaporator coil shall have four interlaced rows for superior sensible and latent cooling with a maximum of 12 fpi.
- D. The condenser coils shall be a coaxial "tube in tube" design. Water flows through the inner tube while refrigerant flows in the annulus between the inner and outer tubes. The coils have a convoluted multi-lead inner tube. The resulting convoluted tube has increased heat transfer surface area per unit length yet still permits full flow of both water and refrigerant around its entire periphery for improved performance. Turbulence imparted by the convolutions to both the water and refrigerant flows further enhances the thermal performance, while inhibiting the accumulation of deposits on the surfaces.
- E. Reheat coil shall be fully integrated into the supply air and fan system and capable of delivering design supply air temperature.
- F. To prevent re-hydration of condensate from evaporator coil, the evaporator coil face and the hot gas reheat coil face shall be separated a minimum of six inches.
- G. UVC Emitters/Lamps: Ultraviolet light (C band) emitters/lamps shall be incorporated downstream of evaporator coils, upstream of hot gas reheat coils, and above all drain pans to control airborne and surface microbial growth and transfer. Applied fixtures must be specifically manufactured for this purpose. Safety interlocks/features shall be provided to limit hazard to operating staff.
- H. Unit shall be equipped with an adjustable 6" filter rack upstream of the evaporator to match the filter requirements specified in the Air Filtration section

- I. Fans shall be statically balanced.

2.11 REFRIGERANT CAPACITY CONTROL

- A. Capacity control for units equipped with digital scroll compressors, or variable speed compressors, shall be accomplished through a 0-10V signal by the MCM to the compressor controls.

2.12 REFRIGERATION SYSTEM

- A. Compressor(s): All units shall have direct-drive, hermetic, scroll type compressors.
- B. Motor shall be suction gas-cooled and shall have a voltage utilization range of plus or minus 10 percent of unit nameplate voltage.
- C. Internal overloads shall be provided with the scroll compressors.
- D. Compressor shall have a crankcase heater to minimize the amount of liquid refrigerant present in the oil sump during off cycles.
- E. Compressor shall be mounted on rubber vibration isolators, to reduce the transmission of noise.
- F. Provide unit with one hermetically sealed refrigerant circuit factory-supplied completely piped with liquid line filter-drier, liquid line charging port, discharge, suction and liquid line pressure ports, sight glass, thermal expansion valve, 4-way reversing valve, suction line accumulator, and charge compensator.
- G. Provide circuit with automatic reset high and low pressure switches for safety control.

2.13 POWER EXHAUST/RETURN SECTION

- A. Provide, a factory installed power exhaust assembly that shall be designed to ventilate return air to atmosphere.
- B. Fan wheel shall be direct drive plenum fan, factory installed and wired to on-board Variable Frequency Drive Other fan construction is not acceptable
- C. Fan mount to be fixed.
- D. Exhaust to ventilate through automatic louver located on both sides of unit cabinet.

2.14 OUTDOOR AIR SECTION ENERGY RECOVERY (ERV)

- A. The rotor media shall be made of aluminum, formed into a honeycomb structure to minimize pressure loss and avoid plugging. Paper, plastic or fibrous media are not acceptable. The rotor media must be coated to resist corrosion. All surfaces must be coated with a non-migrating desiccant layer to insure that adequate latent capacity is provided. The desiccant coating must be firmly bonded to the aluminum surface and will not be dislodged when challenged with high velocity air up to 5000 feet per minute. Products that loose desiccant when served with high velocity air are not acceptable. The cassette must be a slide out design for serviceability. The media shall be cleanable with low temperature steam, hot water or light detergent without degrading the latent recovery.

- B. Sensible and latent recovery efficiencies must be clearly documented through a testing program conducted in accordance with ASHRAE Standard 84 and AHRI 1060. The testing must have been conducted by a qualified independent organization. The performance test reports must be provided for engineering review as part of the submittals for this project.
- C. The rotor design shall ensure laminar airflow to minimize parasitic pressure loss and to optimize the operating efficiency of the system fans. The pressure loss across the media shall be no greater than the scheduled pressure loss values. The energy wheel shall operate effectively up to 180 degrees F.
- D. The rotor media shall be permanent, with an anticipated life of 20 years. It must be tested in accordance with ASTM Standard E-84 and provide smoke and flame spread ratings of less than 25 and 50 as required by NFPA 90A and UL 1995. A copy of the ASTM E-84 test report confirming the method of test and results shall be provided with the submittal. Heat recovery wheels incorporating "throw-away" media and tested to UL900 for Class 2 filters are not acceptable.
- E. The wheel manufacturer must have been producing energy recovery wheels for a minimum of ten years.
- F. The rotor shall be supplied with perimeter brush seals and face contact seals to minimize air leakage and wheel bypass.
- G. The rotor media shall be supported by a structural aluminum hub and aluminum reinforcing spoke system. The rotor bearings must be greaseable and provide L10 life in excess of 20 years.
- H. The cassette framework shall be made of galvanized steel to prevent corrosion.
- I. The rotor must be driven by long-life polyurethane/polyester composite link belt system. The rotor/cassette shall be designed so that belt can be removed or serviced without the removal of the bearing. A 3 phase A/C gear motor shall be utilized to accommodate variable speed applications.
- J. Where variable speed control is required for frost prevention, it must be accomplished by the use of a factory installed and wired A/C inverter. The variable speed drive system shall allow for a minimum 60:1 turndown ratio.

2.15 BUILDING MANAGEMENT SYSTEM

- A. Interface control module to Energy Management System to be furnished and mounted by rooftop unit manufacturer. Through this interface module, all Energy Management functions (specified in Energy Management Section) shall be performed. See Building Automation and Automatic Temperature Control System Specifications. The interface module with necessary controls and sensors shall all be factory mounted (not field mounted). The only field connection to Energy Management System shall be two wire communication link.
- B. Control Functions: Occupied/unoccupied mode, , conditioning mode set points, discharge air set point adjustment, and alarm shutdown.
- C. Diagnostic Functions: Include supply fan status, filter status, outside air damper status.
- D. Provide capabilities for Boolean Processing and trend logs as well as "templated" reports and logs.

2.16 ACCESSORIES

- A. Roof Curb: Refer to section 237200.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Contractor shall verify that roof is ready to receive work and opening dimensions are as shown.
- B. Contractor shall verify that proper power supply adequate to supply the unit.
- C. Examine casing insulation materials and filter media before air-handling unit installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Mount units on factory built roof mounting frame providing watertight enclosure to protect ductwork and utility services. Install roof mounting curb level. Install wind restraints according to curb manufacturer's written instructions.
- C. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- D. Do not operate fan system until filters (temporary or permanent) are in place. Replace temporary filters used during construction and testing, with new, clean filters.

3.03 CONNECTIONS

- A. Comply with requirements for piping specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect duct to unit with a hard duct connection.
- C. Duct installation requirements are specified in other HVAC Sections. Drawings indicate the general arrangement of ducts. The following are specific connection requirements:
 - 1. Install ducts to termination at top of roof curb.
 - 2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.
 - 3. Install duct continuously through roof structure
- D. Ground equipment according to Section 260526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, section assembly, and to assist in testing.
- B. Tests and Inspections:
 - 1. Leak Test: After installation, fill water coil with water, and test coils and connections for leaks.
 - 2. Leak Test: If factory test of unit did not meet leakage rate requirements, unit to be retested in the field after final installation with all sections assembled and sealed to meet required leakage rates.
 - 3. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- D. Remove and replace malfunctioning units and retest as specified above
- E. Prepare test and inspection reports.

3.05 START-UP SERVICE

- A. Engage a factory-authorized service representative to perform start-up service.
 - 1. Complete installation and start-up checks according to manufacturer's written instructions.
 - 2. Verify that shipping, blocking, and bracing are removed.
 - 3. Verify that unit is secure on mountings and supporting devices and that connections to piping, ducts, and electrical systems are complete. Verify that proper thermal-overload protection is installed in motors, controllers, and switches.
 - 4. Verify proper motor rotation direction, free fan wheel rotation, and smooth bearing operations. Reconnect fan drive system, align belts, and install belt guards.
 - 5. Verify that bearings, pulleys, belts, and other moving parts are lubricated with factory-recommended lubricants.
 - 6. Verify that dampers open and close.
 - 7. Install new, clean filters.
 - 8. Verify unit assembly is per manufacturer guidelines.
- B. Starting procedures for units include the following:
 - 1. Energize motor; verify proper operation of motor, drive system, and fan wheel. Adjust fan to indicated rpm.
 - 2. Measure and record motor electrical values for voltage and amperage.
 - 3. Manually operate dampers from fully closed to fully open position and record fan performance.

3.06 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

- B. Comply with requirements in Section 230593 "Testing, Adjusting, and Balancing for HVAC" for air-handling system testing, adjusting, and balancing.
- C. After completing system installation and testing, adjusting, and balancing air-distribution systems, clean filter housings and install new filters.

3.07 CLEANING

- A. After completing system installation and testing, adjusting, and balancing the unit and air-distribution systems and after completing start-up service, clean units internally to remove foreign material and construction dirt and dust. Clean fan wheels, cabinets, dampers, coils, and filter housings, and install new, clean filters.

3.08 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel for a minimum of 2-hours to adjust, operate, and maintain air-handling unit.

3.09 MANUFACTURER'S FIELD SERVICES

- A. Must have twenty authorized technicians within a 50 mile radius of job site.
- B. The contractor shall furnish manufacturer complete submittal wiring diagrams of the package unit as applicable for field maintenance and service.

END OF SECTION 237433

SECTION 238129 - VARIABLE REFRIGERANT FLOW HVAC SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Water-source outdoor units.
- B. Refrigerant piping.
- C. Refrigerant branch units.
- D. Indoor units.

1.02 RELATED REQUIREMENTS

- A. Section 230529 - Hangers and Supports for HVAC Piping and Equipment.
- B. Section 230719 - HVAC Piping Insulation.
- C. Section 230800 - Commissioning of HVAC.
- D. Section 232300 - Refrigerant Piping.
- E. Section 237433 - Dedicated Outdoor Air Units.
- F. Section 251500 - Integrated Automation Software.

1.03 REFERENCE STANDARDS

- A. AHRI 210/240 - Performance Rating of Unitary Air-Conditioning and Air-Source Heat Pump Equipment 2023.
- B. AHRI 1230 - Performance Rating of Variable Refrigerant Flow (VRF) Multi-Split Air-Conditioning and Heat Pump Equipment 2021.
- C. ASHRAE Std 15 - Safety Standard for Refrigeration Systems 2019, with All Amendments and Errata.
- D. ITS (DIR) - Directory of Listed Products Current Edition.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum) 2020.
- F. NFPA 70 - National Electrical Code Most Recent Edition Adopted by Authority Having Jurisdiction, Including All Applicable Amendments and Supplements.
- G. UL 1995 - Heating and Cooling Equipment Current Edition, Including All Revisions.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's standard data sheets showing the following for each item of equipment, marked to correlate to equipment item markings indicated in Contract Documents:
1. Outdoor Units:
 - a. Refrigerant Type and Size of Charge.
 - b. Output and Input Cooling Capacity: Btu/h.
 - c. Output and Input Heating Capacity: Btu/h.
 - d. Operating Temperature Range, Cooling and Heating.
 - e. Flow Capacity: Flow in gpm and pressure drop in ft hd..
 - f. Sound Pressure Level: dB(A).
 - g. Electrical Data: Complete including motor size.
 - h. Maximum number of indoor units that can be served.
 - i. Maximum refrigerant piping run from outdoor unit to indoor unit(s).
 - j. Maximum height difference between outdoor unit to Indoor unit(s), both above and below.
 2. Indoor Units:
 - a. Output and Input Cooling Capacity: Btu/h.
 - b. Output and Input Heating Capacity: Btu/h.
 - c. Fan Capacity: Flow in cfm with respective fan curves.
 - d. External Static Pressure (ESP): In-wc.
 - e. Electrical Data: Complete including motor size.
 - f. Maximum Lift of Built-in Condensate Pump.
 3. Control Panels: Complete data of controllers, input-output points, and zones.
- B. Shop Drawings: Installation drawings custom-made for this project; include as-designed HVAC layouts, locations of equipment items, refrigerant piping sizes and locations, condensate piping sizes and locations, remote sensing devices, control components, electrical connections, control wiring connections. Include:
1. Detailed piping diagrams, with branch balancing devices.
 2. Condensate piping routing, size, and pump connections.
 3. Detailed power wiring diagrams.
 4. Detailed control wiring diagrams.
 5. Locations of required access through fixed construction.
 6. Drawings required by manufacturer.
- C. Operating and Maintenance Data:
1. Manufacturer's complete standard instructions for each unit of equipment and control panel.
 2. Custom-prepared system operation, troubleshooting, and maintenance instructions and recommendations.
 3. Identification of replaceable parts and local source of supply.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications:
1. Company that has been providing variable refrigerant volume heat pump equipment for at least 15 years in the U.S. market.
 2. Company that provides system design software to installers.
- B. Installer Qualifications: Trained and approved by manufacturer of equipment.

- C. The units shall be listed by Electrical Testing Laboratories (ETL) and bear the ETL label.
- D. All wiring shall be in accordance with the National Electrical Code (N.E.C.).
- E. The units shall be manufactured in a facility registered to ISO 9001 and ISO14001 which is a set of standards applying to environmental protection set by the International Standard Organization (ISO).
- F. All units must meet or exceed the 2010 Federal minimum efficiency requirements and the ASHRAE 90.1 efficiency requirements for VRF systems. Efficiency shall be published in accordance with the Air-Conditioning, Heating, and Refrigeration Institute (AHRI) Standard 1230.
- G. System start-up supervision shall be a required service to be completed by the manufacturer or a duly authorized, competent representative that has been factory trained in system configuration and operation. The representative shall provide proof of manufacturer certification indicating successful completion within no more than two (2) years prior to system installation. This certification shall be included as part of the equipment and/or controls submittals.

1.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, and handle equipment and refrigerant piping according to manufacturer's recommendations.

1.07 WARRANTY

- A. The CITY MULTI units shall be covered by the manufacturer's limited warranty for a period of one (3) year parts and labor and seven (7) year compressor to the original owner from date of installation.
- B. Installing contractor shall meet manufacturer requirements to obtain extended manufacturer's limited parts and compressor warranty for a period of ten (10) years to the original owner from date of installation. This warranty shall not include labor.
- C. The CITY MULTI VRF system shall be installed by a contractor with extensive CITY MULTI install and service training. The mandatory contractor service and install training should be performed by the manufacturer.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Daikin
- B. Mitsubishi Electric Trane HVAC US, LLC
- C. Panasonic.
- D. Basis of Design: Trane City Multi VRF

2.02 VARIABLE REFRIGERANT FLOW SYSTEM

- A. Minimum System Requirements:
 - 1. System Testing, Capacity Rating, and Performance:
 - a. AHRI 1230 when cooling capacity is equal or greater than 65,000 Btu/h.
 - b. AHRI 210/240 when cooling capacity is below 65,000 Btu/h.
 - 2. Safety Certification: Bear UL 1995 tested and ITS (DIR) listed certification label.
 - 3. Indoor Air Quality or IAQ:
 - a. Provide filtered outdoor air ventilation as indicated on drawings using the integrated method using DOAS upstream of indoor units; see Section 237433.
 - 4. Cooling Mode Interior Performance:
 - a. Daytime Setpoint: 72 degrees F, plus or minus 2 degrees F.
 - b. Setpoint Range: 70 degrees F to 77 degrees F.
 - c. Night Setback: 80 degrees F.
 - d. Interior Relative Humidity: 50 percent, maximum.
 - 5. Heating Mode Interior Performance:
 - a. Setpoint: 68 degrees F, plus or minus 2 degrees F.
 - b. Setpoint Range: 65 to 75 degrees F.
 - c. Night Setback: 60 degrees F.
 - d. Minimum Interior Relative Humidity: 10 percent RH.

2.03 WATER-SOURCE OUTDOOR UNITS

- A. Manufacturers:
 - 1. Heat Pump, Cooling or Heating Outdoor Units:
 - 2. Heat Recovery, Cooling and Heating Outdoor Units:
 - a. Trane, WR-2 Series Simultaneous Heating/Cooling (Heat Recovery) water-cooled outdoor units.
- B. Heat Recovery Type:
 - 1. DX refrigeration unit piped to one or more compatible indoor units either directly or indirectly through one or more intermediate refrigeration branch units.
 - 2. Manifold two units as recommended by manufacturer to handle sequencing and coordination of multiple indoor units.
 - 3. The water-source unit shall be capable of continuous operation in heating or cooling mode with entering supply water temperature range between 23°F and 113°F without external, field-installed bypass valves.
 - 4. The water-source units are intended for installation indoors with an ambient temperature between 32°FDB and 104°FDB.
- C. Unit Cabinet:
 - 1. Designed to allow side-by-side installation with minimum spacing and vibration isolation.
 - 2. The cabinet(s) shall be fabricated of hot-dip galvanized steel sheet for corrosion resistance with baked enamel finish.
 - 3. Sound Pressure Level: 60 dB when twinned.
- D. Heat Exchanger Side:
 - 1. The water-source heat exchanger shall be a cross-flow, stainless steel brazed plate heat exchanger. The channel plate shall be constructed from AISI 316 SS. The Frame/Pressure plate shall be constructed from AISI 304 SS. The brazing material shall be pure copper.

2. The water-source unit shall be approved for use in a closed water loop system.
3. The heat exchanger shall be rated for a maximum pressure of 290 psi.
4. Threaded piping-end connections for external 2-pipe ground-loop water source.
5. Provide unit-controlled solenoid valve on return water side to start source flow when in use.

E. Refrigeration Side:

1. Factory assembled and wired with instrumentation, switches, and controller(s) to handle unit specifics with direct coordination of remote controller(s) from indoor unit(s).
2. Refrigeration Circuit: inverter driven scroll hermetic compressors, fans, condenser heat sink coil, expansion valves, solenoid valves, distribution headers, capillaries, filters, shutoff valves, oil separators, service ports, and refrigerant regulator.
3. Refrigerant: R-410a factory charged. Controller to alarm when charge is below capacity.
4. Polyolester (POE) oil—widely available and used in conventional domestic systems—shall be required.
5. Variable Volume Control: Compressor shall have an inverter to modulate capacity. The capacity for each compressor shall be variable with a minimum turndown not greater than 24%. Modulate compressed refrigerant capacity automatically to maintain constant suction and condensing pressures under varying refrigerant volume required to handle remote loads. Include defrost control.
6. The water-source unit shall have an internal direct expansion type inverter cooler. The inverter cooler shall provide cooling for all internal cabinet components eliminating the need for cabinet ventilation along with associated clearance requirements and additional space cooling load.
7. Refrigerant piping shall be phosphorus deoxidized copper (copper and copper alloy seamless pipes) of sufficient radial thickness as defined by the VRF equipment manufacturer and installed in accordance with manufacturer recommendations.
8. All refrigerant piping must be insulated with ½" closed cell, CFC-free foam insulation with flame-Spread Index of less than 25 and a smoke-development Index of less than 50 as tested by ASTM E 84 and CAN / ULC S-102. R value of insulation must be at least 3.
9. Provide refrigerant subcooling to ensure the liquid refrigerant does not flash when supplying to use indoor units.
10. Capable of heating operation at low end of operating range as specified, without additional low ambient controls or auxiliary heat source; during heating operation, reverse cycle, oil return, or defrost is not permitted due to potential reduction in space temperature.
11. Power Failure Mode: Automatically restarts operation after power failure without loss of programmed settings.
12. Safety Devices: High pressure sensor with cut-out switch, low pressure sensor with cut-out switch, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, overcurrent protection for the inverter and antirecycling timers.
13. Oil Recovery Cycle: The outdoor unit shall have a high efficiency oil separator plus additional logic controls to ensure adequate oil volume in the compressor is maintained. Oil return sequences must be enabled only during extended periods of reduced refrigerant flow to ensure no disruption to correct refrigerant flow to individual zones during peak loads. Systems which might engage oil return sequence based on hours of operation risk oil return during inopportune periods are not allowed. Systems which rely on sensors (which may fail) to engage oil return sequence are not allowed.

14. Field-installed oil equalization lines between modules are not allowed.

F. Local Controls:

1. Include factory-wired instruments, sensors, switches, and safeties for unit control.
2. Configured to coordinate internal unit operation with remote indoor units and with built-in capacity to coordinate other manifolded outdoor units and remote refrigerant branch unit(s).
3. Self diagnostic, auto-check functions to detect malfunctions and display the type and location.
4. Condensing unit shall include Variable Evaporator Temperature or comparable method of varying system evaporator (refrigerant) temperature in order to reduce compression ratio and power consumption during light load or mild ambient temperatures. Multiple evaporator refrigerant temperature settings shall be required in order to optimize efficiency within required system-specific performance and installation constraints. System shall reduce compression ratio only when/if all indoor units are within 1.8F of setpoint; reducing compression ratio based solely on ambient temperature risks discomfort and is not allowed.
5. Water-source modules shall contain a terminal block with dry contacts for proof of flow status via a field provided flow switch, as well as a dry contact to energize the control circuit for an auxiliary dedicated pump or motorized isolation valve.

G. Power:

1. Electrical Requirement: 208 to 230 VAC, 3-phase, 60 Hz.
2. Interior Mounted: Provide fused NEMA 250 Type 1 disconnect switch.

2.04 REFRIGERANT PIPING

- A. Two-Pipe Run: Provide low-pressure vapor and high-pressure vapor gas pipes for each indoor unit selected for seasonal heating or cooling service.
- B. Three-Pipe Run: Provide low-pressure vapor, high-pressure vapor gas, and liquid pipes for each indoor unit selected for off-season heating and cooling changeover service.
- C. Refrigerant Flow Balancing: Provide refrigerant piping joints and headers specifically designed to ensure proper refrigerant balance and flow for optimum system capacity and performance; T-style joints are prohibited.

2.05 REFRIGERANT BRANCH UNITS

- A. Outdoor unit interface to handle two or more indoor units required to do automatic off-season heating and cooling changeover.
- B. Concealed box consisting internally-piped refrigeration loops, subcooling heat exchanger, and other devices coordinated by electronic valves to facilitate off-season load management between outdoor and indoor units.
- C. Minimum Requirements:
 1. BC (Branch Circuit) Controllers (or comparable branch devices) shall include multiple branches to allow simultaneous heating and cooling by allowing either hot gas refrigerant to flow to indoor unit(s) for heating or subcooled liquid refrigerant to flow to indoor unit(s) for cooling. Refrigerant used for cooling must always be subcooled for optimal indoor unit LEV performance; alternate branch devices which do not include controlled

refrigerant subcooling risk bubbles in liquid supplied to indoor unit LEVs and are not allowed.

2. BC Controllers (or comparable branch devices) shall be equipped with a circuit board that interfaces to the controls system and shall perform all functions necessary for operation. The unit shall have a galvanized steel finish and be completely factory assembled, piped and wired. Each unit shall be run tested at the factory. This unit shall be mounted indoors, with access and service clearance provided for each controller. BC Controllers (or comparable branch devices) shall be suitable for use in plenums in accordance with UL1995 ed 4.
3. Provide one electronic expansion valve for each downstream indoor unit served except when multiple indoor units are connected, provide balancing joints in downstream piping to keep total capacity within branch unit capacity.
4. Future changes to indoor unit quantities or sizes served by BC Controller or comparable branch device must be possible with no piping changes except between the branch device and indoor unit(s) changing.
5. Casing: Galvanized steel sheet with flame and heat resistant foamed polyethylene sound and thermal insulation.
6. Refrigerant Connections: Factory provided service shut-off valves shall be provided for each branch. Braze type.
7. Condensate Drainage: Must have integral resin drain pan. Cabinets filled with solid foam insulation do not allow for future service and are not allowed. Refrigeration components shall have removable insulation that allows easy access for future service needs.
8. The unit electrical power shall be 208/230 volts, 1 phase, 60 Hertz.
9. The BC Controller shall be controlled by integral microprocessors

2.06 INDOOR UNITS

A. Ceiling-Recessed Cassette, Indoor Units:

1. The ceiling-recessed indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, an emergency operation function, a test run switch, and the ability to adjust airflow patterns for different ceiling heights. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4..
2. Unit Cabinet:
 - a. The cabinet panel shall have provisions for a field installed filtered outside air intake.
 - b. Branch ducting shall be allowed from cabinet.
3. Exposed Housing: White, impact resistant, with washable decoration panel.
4. Coil:
 - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
 - b. The coils shall be pressure tested at the factory.
5. Supply Airflow Adjustment:
 - a. Horizontally and vertically adjustable dampers with electronic actuators.
 - b. Four-way distribution field-modifiable to 3-way and 2-way airflow.

- c. The indoor unit shall include an AUTO fan setting capable of maximizing energy efficiency by adjusting the fan speed based on the difference between controller set-point and space temperature. The indoor fan shall be capable of five (5) speed settings, Low, Mid1, Mid2, High and Auto.
- d. The indoor unit fan logic must include multiple setting that can be changed to provide optimum airflow based on ceiling height and number of outlets used.
- e. The indoor unit vanes shall have 5 fixed positions and a swing feature that shall be capable of automatically swinging the vanes up and down for uniform air distribution.
- f. The vanes shall have an Auto-Wave selectable option in the heating mode that shall randomly cycle the vanes up and down to evenly heat the space.
- 6. Return Air Filter: High efficiency, MERV 13.
- 7. Grille shall include a factory-installed "3D i-see" sensor, or equal, to work in conjunction with indoor unit control sequence to prevent unnecessary cooling or heating in unoccupied areas of the zone without decreasing comfort levels. Sensor must detect occupancy (not simply motion) and location of occupants by measuring size & temperature of objects within a 39' detecting diameter (based on 8.8ft mounting height) with 1,856 or more measuring points.
- 8. Fan: Direct-drive turbo type, with motor output range of 1/16 to 1/8 hp.
- 9. Condensate Pump: Built-in with minimum lift of 33 inches.
- 10. Accessories:
 - a. Provide plenum for high efficiency filter and outside air connection.
- 11. Controls:
 - a. A factory-installed drain pan sensor shall provide protection against drain pan overflow by sensing a high condensate level in the drain pan. Should this occur the control shuts down the indoor unit before an overflow can occur. A thermistor error code will be produced should the sensor activate indicating a fault which must be resolved before the unit re-starts.

B. Ceiling-Concealed Ducted Indoor Units:

- 1. Type: Medium and High Static Ducted ceiling-concealed ducted indoor unit shall be factory assembled, wired and run tested. Contained within the unit shall be all factory wiring, piping, electronic modulating linear expansion device, control circuit board and fan motor. The unit shall have a self-diagnostic function, 3-minute time delay mechanism, and an auto restart function. Indoor unit and refrigerant pipes shall be charged with dehydrated air before shipment from the factory. The unit shall be suitable for use in plenums in accordance with UL1995 ed 4.
- 2. The unit shall be ceiling-concealed, ducted—with a 2-position, field adjustable return and a fixed horizontal discharge supply.
- 3. Ducted horizontal discharge and side or back-end return; galvanized steel cabinet.
- 4. The indoor unit fan shall be an assembly with statically and dynamically balanced Sirocco fan(s) direct driven by a single motor with permanently lubricated bearings.\
- 5. The indoor fan shall consist of three (3) speeds, High, Mid, and Low plus the Auto-Fan function.
- 6. Coil
 - a. The indoor coil shall be of nonferrous construction with smooth plate fins on copper tubing. The tubing shall have inner grooves for high efficiency heat exchange. All tube joints shall be brazed with phos-copper or silver alloy.
 - b. The coils shall be pressure tested at the factory.
 - c. Coil shall be provided with a sloped drain pan.

7. Return Air Filter: High efficiency, MERV 13.
8. Sound Pressure: Measured at low speed at 5 feet below unit.
9. Provide external static pressure switch adjustable for high efficiency filter operation
 - a. Medium Static: 0.14 to 0.60 in. WG
 - b. High Static: Up to 1.00 in. WG
10. Condensate Pump: Built-in, with lift of 27 inches, minimum.
11. Switchbox accessible from side or bottom.
12. Accessories: Filter Frame and Filter
 - a. Filter frame shall be constructed of 20 gauge G-60 galvanized steel. Knurled thumb screws on access door allow filter replacement. Foam gasket provides air-tight connection to indoor unit and access door. Filter frame shall be configurable for rear or bottom return.
 - b. Filter shall be rated MERV 13 when tested in accordance with ANSI/ASHRAE 52.2 Standard Rated Class 2 under U.L. Standard 900.

C. Wall Mounted, Indoor Units:

1. DX coil, tubed drain pan, and built-in controls with thermostat remotely coordinated by outdoor air unit to maintain local air temperature setpoint.
2. Variable or three-speed ECM cross-flow fan with automatic airflow adjustment; external static pressure selectable during commissioning.
3. Return Air Filter: Manufacturer's standard.
4. Provide exposed unit casing with removable front grille; foamed polystyrene and polyethylene sound insulation; wall mounting plate; polystyrene condensate drain pan.
5. Airflow Control: Auto-swing louver that closes automatically when unit stops; five (5) steps of discharge angle, set using remote controller; upon restart, discharge angle defaults to same angle as previous operation.
6. Condensate Drain Connection: Side (end), not concealed in wall.

2.07 CONTROLS

A. Overview

1. The control system shall consist of a low voltage communication network and a web-based interface. The controls system shall gather data and generate web pages accessible through a conventional web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the web browser interface.
2. Furnish energy conservation features such as optimal start, request-based logic, and demand level adjustment of overall system capacity as specified in the sequence.
3. System shall be capable of email generation for remote alarm annunciation.

B. Electrical

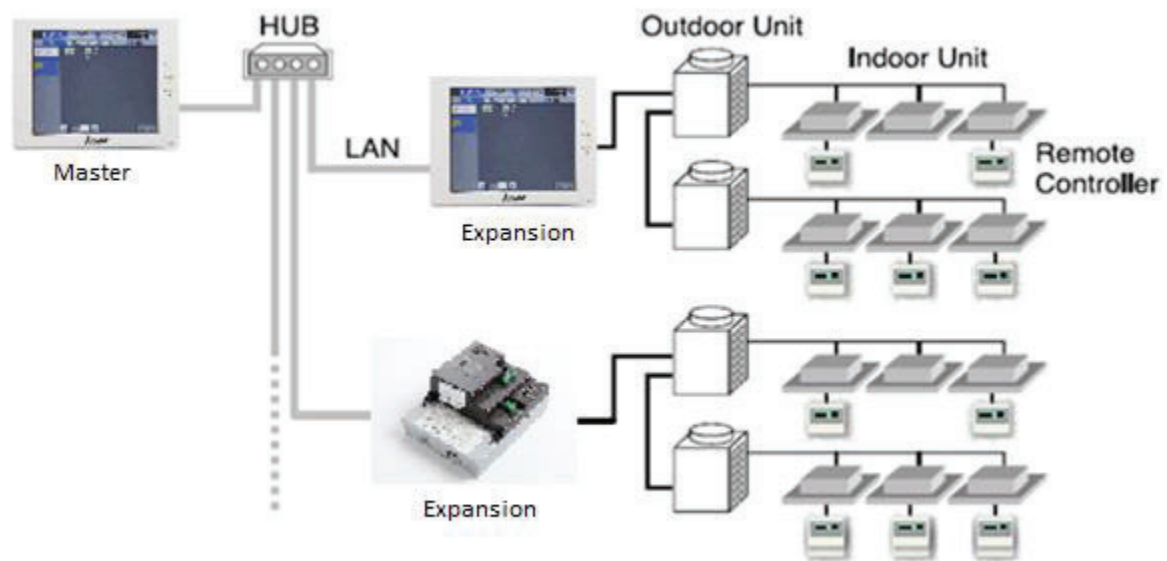
1. Controller power and communications shall be via a common non-polar communications bus and shall operate at 30VDC.
2. Wiring
 - a. Control wiring shall be installed in a daisy chain configuration from indoor unit to indoor unit, to the BC controller (main and subs, if applicable) and to the outdoor unit. Control wiring to remote controllers shall be run from the indoor unit terminal block to the controller associated with that unit.
 - b. Control wiring for centralized controllers shall be installed in a daisy chain configuration from outdoor unit to outdoor unit, to the system controllers

(centralized controllers and/or integrated web based interface), to the power supply.

- c. Wiring shall be 2-conductor (16 AWG), twisted, stranded, shielded wire as defined by the Diamond System Builder output.
- d. Network wiring shall be CAT-5 with RJ-45 connection.

C. City Multi Controls Network (or approved equal)

1. The CITY MULTI Controls Network (CMCN) consists of remote controllers, centralized controllers, and/or integrated web based interface communicating over a high-speed communication bus. The CITY MULTI Controls Network shall support operation monitoring, scheduling, occupancy, error email distribution, personal web browsers, tenant billing, online maintenance support, and integration with Building Management Systems (BMS) using either LonWorks® or BACnet® interfaces. The below figure illustrates a sample CMCN System Configuration.



CMCN System Configuration

D. CMCN Remote Controllers

1. Simple MA Remote Controller:
 - a. The Backlit Simple MA Remote Controller shall be capable of controlling up to 16 indoor units (defined as 1 group).
 - b. The Backlit Simple MA Remote Controller shall only be used in same group with Wireless MA Remote Controllers or with other Backlit Simple MA Remote Controllers, with up to two remote controllers per group.

| Simple MA Remote Controller | | | |
|-----------------------------|-----------------------------------------------------------------------------------------------------------------|------------|------------|
| Item | Description | Operation | Display |
| ON/OFF | Run and stop operation for a single group | Each Group | Each Group |
| Operation Mode | Switches between Cool/Drying/Auto/Fan/Heat/Setback. Operation modes vary depending on the air conditioner unit. | Each Group | Each Group |

| Simple MA Remote Controller | | | |
|-----------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------|---------------|
| Item | Description | Operation | Display |
| | Auto and Setback mode are available for the R2/WR2-Series only. | | |
| Temperature Setting | Sets the temperature from 40°F – 95°F depending on operation mode and indoor unit. Separate COOL and HEAT mode set points available depending on central controller and connected mechanical equipment. | Each Group | Each Group |
| Fan Speed Setting | Available fan speed settings depending on indoor unit. | Each Group | Each Group |
| Air Flow Direction Setting | Air flow direction settings vary depending on the indoor unit model. | Each Group | Each Group |
| Permit / Prohibit Local Operation | Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter). *1: Centrally Controlled is displayed on the remote controller for prohibited functions. | N/A | Each Group *1 |
| Display Indoor Unit Intake Temp | Measures and displays the intake temperature of the indoor unit when the indoor unit is operating. | N/A | Each Group |
| Display Backlight | Pressing the button lights up a backlight. The light automatically turns off after a certain period of time. (The brightness settings can be selected from Bright, Dark, and Light off.) | N/A | Each Unit |
| Error | When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed | N/A | Each Unit |
| Test Run | Operates air conditioner units in test run mode. *2 The display for test run mode will be the same as for normal start/stop (does not display “test run”). | Each Group | Each Group *2 |
| Ventilation Equipment | Up to 16 indoor units can be connected to an interlocked system that has one LOSSNAY unit. | Each Group | N/A |
| Set Temperature Range Limit | Set temperature range limit for cooling, heating, or auto mode. | Each Group | Each Group |

E. Centralized Controller (Web-Enabled)

- The Master Centralized Controller shall be capable of controlling a maximum of two hundred (200) indoor units across multiple CITY MULTI outdoor units with the use of three expansion controllers. The Master Centralized Controller shall be approximately 11-5/32” x 7-55/64” x 2-17/32” in size and shall be powered with an integrated 100-240 VAC power supply. The Master Centralized Controller shall support system configuration, daily/weekly scheduling, monitoring of operation status, night setback

settings, free contact interlock configuration and malfunction monitoring. When being used alone without the expansion controllers, the Master Centralized Controller shall have five basic operation controls which can be applied to an individual indoor unit, a collection of indoor units (up to 50 indoor units), or all indoor units (collective batch operation). This basic set of operation controls for the Master Centralized Controller shall include on/off, operation mode selection (cool, heat, auto (R2/WR2-Series only), dry, setback (R2/WR2-Series only) and fan), temperature setting, fan speed setting, and airflow direction setting. Since the master provides centralized control it shall be able to enable or disable operation of local remote controllers. In terms of scheduling, the Master Centralized Controller shall allow the user to define both daily and weekly schedules (up to 24 scheduled events per day) with operations consisting of ON/OFF, mode selection, temperature setting, air flow (vane) direction, fan speed, and permit/prohibit of remote controllers.

| Master Centralized Controller | | | |
|--------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------|--------------------------|
| Item | Description | Operation | Display |
| ON/OFF | Run and stop operation. | Each Block, Group or Collective | Each Group or Collective |
| Operation Mode | Switches between Cool/Dry/Auto/Fan/Heat. (Group of Lossnay unit: automatic ventilation/vent-heat/interchange/normal ventilation) Operation modes vary depending on the air conditioner unit. Auto mode is available for the R2/WR2-Series only. | Each Block, Group or Collective | Each Group |
| Temperature Setting | Sets the temperature from 57°F – 87°F depending on operation mode and indoor unit. | Each Block, Group or Collective | Each Group |
| Fan Speed Setting | Available fan speed settings depending on indoor unit. | Each Block, Group or Collective | Each Group |
| Air Flow Direction Setting | Air flow direction settings vary depending on the indoor unit model. *1. Louver cannot be set. | *1 Each Block, Group or Collective | Each Group |
| Schedule Operation | Annual/weekly/today schedule can be set for each group of air conditioning units. Optimized start setting is also available. *1. The system follows either the current day, annual schedule, or weekly, which are in the descending order of overriding priority. | *2 Each Block, Group or Collective | Each Group |

| Master Centralized Controller | | | |
|-----------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------|---------------------------------|
| Item | Description | Operation | Display |
| | <p>Twenty-four events can scheduled per day, including ON/OFF, Mode, Temperature Setting, Air Direction, Fan Speed and Operation Prohibition.</p> <p>Five types of weekly schedule (seasonal) can be set.</p> <p>Settable items depend on the functions that a given air conditioning unit supports.</p> | | |
| Optimized Start | Unit starts 5 - 60 minutes before the scheduled time based on the operation data history in order to reach the scheduled temperature at the scheduled time. | Each Block, Group or Collective | Each Block, Group or Collective |
| Night Setback Setting | The function helps keep the indoor temperature in the temperature range while the units are stopped and during the time this function is effective. | Each Group | Each Group |
| Permit / Prohibit Local Operation | <p>Individually prohibit operation of each local remote control function (Start/Stop, Change operation mode, Set temperature, Reset filter).</p> <p>*3. Centrally Controlled is displayed on the remote controller for prohibited functions.</p> | Each Block, Group or Collective | *3 Each Group |
| Room Temp | Displays the room temperature of the group. Space temperature displayed on the indoor unit icon on the touch screen interface. | N/A | Each Group |
| Error | <p>When an error is currently occurring on an air conditioner unit, the afflicted unit and the error code are displayed</p> <p>*4. When an error occurs, the LED flashes. The operation monitor screen shows the abnormal unit by flashing it. The error monitor screen shows the abnormal unit address, error code and source of detection. The error log monitor screen shows the time and date, the abnormal unit address, error code and source of detection</p> | N/A | *4 Each Unit or Collective |
| Outdoor Unit Status | Compressor capacity percentage and system pressure (high and low) pressure (excludes S-Series) | Each ODU | Each ODU |

| Master Centralized Controller | | | |
|--------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------|----------------------|
| Item | Description | Operation | Display |
| Connected Unit Information | MNET addresses of all connected systems | Each IDU, ODU and BC | Each IDU, ODU and BC |
| Ventilation Equipment | This interlocked system settings can be performed by the master system controller. When setting the interlocked system, use the ventilation switch the free plan LOSSNAY settings between “Hi”, “Low” and “Stop”. When setting a group of only free plan LOSSNAY units, you can switch between “Normal ventilation”, “Interchange ventilation” and “Automatic ventilation”. | Each Group | Each Group |
| Multiple Language | Other than English, the following languages can be selected: Spanish, French, Japanese, Dutch, Italian, Russian, Chinese, and Portuguese. | N/A | Collective |
| External Input / Output | By using accessory cables you can set and monitor the following. Input By level: “Batch start/stop”, “Batch emergency stop” By pulse: “batch start/stop”, “Enable/disable remote controller” Output: “start/stop”, “error/Normal” *5. Requires the external I/O cables (PAC-YG10HA-E) sold separately. | *5 Collective | *5 Collective |

2. All Master Centralized Controllers shall be equipped with two RJ-45 Ethernet ports to support interconnection with a network PC via a closed/direct Local Area Network (LAN) or to a network switch for IP communication to up to three expansion controllers for display of up to two hundred (200) indoor units on the main master centralized controller interface.
3. The Master Centralized Controller shall be capable of performing initial settings via the high-resolution, backlit, color touch panel on the controller or via a PC browser using the initial settings.
4. Standard software functions shall be available so that the building manager can securely log into each master centralized controller via the PC’s web browser to support operation monitoring, scheduling, error email, interlocking and online maintenance diagnostics. Additional optional software functions of personal browser for PCs and MACs and Energy shall be available but are not included. The Energy Apportionment function shall require a LIC-Charge software license.

F. CMCN Network Integration: BACnet Integration

1. The Mitsubishi Electric Cooling & Heating BACnet® hardware, which is built into all networked central controllers, shall be compliant with BACnet® Protocol (ANSI/ASHRAE 135-2010) and be Certified by the (BTL) BACnet® Testing Laboratories. The BACnet® interface shall support BACnet Broadcast Management (BBMD). The BACnet® interface shall support a maximum of 50 indoor units. Operation and monitoring points include, but are not limited to, on/off, operation mode, fan speed, prohibit remote controller, filter sign reset, alarm state, error code, and error address.
2. Licenses:
 - a. LIC-BACnet Master: Master Controller license for Master Centralized Controller and Non Touch Screen, Networked Centralized Controller
 - b. LIC-BACnet Expansion: Expansion Controller license for Expansion Controller and Non Touch Screen, Networked Centralized Controller
3. LIC-BACnet Specifications:
 - a. Control up to 50 groups
 - b. 1 to 16 indoor units can be collectively controlled in a group
 - c. Supports dual set point functionality (connected model dependant)
 - d. BTL Compliant
 - e. BACnet communication specifications are based on ANSI/ASHRAE Standards 135-2010
4. PC Requirements:
 - a. CPU: 1GHz or higher
 - b. Memory: 1GB or more
 - c. HDD Space: 100 MB or more
 - d. Screen Resolution: 1024 x 768 or higher
 - e. OS: Microsoft Windows 7 32-bit/64-bit, Microsoft 8.1 32-bit/64-bit. Not compatible with Windows Vista
 - f. Execution Environment: Microsoft .NET Framework 4.5 or later
 - g. Others: Pointing device such as a mouse, internet connection (required when installing a .NET Framework)
5. BACnet Points List

| Object List |
|-----------------------------------------------------------|
| On Off Setup |
| On Off State, Number of ON/OFF, Cumulative operation time |
| Alarm Signal (4-digit error code) |
| Error Code |
| Operational Mode Setup |
| Operational Mode State |
| Fan Speed Setup |
| Fan Speed State |
| Room Temp [Water Temp] |
| Set Temp [Set Water Temp] |
| Set Temp Cool |
| Set Temp Heat |
| Set Temp Auto |
| Filter Sign [Circulating Water Exchange Sign] |
| Filter Sign Reset [Circulating Water Exchange Sign Reset] |

PART

| |
|--------------------------------------------------------------------------------------|
| Prohibition On Off |
| Prohibition Mode |
| Prohibition Filter Sign Reset [Prohibition Circulating Water Exchange Sign Reset] |
| Prohibition Set Temperature |
| M-NET Communication State |
| System Forced Off |
| Air Direction Setup |
| Air Direction State |
| Set High Limit Setback Temp |
| Set Low Limit Setback Temp |
| Ventilation Mode Setup |
| Ventilation Mode State |
| Air To Water Mode Setup |
| System Alarm Signal (4-digit error code) |
| PI Controller Alarm Signal (4-digit error code) |
| Group Apportioned Electric Energy |
| Interlocked Units Apportioned Electric Energy |
| PI controller Electric Energy 1–4 |
| Pulse Input Electric Energy 1–4 |
| Group Apportionment Parameter |
| Interlocked Units Apportionment Parameter |
| Night Purge State |
| Thermo On Off State |
| Trend Log Room Temp |
| Trend Log Group Apportioned Electric Energy |
| Trend Log Interlocked Units Apportioned Electric Energy |
| Trend Log PI controller Electric Energy 1–4 |
| Trend Log Pulse Input Electric Energy 1–4 |
| Trend Log Group Apportionment Parameter |
| Trend Log Interlocked Units Apportionment Parameter |

3 EXECUTION

3.01 EXAMINATION

- A. Verify that required electrical services have been installed and are in the proper locations prior to starting installation.
- B. Verify that condensate piping has been installed and is in the proper location prior to starting installation.

3.02 INSTALLATION

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

- C. Perform wiring in accordance with NFPA 70, National Electric Code (NEC).
- D. Coordinate with installers of systems and equipment connecting to this system.
- E. Refrigerant Piping: See Section 232300 with Section 230719 for insulation, and Section 230529 for hangers and supports unless following specific manufacturer recommendations.
- F. Connect indoor units to condensate piping.
- G. Coordinate BAS, BMS, or Integrated Automation linking between local controller(s).

3.03 FIELD QUALITY CONTROL

- A. Provide manufacturer's field representative to inspect installation prior to startup.

3.04 SYSTEM STARTUP

- A. Provide manufacturer's field representative to perform system startup.
- B. Prepare and start equipment and system in accordance with manufacturer's instructions and recommendations.
- C. Adjust equipment for proper operation within manufacturer's published tolerances.

3.05 COMMISSIONING

- A. See Section 019113 - General Commissioning Requirements for additional requirements.
- B. Execute mechanical system commissioning as indicated on Section 230800.
- C. Replace components not functioning properly.

3.06 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. Conduct walking tour of project.
 - 3. 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 one day of training.

3.07 PROTECTION

- A. Protect installed components from subsequent construction operations.
- B. Replace exposed components broken or otherwise damaged beyond repair.

END OF SECTION 238129

SECTION 238200 - CONVECTION HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Electric unit heaters.
- B. Electric cabinet unit heaters.
- C. Air coils.

1.02 RELATED REQUIREMENTS

- A. Section 230513 - Common Motor Requirements for HVAC Equipment.
- B. Section 230913 - Instrumentation and Control Devices for HVAC.
- C. Section 230993 - Sequence of Operations for HVAC Controls.
- D. Section 260583 - Wiring Connections: Electrical characteristics and wiring connections. Installation of room thermostats. Electrical supply to units.

1.03 REFERENCE STANDARDS

- A. SMACNA (DCS) - HVAC Duct Construction Standards Metal and Flexible.

1.04 SUBMITTALS

- A. Product Data: Provide typical catalog of information including arrangements.
- B. Shop Drawings:
 - 1. Submit schedules of equipment and enclosures typically indicating length and number of pieces of element and enclosure, corner pieces, end caps, cap strips, access doors, pilaster covers, and comparison of specified heat required to actual heat output provided.
- C. Manufacturer's Instructions: Indicate installation instructions and recommendations.
- D. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions, installation instructions, maintenance and repair data, and parts listings.
- E. Warranty: Submit manufacturer's warranty and ensure forms have been completed in Owner's name and registered with manufacturer.

1.05 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide 1 year manufacturer's warranty for cabinet unit heaters and air coils.

PART 2 PRODUCTS

2.01 ELECTRIC UNIT HEATERS

- A. Manufacturers:
 - 1. INDEECO (Industrial Engineering and Equipment Company); _____
 - 2. Markel, a TPI Company; _____
 - 3. Trane.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Assembly: Suitable for mounting from ceiling or structure above with built-in controls, thermal safety cut-out, and electric terminal box.
- D. Acceptable Heating Element Assemblies:
 - 1. Horizontal Projection Units:
 - a. Steel fins copper brazed to steel sheath and epoxy sealed for moisture resistance.
 - b. Nickel chromium resistance wire surrounded with magnesium oxide and sheathed in steel, spiral-finned tubes.
 - c. High-mass, all steel tubular type, copper brazed, centrally located and installed in fixed element banks.
- E. Housing:
 - 1. Horizontal Projection Units:
 - a. Construction materials to consist of heavy gauge steel with high gloss baked enamel finish.
 - b. Provide with bracket for mounting from wall or ceiling.
 - c. Provisions for access to internal components for maintenance, adjustments, and repair.
- F. Air Inlets and Outlets:
 - 1. Inlets: Provide protective grilles with fan blade guard.
 - 2. Outlets: Provide directional louvers.
- G. Fan: Factory balanced, direct drive, axial type with fan guard per.
- H. Motor: Totally enclosed, thermally protected, and provided with permanently lubricated bearings per 230513.
- I. Controls:
 - 1. Disconnect.
 - 2. Terminal block for remote control.
 - 3. Fan speed switch.
- J. Electrical Characteristics:
 - 1. 208 volts, three phase, 60 Hz.
 - 2. Disconnect Switch: Factory mount disconnect switch.

2.02 ELECTRIC CABINET UNIT HEATERS

- A. Manufacturers:
 - 1. INDEECO (Industrial Engineering and Equipment Company); _____

2. Markel, A TPI Company; _____
 3. Trane.
- B. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
- C. Heating Elements: Provide resistance wire enclosed in steel sheath.
- D. Cabinet: Minimum 18 gauge, 0.0478 inch thick steel cabinet with exposed corners and edges rounded, easily removed panels, glass fiber insulation and integral air outlet, and inlet grilles.
- E. Finish:
1. Factory applied, painted finish.
 2. Color: As selected from color chart.
- F. Fans: Centrifugal forward-curved double-width wheels, statically and dynamically balanced, direct driven.
- G. Motor: Tap wound multiple speed permanent split capacitor with sleeve bearings, resiliently mounted per section 230513.
- H. Controls:
1. Control transformer.
 2. Control relays.
 3. Thermal cutout with automatic reset to de-energize electric heating elements in the event of overheating.
 4. Fan speed switch.
 5. Thermostat.
- I. Filter: Easily removed, 1 inch thick glass fiber throw-away type, located to filter air before coil.
- J. Electrical Characteristics:
1. 208 volts, three phase, 60 Hz.

2.03 AIR COILS

- A. Manufacturers:
1. Electric Coils:
 - a. INDEECO (Industrial Engineering and Equipment Company); _____
 - b. RenewAire.
- B. Electric Coils:
1. Provide products listed, classified, and labeled by Underwriters Laboratories Inc. (UL), Intertek (ETL), or testing firm acceptable to Authority Having Jurisdiction as suitable for the purpose indicated.
 2. Assembly: Terminal control box with hinged or screwed access cover, heating element, casing, and controls.
 3. Open Coil: Nickel chromium heating element, stainless steel or nickel plated terminals supported in ceramic bracket bushings.
 4. Frame: Heavy gauge galvanized steel.
 5. Standard Built-In Components:
 - a. Interlock disconnect switch.
 - b. Contactors.

- c. Fused transformers.
 - d. Airflow proving switch.
 - e. Time-delay relay.
 - f. Load and control terminal blocks.
- 6. Over-Temperature Protection: Provide thermal cutouts for primary and secondary over-temperature protection.
- 7. Additional Controls:
 - a. SCR control.
 - b. Temperature sensor downstream.
- 8. Electrical Characteristics:
 - a. 208 volts, three phase, 60 Hz.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that surfaces are suitable for installation.
- B. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

3.02 INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Install equipment exposed to finished areas after walls and ceilings are finished and painted.
- C. Do not damage equipment or finishes.
- D. Unit Heaters:
 - 1. Hang from building structure, with pipe hangers anchored to building, not from piping or electrical conduit.
 - 2. Mount as high as possible to maintain greatest headroom unless otherwise indicated.
- E. Cabinet Unit Heaters:
 - 1. Install as indicated.
 - 2. Coordinate to ensure correct recess size for recessed units.
- F. Units with Electric Heating Elements:
 - 1. Install as indicated including electrical devices furnished by manufacturer but not factory installed.
 - 2. Straighten bent fins on air coils.
 - 3. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.
 - 4. Install wiring in accordance with the manufacturer's wiring diagram submittal and Section 260583.
- G. Air Coils:
 - 1. Install in ducts and casings in accordance with SMACNA (DCS).
 - a. Provide airtight seals between coil and casing or duct.
 - 2. Coil Safeguards:
 - a. Protect coils to prevent damage to flanges and fins.

- b. Comb out damaged fins.
- 3. Install all coils level except cleanable coils with 1:50 pitch.
- 4. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Operational Test: After electrical circuitry has been energized, operate electric coils to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION 238200

SECTION 238241 - WATER-TO-WATER HEAT PUMPS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Hydronic, single-stage WWHP.

1.02 RELATED REQUIREMENTS

- A. Section 230529 - Hangers and Supports for HVAC Piping and Equipment.
- B. Section 230548 - Vibration and Seismic Controls for HVAC.
- C. Section 230593 - Testing, Adjusting, and Balancing for HVAC.
- D. Section 232113 - Hydronic Piping: Load-side piping.
- E. Section 232114 - Hydronic Specialties: Valves, strainers, p-t test plugs, and other fittings.
- F. Section 260583 - Wiring Connections.

1.03 REFERENCE STANDARDS

- A. ASHRAE Std 90.1 I-P - Energy Standard for Buildings Except Low-Rise Residential Buildings.
- B. ASTM E84 - Standard Test Method for Surface Burning Characteristics of Building Materials.
- C. UL 723 - Standard for Test for Surface Burning Characteristics of Building Materials.
- D. UL 1995 - Heating and Cooling Equipment.

1.04 SUBMITTALS

- A. Product Data: Manufacturer's data sheets for each product furnished, including:
 - 1. Electrical and performance data showing compliance with specifications.
 - 2. Required water flow rates and temperatures for inflow and outflow.
 - 3. Detailed electrical wiring diagrams.
 - 4. Storage and handling requirements and recommendations.
 - 5. Installation instructions.
 - 6. Start-up, troubleshooting, and TAB instructions.
 - 7. Specimen warranty.
- B. Shop Drawings: Show piping connections and interface to source-side and load-side piping, circulator pumps, hot water piping, and drains. Include control wiring diagrams prepared specifically for this project, including unit controls interface.
- C. Operation and Maintenance Data: Include replaceable parts lists, parts sources, and troubleshooting guide.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Verify upon delivery that equipment nameplate data, including electrical data, matches specified and ordered equipment. Verify that refrigerant charge has been retained during shipping.
- B. Store products in manufacturer's unopened packaging until ready for installation.
- C. Store products under cover and elevated above grade.

1.06 WARRANTY

- A. Provide one-year from startup or 18 months from shipment, manufacturer warranty. Warrant that all products are free from defects in material and workmanship and have the capacities and ratings set forth in manufacturer's catalogs and bulletins.
- B. Compressor shall have 5 year parts warranty.

PART 2 PRODUCTS

2.01 WATER-TO-WATER HEAT PUMP FABRICATION REQUIREMENTS

- A. Description: Packaged water-source heat pump with temperature controls; factory assembled, tested, and rated according to ASHRAE/ARI/ISO-13256-2.
 - 1. Products shall be designed, rated, and certified in accordance with ISO-AHRI 13256-2.
- B. Energy Efficiency: ASHRAE Std 90.1 I-P EER and COP ratings, minimum.
- C. Factory assemble internal components, safety-controls, accessories, filters, piping, cable, and wires, then charge with R-410A refrigerant prior to testing.
- D. Include marked terminal strip to interface field mounted components and accessories.
- E. Comply with UL 1995, place service and caution labels on unit in appropriate locations.
- F. Cabinet Assembly:
 - 1. Construct of zinc-coated, heavy-gauge, galvanized steel with exposed edges rounded.
 - 2. Finish: Factory apply electrostatic powder paint or baked enamel finish. Coordinate with Engineer of Record for specific color finish requirements of console units or other units installed within occupied spaces.
 - 3. Provide front and side access panels for inspection, cleaning, and servicing of refrigerant, controls, and heat exchangers.
 - 4. Interior Insulation: Minimum 1/2 inch thick, dual density, bonded glass fiber.
 - 5. Provide flame spread of less than 25, and smoke developed classification of less than 50 when tested in accordance with ASTM E84 and UL 723.
 - 6. Sound and Noise Suppression:
 - a. Mechanical Rooms: 18 gauge, 0.05 inch, minimum.
 - b. Occupied Spaces: 16 gauge, 0.06 inch, minimum.
 - c. Compressor enclosure lined with 1/2 inch thick insulation.
 - d. Include vibration isolation between compressor and heat exchanger.
 - e. Include length-wise unit base stiffeners.
 - f. Foam gasket sealant around compressor and end panel perimeter.
- G. Compressor Section:

1. Provide rubber mounting vibration isolation devices underneath mounting base.
 2. Safety Interlocked Devices:
 - a. Thermal overload protection.
 - b. High pressure switch for protection against excessive discharge pressure.
 - c. Low pressure safety for protection against loss of refrigerant charge.
- H. Refrigerant Tubing Lines:
1. Tubing made of copper with service pressure ports on high and low pressure sides.
 2. Free from contaminants and conditions such as drilling fragments, dirt, and oil.
 3. Include drier, thermal expansion valve, and other related components.
- I. Water-to-Refrigerant Heat Exchanger:
1. Coaxial Coil Type: The source-side heat exchanger shall be constructed of copper with an option of cupronickel. The load-side heat exchanger shall be constructed of copper. Both heat exchangers shall be deeply fluted to enhance heat transfer and minimize fouling and scaling.
 2. Insulate heat exchanger, water lines, and refrigerant suction lines for prevention of condensation at temperatures below 60 degrees F.
 3. Provide rubber isolation to the heat exchanging device for enhanced sound attenuation.
 4. Freeze Protection: 20 degrees F by thermistor sensing.
 5. Minimum Working Pressure: 400 psi water side, 650 psi DX side.
 6. End Connections: Copper NPT. Provide flow shut-off ball valves.
 7. Accessories:
 - a. Strainer, PT test plug, and flow regulator.
 - b. Unit-controlled, return-water-side solenoid valve.
- J. Electrical:
1. Provide factory-installed phase loss safety device for 3-phase units.
 2. Configure unit for single point connection, include terminal for field-installed components.
- K. Unit Controls: DDC.
1. Temperature-control devices and sequence of operations are specified in Section 230923 "Direct Digital Control for HVAC Systems" and Section 230993 "Sequence of Operations for HVAC Controls."
 2. Unit shall have standalone controller with terminal strip.
 3. Tested to monitor and handle sequencing functions and other operational modes using supplied field mounted sensors and switches.
 4. Coordination and Sequencing:
 - a. Internal Devices: Include compressors, sensors, switches, valves, safeties, other components.
 - b. Field-Installed Devices: Solenoid valves, EWT sensors, LWT sensors, load-pump contact, source pump contact, and other devices required for operation.
 - c. Safeties: At minimum include anti-short-cycle compressor protection, condensate overflow, refrigerant high-pressure, refrigerant low-pressure, loss-of-charge, and refrigerant freeze protection.
 5. Power:
 - a. Factory-mounted and internally-wired into nonfused electrical disconnect.
 - b. Configure safety-lockout circuits to be reset either using reset switch or power cycling.
 - c. 24 VAC/VDC, include minimum of 10 VA spare load capacity for potential field use.

PART 3 EXECUTION

3.01 PREPARATION

- A. Clean surfaces thoroughly prior to installation.
- B. Ensure electric utility connections are achieved in an orderly and expeditious manner.
- C. Verify that equipment is undamaged, including refrigerant components and shipped loose items.

3.02 INSTALLATION

- A. Install equipment in accordance with manufacturer's written installation instructions.
- B. Unit Mounting:
 - 1. Above Finished Floor: Include hangers and supports; see Section 230529.
 - 2. Do not obstruct maintenance access to equipment by any type of piping, electrical conduit, or any other utility.
- C. Ground-Water Source:
 - 1. Complete installation to ground-water piping source buried loop, then complete water side connections; see Sections 232113, and 232114 for related piping and hydronic specialties.
 - 2. Fit-in and install externally interconnected equipment and device components such as pumps and heat exchanger(s) as applicable to specific selections.
 - 3. Flush and clean piping before placing in operation; take precautions to prevent introduction of debris into piping systems.
- D. Electrical: Provide equipment raceway, wiring, and cables; see Section 260583.
- E. Start system and adjust controls and equipment for satisfactory operation.
- F. Adjust water temperature control system and place in operation so that water quantities circulated are as required.

3.03 FIELD QUALITY CONTROL

- A. Upon completion and before final acceptance of work, test each system to demonstrate compliance with the contract requirements.
 - 1. Adjust controls and balance systems prior to final acceptance of completed systems.
 - 2. Test controls through every cycle of operation.
 - 3. Test safety controls to demonstrate performance of required function.
 - 4. Furnish water, electricity, instruments, connecting devices, and personnel for tests.
 - 5. Clean equipment, piping, strainers, ducts, and filters.
 - 6. Coordinate testing with testing of related piping, specified elsewhere.
 - 7. Correct defects in work and repeat tests.
- B. Operational Testing: After demonstration of satisfactory operation perform operational testing:
 - 1. Test each item of equipment in operation for continuous period of not less than 24 hours under every condition of operation in accordance with equipment manufacturer's recommendations.

2. Verify that each item of equipment operating parameters are within limits recommended by the manufacturer.
 3. Manufacturer's Recommended Test: Conduct the manufacturer's recommended field testing; provide a factory trained field representative authorized by and to represent the equipment manufacturer during the complete execution of the field testing.
- C. See Section 230593 for additional testing, adjusting, and balancing (TAB) requirements of piping, equipment, and controls.
- D. Within 30 calendar days after acceptable completion of testing, submit each test report for review and approval; include:
1. Unit nameplate data and actual voltage and ampere consumption.
 2. Load-side supply and return water flow and temperatures and measurement equipment.
 3. Source-side supply and return water flow and temperatures and measurement equipment.
 4. Ambient air temperature at heat pump unit.
 5. Date, name, and signature of person testing and reporting.

3.04 CLOSEOUT ACTIVITIES

- A. Training: Upon completion of work, coordinate with owner for time, provide services of water source heat pump manufacturer's technical representative for period of not less than one 8-hour working day for instruction of Owner's operating personnel in proper operation and maintenance of equipment.

3.05 PROTECTION

- A. Protect installed products until completion of project.
- B. Touch-up, repair, or replace damaged products before Date of Substantial Completion.

END OF SECTION 238241

SECTION 238300 - RADIANT HEATING AND COOLING UNITS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Radiant heating hydronic piping.

1.02 RELATED REQUIREMENTS

- A. Section 083100 - Access Doors and Panels.

1.03 REFERENCE STANDARDS

- A. ASTM F1807 - Standard Specification for Metal Insert Fittings Utilizing a Copper Crimp Ring, or Alternate Stainless Steel Clamps, for SDR9 Cross-linked Polyethylene (PEX) Tubing and SDR9 Polyethylene of Raised Temperature (PE-RT) Tubing.

1.04 SUBMITTALS

- A. Product Data: Provide data for each type of product.
 - 1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.
- B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.
 - 1. Shop Drawing Scale: 1/4 inch = 1 foot.
 - 2. Items to be coordinated with the radiant heating system, including but not limited to the following:
 - a. Stairways and handrails.
 - b. Foundation wall penetrations.
 - c. Footings and foundations.
- C. Operation and Maintenance Data: Include manufacturer's descriptive literature, operating instructions of equipment and controls, installation instructions, maintenance and repair data, and parts listings.

1.05 WARRANTY

- A. Submit, for owner's acceptance, manufacturer's standard warranty document executed by authorized company official.
- B. Manufacturer's warranty is in addition to, and not a limitations of, other rights Owner may have under contract documents.
 - 1. Warranty cover the repair or replacement of any tubing or fittings proven defective.
 - 2. Warranty may transfer to subsequent owners.
 - 3. Warranty period for tubing is 25-year, non-pro-rated warranty against failure due to material defect in material and workmanship, beginning with the date of substantial

- completion.
- 4. Warranty period for manifolds is 2-year, non-pro-rated warranty against failure due to material defect in material and workmanship, beginning with the date of substantial completion.
- 5. Warranty period for controls and electrical equipment is 2-year, non-pro-rated warranty against failure due to material defect in material and workmanship, beginning with the date of substantial completion.

1.06 SYSTEM START-UP

- A. Do not start the equipment for a minimum of 25 days or as specified by mortar, concrete and/or covering manufacturer as applicable.
- B. Verify all electrical components are installed per local and National Electric Code prior to start-up.

PART 2 PRODUCTS

2.01 RADIANT-HEATING HYDRONIC PIPING

- A. Applications:
 - 1. Provide the following types of hydronic, radiant heating piping for the applications described:
 - a. Piping in Interior Reinforced Concrete Floors: EPDM.
 - b. Piping in Level Fill Concrete Floors (Not Reinforced): EPDM.
- B. Onix (EPDM) Pipe and Fittings:
 - 1. Manufacturers:
 - a. Watts Radiant Inc, a Watts Water Technologies Company; _____: www.wattsradiant.com/#sle.
 - b. Or approved equal.
 - 2. Pipe Material: Spiral Bradided multi-composite design constructed of:
 - a. A Durel inner tube made of peroxide-cured, cross-linked EPDM
 - b. An aluminum AlumaShield solid oxygen barrier
 - c. A contour extrusion layer of EPDM
 - d. An Aramid reinforced fiber
 - e. An outer cover of HiGuard composed of sulfur-cured, cross-linked EPDM
 - 3. Wall Thickness: Minimum 1/4 inch.
 - 4. Oxygen Barrier: Ductile aluminum foil layer applied to the inner tube to limit oxygen diffusion through the pipe to maximum 0.0000436996 grains per cu ft/day at 104 degrees F according to DIN 4726.
 - 5. Reinforcing Braid: Braided-aluminum wire between the inner and outer tube.
 - 6. Fittings: For system compatibility, use fittings offered by the tubing manufacturer.
 - 7. Pressure/Temperature Rating: Minimum 100 psig and 180 degrees F.
 - a. Tubing shall be capable of withstanding temperatures of -35 degrees F to 325 degrees F intermittently without delimitation.
 - b. Tubing shall remain flexible as temperatures down to -35 degrees F.
 - 8. UV resistance: Tubing shall be UV resistant.
 - 9. Crushability: Tubing shall be crush-proof, recovering its original cross-section area after flattening.
 - 10. Minimum Bend Radius:

- a. 3/8" (9.53 mm) Onix has a 3" (76 mm) bend radius
- b. 1/2" (12.7 mm) Onix has a 4" (102 mm) bend radius
- c. 5/8" (15.88 mm) Onix has a 5" (127 mm) bend radius
- d. 3/4" (19.05 mm) Onix has a 6" (152 mm) bend radius
- e. 1" (25.4 mm) Onix has a 8" (203 mm) bend radius

C. Manifolds

- 1. Provide 1" (25 mm) Stainless Steel manifolds offered by the respective tubing manufacturer for system compatibility.
- 2. Manifolds shall provide individual flow control for each loop of the manifold through valve actuators available from manifold supplier.
- 3. Manifolds shall feature manual flow balancing capability within the manifold body for balancing unequal loop lengths across the manifold. Balance valves shall not be ball valves.
- 4. Manifolds accommodate 3/8 - 3/4" Onix tubing.
- 5. Each manifold location shall have the ability to vent air manually from the system.
- 6. Stainless Steel 1" Manifolds
 - a. Heavy-duty, DIN standard, 304 stainless steel
 - b. Matching fittings and accessories are made of solid brass and are heavily plated with nickel to match the appearance of the manifold trunk.
 - c. Internal balancing valves.
 - d. 0- 2 1/2 GPM flow meters.
 - e. Manifold brackets.
 - f. All connections are BSP (British Standard Pipe) or straight thread and required the use of the included gasket.
 - g. 2 1/8" OC circuit spacing.
 - h. 12 GPM maximum flow rate.
 - i. 194 degrees F maximum operating temperature.
 - j. 87 psi maximum operating pressure.
 - k. 2 1/2 GPM per circuit maximum flow rate.

D. Manifold Mounting Boxes

- 1. Sizes – Watts Radiant manifold mounting boxes come in 3 sizes:
 - a. 15 3/4" by 28 1/2" by 4 1/4" (400mm by 724 mm by 108 mm)
 - b. 24 1/2" by 28 1/2" by 4 3/8" (622mm by 724 mm by 111 mm)
 - c. 39 1/2" by 28 1/2" by 4 3/8" (1003mm by 724 mm by 111 mm)
- 2. Each box shall be designed to be recessed into a 4" or 6" (102 mm or 152 mm) stud wall.
- 3. Included elevators can raise the box from 1 1/2" to 4 1/2" (38 – 114 mm) off of the floor.
- 4. Each manifold box is constructed of powder-coated sheet metal, providing increased resistance to corrosion and job-site abuse.
- 5. Inside Manifold Mounting Brackets:
 - a. Manifold boxes come with 2 fixed horizontal attachment rails and 2 adjustable rails.
 - b. Each Watts Radiant manifold option will utilize different rail positions, depending on the bracket used.

E. Accessories: Provide accessories associated with the installation of the radiant heating system as recommended by or available from the tubing manufacturer.

- 1. ThermalPro: The ThermalPro provides mixing control and zone pumping all in a compact, unique package that conveniently connects directly to Watts Radiant Stainless Steel manifolds.

- a. The ThermalPro module includes the following items:
 - 1) Mix Valve
 - 2) 3 speed 1/25 hp Circulator
 - 3) Temperature Gauge
 - 4) Maximum Temperature Sensor
 - 5) Trunk Isolation Valves
 - 6) BSP to NPT Transition Nipple
 - b. Mounting:
 - 1) The ThermalPro can be wall mounted with standard cush clamps or other copper pipe mounted brackets.
 - 2) The ThermalPro can be integrated into a standard Watts Radiant manifold box.
2. Staples: Watts Radiant Foamboard Staples
3. Terminal 90-degree Exit Bend: Terminal Bend Supports
- F. Distribution Manifolds (Manufacturer's Standard):
 1. Manifold: Minimum 1 inch, stainless steel.
 2. Main Shutoff Valves:
 - a. Factory installed on supply and return connections.
 - b. Two-piece brass body.
 - c. Ball: Chrome-plated bronze.
 - d. Seals: PTFE.
 - e. CWP Rating: 150 psig.
 - f. Maximum Operating Temperature: 225 degrees F.
 3. Manual Air Vents:
 - a. Body to consist of brass.
 - b. Internal Parts: Nonferrous.
 - c. Operator: Key furnished with valve or screwdriver bit.
 - d. Inlet Connection: 1/2 inch.
 - e. Discharge Connection: 1/8 inch.
 - f. CWP Rating: 150 psig.
 - g. Maximum Operating Temperature: 225 degrees F.
 4. Balancing Valves:
 - a. Body: Provide plastic, bronze, or _____, plug, globe, or _____ cartridge type.
 - b. Plug: EPDM.
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - d. Seat: PTFE.
 - e. Visual Flow Indicator: Flowmeter with visible indication in a clear plastic cap at top of valve.
 - f. Differential Pressure Gauge Connections: Integral seals for portable meter to measure loss across calibrated orifice.
 - g. Handle Style: Knob, with memory stop to retain set position if used for shutoff.
 - h. CWP Rating: Minimum 125 psig.
 - i. Maximum Operating Temperature: 250 degrees F.
 5. Zone Control Valves:
 - a. Body: Provide brass, bronze, or _____, plug, globe, or _____ cartridge type.
 - b. Plug: EPDM.
 - c. Globe Cartridge and Washer: Brass with EPDM composition washer.
 - d. Seat: PTFE.
 - e. Actuator: Replaceable electric motor.

- f. CWP Rating: Minimum 125 psig.
 - g. Maximum Operating Temperature: 250 degrees F.
 - 6. Thermometers:
 - a. Mounted on supply and return connections.
 - b. Case: Dry type, metal or plastic, 2 inch diameter.
 - c. Element: Bi-metallic coil.
 - d. Movement: Mechanical, connecting element and pointer.
 - e. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
 - f. Pointer: Black metal.
 - g. Window: Plastic.
 - h. Connector: Rigid, back type.
 - i. Thermal System: Bi-metallic coil.
 - j. Accuracy: Plus or minus 1 percent of range, 1 scale division, or _____ to maximum of 1.5 percent of range.
 - 7. Mounting Brackets: Provide copper, plastic, rubber-clad steel, or _____, where in contact with manifold.
- G. Piping Specialties (Manufacturer's Standard):
- 1. Cable Ties:
 - a. Fungus-inert, self-extinguishing, one-piece, self-locking, Type 6/6 nylon cable ties.
 - b. Minimum Width: 1/8 inch.
 - c. Minimum Tensile Strength: 20 lb.
 - d. Temperature Range: Minus 40 degrees F to plus 185 degrees F.
 - 2. Floor Mounting Staples:
 - a. Steel, with corrosion-resistant coating and smooth finish without sharp edges.
 - b. Minimum Thickness: 3/32 inch.
 - c. Width: Minimum, wider than tubing.
 - 3. Floor Mounting Tracks:
 - a. Aluminum or plastic channel track with smooth finish and no sharp edges.
 - b. Minimum Thickness: 1/16 inch.
 - c. Slot Width: Snap fit to hold tubing.

2.02 CONTROLS

- A. Temperature-control devices and sequence of operations are specified in Section 230923 "Direct Digital Control for HVAC Systems" and Section 230993 "Sequence of Operations for HVAC Controls."

PART 3 EXECUTION

3.01 EXAMINATION

- A. Hydronic Radiant Heating Piping:
 - 1. Examine surfaces and substrates to receive radiant heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
 - a. Ensure that surfaces and pipes in contact with radiant heating piping are free of burrs and sharp protrusions.
 - b. Ensure that surfaces and substrates are level and plumb.

2. Proceed with installation only after unsatisfactory conditions are corrected.

3.02 INSTALLATION

A. Install in accordance with manufacturer's recommendations.

B. Hydronic Radiant Heating Piping:

1. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems.
2. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations.
3. Install piping as indicated unless deviations to layout are approved on shop drawings or coordination drawings.
4. Install radiant heating piping continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels.
5. Connect radiant piping to manifold in a reverse-return arrangement.
6. Do not bend pipes in radius smaller than manufacturer's minimum bend radius dimension.
7. Piping in Interior Reinforced Concrete Floors:
 - a. Secure piping in concrete floors by attaching pipes to reinforcement using cable ties.
 - b. Space cable ties a maximum of 18 inches and at center of turns or bends.
 - c. Maintain 2 inch minimum cover.
 - d. Install a sleeve of 3/8 inch thick, foam type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints.
 - e. Maintain minimum 40 psig pressure in piping during concrete placement and continue for 24 hours after placement.
8. Piping in Level Fill Concrete Floors (Not Reinforced):
 - a. Secure piping in concrete floors by attaching pipes to subfloor using tracks, clamps, or staples.
 - b. Space tracks, clamps, or staples a maximum of 18 inches on center and at center turn of bends.
 - c. Maintain 3/4 inch minimum cover.
 - d. Install a sleeve of 3/8 inch thick, foam type insulation or PE pipe around tubing and extending for a minimum of 10 inches on each side of slab joints to protect the tubing passing through expansion or control joints.
 - e. Maintain minimum 40 psig pressure in piping during the concrete pour and continue for 24 hours during curing.
9. After concrete has cured as recommended by concrete supplier, operate radiant-heating system as follows:
 - a. Start system heating at a maximum of 10 deg F above the ambient temperature and increase 10 deg F each following day until design temperature is achieved.
 - b. For freeze protection, operate at a minimum of 60 deg F supply-water temperature.
10. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Engineer of Record.
11. After system balancing has been completed, mark balancing valves to permanently indicate final position.
12. Perform the following adjustments before operating the system:
 - a. Open valves to fully open position.
 - b. Check operation of automatic valves.

- c. Set temperature controls so all zones call for full flow.
- d. Purge air from piping.

3.03 FIELD QUALITY CONTROL

A. Hydronic Radiant Heating Piping:

- 1. Prepare radiant heating piping for testing as follows:
 - a. Open all isolation valves and close bypass valves.
 - b. Open and verify operation of zone control valves.
 - c. Flush with clean water and clean strainers.
- 2. Perform the following tests and inspections with the assistance of a factory authorized service representative:
- 3. Execute, complete, and pass required radiant-heating piping tests and inspections to accept installed piping.
- 4. Prepare test and inspection reports.
- 5. Protect hydronic piping system from damage during construction.

END OF SECTION 238300

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Single conductor building wire.
- B. Underground feeder and branch-circuit cable.
- C. Metal-clad cable.
- D. Variable-frequency drive cable.
- E. Wiring connectors.
- F. Electrical tape.
- G. Oxide inhibiting compound.
- H. Wire pulling lubricant.
- I. Cable ties.
- J. Firestop sleeves.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 260505 - Selective Demolition for Electrical: Disconnection, removal, and/or extension of existing electrical conductors and cables.
- C. Section 260526 - Grounding and Bonding for Electrical Systems: Additional requirements for grounding conductors and grounding connectors.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 284600 - Fire Detection and Alarm: Fire alarm system conductors and cables.

1.03 REFERENCE STANDARDS

- A. ASTM B3 - Standard Specification for Soft or Annealed Copper Wire.
- B. ASTM B8 - Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.
- C. ASTM B33 - Standard Specification for Tin-Coated Soft or Annealed Copper Wire for Electrical Purposes.
- D. ASTM B787/B787M - Standard Specification for 19 Wire Combination Unilay-Stranded Copper Conductors for Subsequent Insulation.

- E. ASTM D3005 - Standard Specification for Low-Temperature Resistant Vinyl Chloride Plastic Pressure-Sensitive Electrical Insulating Tape.
- F. ASTM D4388 - Standard Specification for Nonmetallic Semi-Conducting and Electrically Insulating Rubber Tapes.
- G. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- H. NECA 120 - Standard for Installing Armored Cable (AC) and Type Metal-Clad (MC) Cable.
- I. NEMA WC 70 - Power Cables Rated 2000 Volts or Less for the Distribution of Electrical Energy.
- J. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- K. NFPA 70 - National Electrical Code.
- L. NFPA 79 - Electrical Standard for Industrial Machinery.
- M. UL 44 - Thermoset-Insulated Wires and Cables.
- N. UL 83 - Thermoplastic-Insulated Wires and Cables.
- O. UL 267 - Outline of Investigation for Wire-Pulling Compounds.
- P. UL 486A-486B - Wire Connectors.
- Q. UL 486C - Splicing Wire Connectors.
- R. UL 486D - Sealed Wire Connector Systems.
- S. UL 510 - Polyvinyl Chloride, Polyethylene, and Rubber Insulating Tape.
- T. UL 1569 - Metal-Clad Cables.
- U. UL 2277 - Outline of Investigation for Flexible Motor Supply Cable and Wind Turbine Tray Cable.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes of raceways, boxes, and equipment enclosures installed under other sections with the actual conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate with electrical equipment installed under other sections to provide terminations suitable for use with the conductors to be installed.
 - 3. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conductors and cables, including detailed information on materials, construction, ratings, listings, and

available sizes, configurations, and stranding.

- C. Field Quality Control Test Reports.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Project Record Documents: Record actual installed circuiting arrangements. Record actual routing for underground circuits.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 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.
 - 1. Exceptions:
 - a. Use variable-frequency drive cable for connection between variable-frequency motor controllers and associated motors.
- C. Nonmetallic-sheathed cable is not permitted.
- D. Underground feeder and branch-circuit cable is not permitted.
- E. Service entrance cable is permitted only as follows:
 - 1. Where not otherwise restricted, may be used:
 - a. For overhead service drop, installed in raceway to service head.
 - b. For underground service entrance, installed in raceway.
- F. Metal-clad cable is permitted only as follows:
 - 1. Where not otherwise restricted, may be used:
 - a. Where concealed above accessible ceilings for final connections from junction boxes to luminaires.
 - 1) Maximum Length: 6 feet.
 - b. Where concealed in hollow stud walls, above accessible ceilings, and under raised floors for branch circuits up to 20 A.
 - 1) Exception: Provide single conductor building wire in raceway for circuit homerun from first outlet to panelboard.
 - 2. In addition to other applicable restrictions, may not be used:
 - a. Unless approved by Owner.

- b. Where not approved for use by the authority having jurisdiction.
- c. Where exposed to view.
- d. Where exposed to damage.
- e. For damp, wet, or corrosive locations, unless provided with a PVC jacket listed as suitable for those locations.

2.02 CONDUCTOR AND CABLE GENERAL REQUIREMENTS

- A. Provide products that comply with requirements of NFPA 70.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Unless specifically indicated to be excluded, provide all required conduit, boxes, wiring, connectors, etc. as required for a complete operating system.
- D. Comply with NEMA WC 70.
- E. Thermoplastic-Insulated Conductors and Cables: Listed and labeled as complying with UL 83.
- F. Thermoset-Insulated Conductors and Cables: Listed and labeled as complying with UL 44.
- G. Conductors for Grounding and Bonding: Also comply with Section 260526.
- H. Conductors and Cables Installed Exposed in Spaces Used for Environmental Air (only where specifically permitted): Plenum rated, listed and labeled as suitable for use in return air plenums.
- I. Conductor Material:
 - 1. Provide copper conductors only. Aluminum conductors are not acceptable for this project. Conductor sizes indicated are based on copper.
 - 2. Copper Conductors: Soft drawn annealed, 98 percent conductivity, uncoated copper conductors complying with ASTM B3, ASTM B8, or ASTM B787/B787M unless otherwise indicated.
 - 3. Tinned Copper Conductors: Comply with ASTM B33.
- J. Minimum Conductor Size:
 - 1. Branch Circuits: 12 AWG.
 - a. Exceptions:
 - 2. Control Circuits: 14 AWG.
- K. Where conductor size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
- L. Conductor Color Coding:
 - 1. Color code conductors as indicated unless otherwise required by the authority having jurisdiction. Maintain consistent color coding throughout project.
 - 2. Color Coding Method: Integrally colored insulation.
 - a. Conductors size 4 AWG and larger may have black insulation color coded using vinyl color coding electrical tape.
 - 3. Color Code:
 - a. 480Y/277 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Brown.
 - 2) Phase B: Orange.
 - 3) Phase C: Yellow.

- 4) Neutral/Grounded: Gray.
- b. 208Y/120 V, 3 Phase, 4 Wire System:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
 - 4) Neutral/Grounded: White.
- c. Equipment Ground, All Systems: Green.
- d. For control circuits, comply with manufacturer's recommended color code.

2.03 SINGLE CONDUCTOR BUILDING WIRE

- A. Manufacturers:
 - 1. Copper Building Wire:
 - a. General Cable Technologies Corporation; _____: www.generalcable.com/#sle.
 - b. Service Wire Co: www.servicewire.com/#sle.
 - c. Southwire Company: www.southwire.com/#sle.
- B. Description: Single conductor insulated wire.
- C. Conductor Stranding:
 - 1. Feeders and Branch Circuits: Stranded for all sizes.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation:
 - 1. Copper Building Wire: Type THHN/THWN or THHN/THWN-2, except as indicated below.
 - a. Installed Underground: Type XHHW-2.

2.04 METAL-CLAD CABLE

- A. Manufacturers:
 - 1. AFC Cable Systems Inc: www.afcweb.com/#sle.
 - 2. Service Wire Co: www.servicewire.com/#sle.
 - 3. Southwire Company: www.southwire.com/#sle.
- B. Description: NFPA 70, Type MC cable listed and labeled as complying with UL 1569, and listed for use in classified firestop systems to be used.
- C. Conductor Stranding:
 - 1. Size 10 AWG and Smaller: Solid.
 - 2. Size 8 AWG and Larger: Stranded.
- D. Insulation Voltage Rating: 600 V.
- E. Insulation: Type THHN, THHN/THWN, or THHN/THWN-2.
- F. Grounding: Full-size integral equipment grounding conductor.
- G. Armor: Steel, interlocked tape.
- H. Provide PVC jacket applied over cable armor where indicated or required for environment of installed location.

2.05 VARIABLE-FREQUENCY DRIVE CABLE

- A. Manufacturers:
 - 1. Service Wire Co; ServiceDrive: www.servicewire.com/#sle.
- B. Description: Flexible motor supply cable listed and labeled as complying with UL 2277 in accordance with NFPA 79; specifically designed for use with variable frequency drives and associated nonlinear power distortions.
- C. Conductor Stranding: Stranded.
- D. Insulation Voltage Rating: 1000 V.
- E. Insulation: Use only thermoset insulation types; thermoplastic insulation types are not permitted.
- F. Grounding: Full-size integral equipment grounding conductor or symmetrical arrangement of multiple conductors of equivalent size.
- G. Provide metallic shielding.
- H. Jacket: PVC or Chlorinated Polyethylene (CPE).

2.06 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. Connectors for Grounding and Bonding: Comply with Section 260526.
- C. Wiring Connectors for Splices and Taps:
 - 1. Copper Conductors Size 8 AWG and Smaller: Use twist-on insulated spring connectors.
 - 2. Copper Conductors Size 6 AWG and Larger: Use mechanical connectors or compression connectors.
- D. Wiring Connectors for Terminations:
 - 1. Provide terminal lugs for connecting conductors to equipment furnished with terminations designed for terminal lugs.
 - 2. Provide compression adapters for connecting conductors to equipment furnished with mechanical lugs when only compression connectors are specified.
 - 3. Where over-sized conductors are larger than the equipment terminations can accommodate, provide connectors suitable for reducing to appropriate size, but not less than required for the rating of the overcurrent protective device.
 - 4. Copper Conductors Size 8 AWG and Larger: Use mechanical connectors or compression connectors where connectors are required.
- E. Do not use insulation-piercing or insulation-displacement connectors designed for use with conductors without stripping insulation.
- F. Do not use push-in wire connectors as a substitute for twist-on insulated spring connectors.
- G. 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.

1. Manufacturers:
 - a. 3M: www.3m.com/#sle.
 - b. Ideal Industries, Inc: www.idealindustries.com/#sle.
 - c. NSI Industries LLC: www.nsiindustries.com/#sle.

H. Mechanical Connectors: Provide bolted type or set-screw type.

1. Manufacturers:
 - a. Burndy LLC; _____: www.burndy.com/#sle.
 - b. IlSCO: www.ilsco.com/#sle.
 - c. Thomas & Betts Corporation: www.tnb.com/#sle.

2.07 ACCESSORIES

A. Electrical Tape:

1. Manufacturers:
 - a. 3M: www.3m.com/#sle.
2. 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.
3. 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.
4. Rubber Splicing Electrical Tape: Ethylene Propylene Rubber (EPR) tape, complying with ASTM D4388; minimum thickness of 30 mil; suitable for continuous temperature environment up to 194 degrees F and short-term 266 degrees F overload service.

B. Oxide Inhibiting Compound: Listed; suitable for use with the conductors or cables to be installed.

C. Wire Pulling Lubricant:

1. Listed and labeled as complying with UL 267.
2. Suitable for use with conductors/cables and associated insulation/jackets to be installed.
3. Suitable for use at installation temperature.

D. Cable Ties: Material and tensile strength rating suitable for application.

PART 3 - EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper; stranded for all.
- B. Branch Circuits: Copper; stranded for all
- C. VFC Output Circuits Cable: Extra-flexible stranded for all sizes.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type XHHW-2, single conductors in raceway.
 - B. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway
 - C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway
 - D. NFPA 70 restricts use of exposed Type NM cable in some types of construction. See NFPA 70, Article 334, for complete listing of restrictions.
 - E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
 - F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Metal-clad cable, Type MC.
 - G. Coordinate "Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground" Paragraph below with Section 260543 "Underground Ducts and Raceways for Electrical Systems."
 - H. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway
 - I. Branch Circuits Installed below Raised Flooring: Metal-clad cable, Type MC.
 - J. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
 - K. Retain one shield option with Type TC-ER cable in "VFC Output Circuits" Paragraph below.
 - L. VFC Output Circuits: Type XHHW-2 in metal conduit.
- 3.03 Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace:
- A. Type THHN/THWN-2, single conductors in raceway. CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS
 - B. Service Entrance: Type XHHW-2, single conductors in raceway.
 - 1. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway
 - C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway
 - D. NFPA 70 restricts use of exposed Type NM cable in some types of construction. See NFPA 70, Article 334, for complete listing of restrictions.
 - E. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
 - F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Metal-clad cable, Type MC.
 - G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway
 - H. Branch Circuits Installed below Raised Flooring: Metal-clad cable, Type MC.

- I. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- J. Retain one shield option with Type TC-ER cable in "VFC Output Circuits" Paragraph below.
- K. VFC Output Circuits: Type XHHW-2 in metal conduit.
- L. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway
- M. Feeders Installed below Raised Flooring: Type THHN/THWN-2, single conductors in raceway
- N. NFPA 70 restricts use of exposed Type NM cable in some types of construction. See NFPA 70, Article 334, for complete listing of restrictions.
- O. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
- P. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Metal-clad cable, Type MC.
- Q. Coordinate "Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground" Paragraph below with Section 260543 "Underground Ducts and Raceways for Electrical Systems."
- R. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type XHHW-2, single conductors in raceway
- S. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- T. Retain one shield option with Type TC-ER cable in "VFC Output Circuits" Paragraph below.
- U. VFC Output Circuits: Type XHHW-2 in metal conduit.

PART 3 EXECUTION

4.01 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.

4.02 PREPARATION

- A. Clean raceways thoroughly to remove foreign materials before installing conductors and cables.

4.03 INSTALLATION

- A. Circuiting Requirements:
 - 1. Unless dimensioned, circuit routing indicated is diagrammatic.
 - 2. When circuit destination is indicated without specific routing, determine exact routing required.
 - 3. Arrange circuiting to minimize splices.
 - 4. Include circuit lengths required to install connected devices within 10 ft of location indicated.
 - 5. Maintain separation of Class 1, Class 2, and Class 3 remote-control, signaling, and power-limited circuits in accordance with NFPA 70.
 - 6. Maintain separation of wiring for emergency systems in accordance with NFPA 70.
 - 7. Circuiting Adjustments: Unless otherwise indicated, when branch circuits are indicated as separate, combining them together in a single raceway is not permitted.
 - a. Provide no more than three _____ current-carrying conductors in a single raceway. Dedicated neutral conductors are considered current-carrying conductors.
 - b. Increase size of conductors as required to account for ampacity derating.
 - c. Size raceways, boxes, etc. to accommodate conductors.
 - 8. Common Neutrals: Unless otherwise indicated, sharing of neutral/grounded conductors among up to three single phase branch circuits of different phases installed in the same raceway is not permitted. Provide dedicated neutral/grounded conductor for each individual branch circuit.
- B. Install products in accordance with manufacturer's instructions.
- C. Perform work in accordance with NECA 1 (general workmanship).
- D. Install metal-clad cable (Type MC) in accordance with NECA 120.
- E. Installation in Raceway:
 - 1. Tape ends of conductors and cables to prevent infiltration of moisture and other contaminants.
 - 2. Pull all conductors and cables together into raceway at same time.
 - 3. Do not damage conductors and cables or exceed manufacturer's recommended maximum pulling tension and sidewall pressure.
 - 4. Use suitable wire pulling lubricant where necessary, except when lubricant is not recommended by the manufacturer.
- F. Paralleled Conductors: Install conductors of the same length and terminate in the same manner.
- G. Secure and support conductors and cables in accordance with NFPA 70 using suitable supports and methods approved by the authority having jurisdiction. Provide independent support from building structure. Do not provide support from raceways, piping, ductwork, or other systems.
 - 1. Installation Above Suspended Ceilings: Do not provide support from ceiling support system. Do not provide support from ceiling grid or allow conductors and cables to lay on ceiling tiles.
 - 2. Installation in Vertical Raceways: Provide supports where vertical rise exceeds permissible limits.
- H. Terminate cables using suitable fittings.
 - 1. Metal-Clad Cable (Type MC):
 - a. Use listed fittings.
 - b. Cut cable armor only using specialized tools to prevent damaging conductors or insulation. Do not use hacksaw or wire cutters to cut armor.

- I. Variable-Frequency Drive Cable: Terminate shielding at both variable-frequency motor controller and associated motor using glands or termination kits recommended by manufacturer.
- J. Install conductors with a minimum of 12 inches of slack at each outlet.
- K. Neatly train and bundle conductors inside boxes, wireways, panelboards and other equipment enclosures.
- L. Group or otherwise identify neutral/grounded conductors with associated ungrounded conductors inside enclosures in accordance with NFPA 70.
- M. Make wiring connections using specified wiring connectors.
 - 1. Make splices and taps only in accessible boxes. Do not pull splices into raceways or make splices in conduit bodies or wiring gutters.
 - 2. Remove appropriate amount of conductor insulation for making connections without cutting, nicking or damaging conductors.
 - 3. Do not remove conductor strands to facilitate insertion into connector.
 - 4. Clean contact surfaces on conductors and connectors to suitable remove corrosion, oxides, and other contaminants. Do not use wire brush on plated connector surfaces.
 - 5. Mechanical Connectors: Secure connections according to manufacturer's recommended torque settings.
- N. Insulate splices and taps that are made with uninsulated connectors using methods suitable for the application, with insulation and mechanical strength at least equivalent to unspliced conductors.
- O. Insulate ends of spare conductors using vinyl insulating electrical tape.
- P. Field-Applied Color Coding: Where vinyl color coding electrical tape is used in lieu of integrally colored insulation as permitted in Part 2 under "Color Coding", apply half overlapping turns of tape at each termination and at each location conductors are accessible.
- Q. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- R. 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.

4.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.3.2. The insulation resistance test is required for all conductors. The resistance test for parallel conductors listed as optional is not required.
- D. Correct deficiencies and replace damaged or defective conductors and cables.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Grounding and bonding requirements.
- B. Conductors for grounding and bonding.
- C. Connectors for grounding and bonding.
- D. Ground bars.
- E. Ground rod electrodes.

1.02 RELATED REQUIREMENTS

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Additional requirements for conductors for grounding and bonding, including conductor color coding.
- B. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- C. Section 265600 - Exterior Lighting: Additional grounding and bonding requirements for pole-mounted luminaires.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B. NEMA GR 1 - Grounding Rod Electrodes and Grounding Rod Electrode Couplings.
- C. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- D. NFPA 70 - National Electrical Code.
- E. UL 467 - Grounding and Bonding Equipment.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Verify exact locations of underground metal water service pipe entrances to building.
 - 2. Coordinate the work with other trades to provide steel reinforcement complying with specified requirements for concrete-encased electrode.
 - 3. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not install ground rod electrodes until final backfill and compaction is complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for grounding and bonding system components.
- C. Field quality control test reports.
- D. Project Record Documents: Record actual locations of grounding electrode system components and connections.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 GROUNDING AND BONDING REQUIREMENTS

- A. 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 System Resistance:
 - 1. Achieve specified grounding system resistance under normally dry conditions unless otherwise approved by Engineer of Record. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. 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. Metal In-Ground Support Structure:
 - a. Provide connection to metal in-ground support structure that is in direct contact with earth in accordance with NFPA 70.
 - 4. Concrete-Encased Electrode:
 - a. Provide connection to concrete-encased electrode consisting of not less than 20 feet of either steel reinforcing bars or bare copper conductor not smaller than 4 AWG embedded within concrete foundation or footing that is in direct contact with earth in accordance with NFPA 70.
 - 5. Ground Rod Electrode(s):
 - a. Provide three electrodes in an equilateral triangle configuration 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.
 - 6. Provide additional ground electrode(s) as required to achieve specified grounding electrode system resistance.
 - 7. 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.
 - 8. Ground Riser: Provide common grounding electrode conductor not less than 3/0 AWG for tap connections to multiple separately derived systems as permitted in NFPA 70.
- F. Service-Supplied System Grounding:
- 1. For each service disconnect, provide grounding electrode conductor to connect neutral (grounded) service conductor to grounding electrode system. Unless otherwise indicated, make connection at neutral (grounded) bus in service disconnect enclosure.
 - 2. For each service disconnect, provide main bonding jumper to connect neutral (grounded) bus to equipment ground bus where not factory-installed. Do not make any other connections between neutral (grounded) conductors and ground on load side of service disconnect.
- G. Separately Derived System Grounding:
- 1. Separately derived systems include, but are not limited to:
 - a. Transformers (except autotransformers such as buck-boost transformers).
 - b. 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. 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.
 5. Where the source and first disconnecting means are in separate enclosures, provide supply-side bonding jumper between source and first disconnecting means.
- H. 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. Where circuit conductor sizes are increased for voltage drop, increase size of equipment grounding conductor proportionally in accordance with NFPA 70.
 3. Unless otherwise indicated, connect wiring device grounding terminal to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
 4. Terminate branch circuit equipment grounding conductors on solidly bonded equipment ground bus only. Do not terminate on neutral (grounded) or isolated/insulated ground bus.
 5. Provide bonding jumper across expansion or expansion/deflection fittings provided to accommodate conduit movement.
 6. Provide bonding for interior metal piping systems in accordance with NFPA 70. This includes, but is not limited to:
 - a. Metal water piping where not already effectively bonded to metal underground water pipe used as grounding electrode.
 - b. Metal gas piping.
- I. Communications Systems Grounding and Bonding:
1. Provide intersystem bonding termination at service equipment or metering equipment enclosure and at disconnecting means for any additional buildings or structures in accordance with NFPA 70.
 2. Provide bonding jumper in raceway from intersystem bonding termination to each communications room or backboard and provide ground bar for termination.
 - a. Bonding Jumper Size: 6 AWG, unless otherwise indicated or required.
 - b. Raceway Size: 3/4 inch trade size unless otherwise indicated or required.
 - c. Ground Bar Size: 1/4 by 2 by 12 inches unless otherwise indicated or required.
 - d. Ground Bar Mounting Height: 18 inches above finished floor unless otherwise indicated.

2.02 GROUNDING AND BONDING COMPONENTS

- A. General Requirements:
1. Provide products listed, classified, and labeled as suitable for the purpose intended.
 2. Provide products listed and labeled as complying with UL 467 where applicable.
- B. Conductors for Grounding and Bonding, in Addition to Requirements of Section 260526:
1. Use insulated copper conductors unless otherwise indicated.
 - a. Exceptions:

- 1) Use bare copper conductors where installed underground in direct contact with earth.
 - 2) Use bare copper conductors where directly encased in concrete (not in raceway).
- C. Connectors for Grounding and Bonding:
1. Description: Connectors appropriate for the application and suitable for the conductors and items to be connected; listed and labeled as complying with UL 467.
 2. Unless otherwise indicated, use exothermic welded connections for underground, concealed and other inaccessible connections.
 3. Unless otherwise indicated, use mechanical connectors, 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.
 4. Manufacturers:
 - a. Erico International Corporation; _____: www.erico.com/#sle.
 - b. Harger Lightning & Grounding; _____: www.harger.com/#sle.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that work likely to damage grounding and bonding system components has been completed.
- B. Verify that field measurements are as indicated.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Ground Rod Electrodes: Unless otherwise indicated, install ground rod electrodes vertically. Where encountered rock prohibits vertical installation, install at 45 degree angle or bury horizontally in trench at least 30 inches (750 mm) deep in accordance with NFPA 70 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 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS except Section 4.
- C. Perform inspections and tests listed in NETA ATS, Section 7.13.
- D. Perform ground electrode resistance tests under normally dry conditions. Precipitation within the previous 48 hours does not constitute normally dry conditions.
- E. Investigate and correct deficiencies where measured ground resistances do not comply with specified requirements.
- F. Submit detailed reports indicating inspection and testing results and corrective actions taken.

END OF SECTION 260526

SECTION 260529 - 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 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 260533.13 - Conduit for Electrical Systems: Additional support and attachment requirements for conduits.
- C. Section 260533.16 - Boxes for Electrical Systems: Additional support and attachment requirements for boxes.
- D. Section 265100 - Interior Lighting: Additional support and attachment requirements for interior luminaires.
- E. Section 265600 - Exterior Lighting: Additional support and attachment requirements for exterior luminaires.

1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- D. MFMA-4 - Metal Framing Standards Publication.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- F. NFPA 70 - National Electrical Code.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.
 - 2. Coordinate work to provide additional framing and materials required for installation.
 - 3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
 - 4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.

5. Notify Engineer of Record of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has cured; see Section 033000.

1.05 SUBMITTALS

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

1.06 QUALITY ASSURANCE

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. NFPA 70.
 - b. Requirements of authorities having jurisdiction.
2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of electrical work.
3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported with minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
6. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
 - a. Indoor Dry Locations: Use zinc-plated steel or approved equivalent unless otherwise indicated.
 - b. Outdoor and Damp or Wet Indoor Locations: Use galvanized steel, stainless steel, or approved equivalent unless otherwise indicated.
 - c. Zinc-Plated Steel: Electroplated in accordance with ASTM B633.
 - d. Galvanized Steel: Hot-dip galvanized after fabrication in accordance with ASTM A123/A123M or ASTM A153/A153M.

- B. Conduit and Cable Supports: Straps and clamps suitable for 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 and brackets suitable for boxes to be supported.
- D. Metal Channel/Strut Framing Systems:
 - 1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
 - 2. Comply with MFMA-4.
- E. Hanger Rods: Threaded, zinc-plated steel unless otherwise indicated.
 - 1. Minimum Size, Unless Otherwise Indicated or Required:
 - a. Equipment Supports: 1/2-inch diameter.
 - b. Busway Supports: 1/2-inch diameter.
 - c. Single Conduit up to 1-inch (27 mm) Trade Size: 1/4-inch diameter.
 - d. Single Conduit Larger than 1-inch (27 mm) Trade Size: 3/8-inch diameter.
 - e. Trapeze Support for Multiple Conduits: 3/8-inch diameter.
 - f. Outlet Boxes: 1/4-inch diameter.
 - g. Luminaires: 1/4-inch diameter.
- F. Anchors and Fasteners:
 - 1. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for 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. Powder-actuated fasteners are not permitted.
 - 10. Hammer-driven anchors and fasteners are not permitted.
 - 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.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

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

- B. Install hangers and supports in accordance with NECA 1.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Engineer of Record, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Engineer of Record, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 - 1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 - 2. Use metal channel/strut secured to studs to support equipment surface mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 - 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 - 4. Securely fasten floor-mounted equipment. Do not install equipment such that it relies on its own weight for support.
- H. Conduit Support and Attachment: See Section 260533.13 for additional requirements.
- I. Box Support and Attachment: See Section 260533.16 for additional requirements.
- J. Interior Luminaire Support and Attachment: See Section 265100 for additional requirements.
- K. Exterior Luminaire Support and Attachment: See Section 265600 for additional requirements.
- L. Preset Concrete Inserts: Use manufacturer provided closure strips to inhibit concrete seepage during concrete pour.
- M. Secure fasteners in accordance with manufacturer's recommended torque settings.
- N. Remove temporary supports.

3.03 FIELD QUALITY CONTROL

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

END OF SECTION 260529

SECTION 260533.13 - CONDUIT FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Galvanized steel intermediate metal conduit (IMC).
- C. Liquidtight flexible metal conduit (LFMC).
- D. Galvanized steel electrical metallic tubing (EMT).
- E. Stainless steel electrical metallic tubing (EMT).
- F. Rigid polyvinyl chloride (PVC) conduit.
- G. Reinforced thermosetting resin conduit (RTRC).

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete encasement of conduits.
- B. Section 078400 - Firestopping.
- C. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Cable assemblies consisting of conductors protected by integral metal armor.
- D. Section 260526 - Grounding and Bonding for Electrical Systems.
 - 1. Includes additional requirements for fittings for grounding and bonding.
- E. Section 260529 - Hangers and Supports for Electrical Systems.
- F. Section 260533.16 - Boxes for Electrical Systems.
- G. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- H. Section 270533.13 - Conduit for Communications Systems.

1.03 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).
- C. ANSI C80.5 - American National Standard for Electrical Rigid Metal Conduit -- Aluminum (ERMC-A).
- D. ANSI C80.6 - American National Standard for Electrical Intermediate Metal Conduit.
- E. NECA 1 - Standard for Good Workmanship in Electrical Construction.

- F. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- G. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC).
- H. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- I. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.
- J. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
- K. NEMA TC 14 (SERIES) - Reinforced Thermosetting Resin Conduit and Fittings Series.
- L. NFPA 70 - National Electrical Code.
- M. UL 6 - Electrical Rigid Metal Conduit-Steel.
- N. UL 514B - Conduit, Tubing, and Cable Fittings.
- O. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
- P. UL 797 - Electrical Metallic Tubing-Steel.
- Q. UL 797A - Electrical Metallic Tubing - Aluminum and Stainless Steel.
- R. UL 1242 - Electrical Intermediate Metal Conduit-Steel.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate minimum sizes of conduits with actual type and quantity of conductors to be installed, including adjustments for conductor sizes increased for voltage drop.
 - 2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment, and other potential conflicts.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
 - 4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
 - 5. Notify Engineer of Record of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not begin installation of conductors and cables until installation of conduit between termination points is complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
- C. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2-inch (53 mm) trade size and larger.

1.06 QUALITY ASSURANCE

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, manufacturer's instructions, and product listing.
- B. Unless otherwise indicated and where not otherwise restricted, use conduit types indicated for specified applications. Where more than one listed application applies, comply with most restrictive requirements. Where conduit type for particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Under Slab on Grade: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit (RMC), galvanized steel electrical metallic tubing (EMT), stainless steel electrical metallic tubing (EMT), rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
 - 2. Exterior, Direct-Buried: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit, galvanized steel electrical metallic tubing (EMT), stainless steel electrical metallic tubing (EMT), rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
 - 3. Exterior, Embedded Within Concrete: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), PVC-coated galvanized steel rigid metal conduit (RMC), galvanized steel electrical metallic tubing (EMT), stainless steel electrical metallic tubing (EMT), rigid PVC conduit, or reinforced thermosetting resin conduit (RTRC).
 - 4. Where rigid polyvinyl chloride (PVC) conduit is provided, transition to galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), or schedule 80 rigid PVC conduit where emerging from underground.
 - 5. Where rigid polyvinyl (PVC) conduit larger than 2-inch (53 mm) trade size is provided, use galvanized steel rigid metal conduit (RMC) elbows, stainless steel rigid metal conduit (RMC) elbows, galvanized steel intermediate metal conduit (IMC) elbows, stainless steel intermediate metal conduit (IMC) elbows, PVC-coated galvanized steel rigid metal conduit (RMC) elbows, or concrete-encased PVC elbows for bends.
 - 6. Where galvanized rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or galvanized steel electrical metallic tubing (EMT) emerges from concrete into soil, use corrosion protection tape, factory-applied corrosion protection coating, or field-applied corrosion protection compound acceptable to authorities having

jurisdiction to provide supplementary corrosion protection for minimum of 4 inches on either side of where conduit emerges.

- D. Embedded Within Concrete:
 - 1. Within Slab on Grade: Not permitted.
- E. Concealed Within Hollow Stud Walls: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
- F. Concealed Above Accessible Ceilings: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
- G. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
- H. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
- I. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), stainless steel intermediate metal conduit (IMC), galvanized steel electrical metallic tubing (EMT), or stainless steel electrical metallic tubing (EMT).
 - 1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
 - b. Loading dock..
 - c. Mechanical Rooms.
- J. Exposed, Interior, Subject to Severe Physical Damage: Use galvanized steel rigid metal conduit (RMC), stainless steel rigid metal conduit (RMC), galvanized steel intermediate metal conduit (IMC), or stainless steel intermediate metal conduit (IMC).

2.02 CONDUIT - GENERAL REQUIREMENTS

- A. Comply with NFPA 70.
- B. Provide conduit, fittings, supports, and accessories required for complete raceway system.
- C. Provide products listed, classified, and labeled as suitable for purpose intended.
- D. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Branch Circuits: 3/4-inch trade size.
 - 2. Branch Circuit Homeruns: 3/4-inch trade size.
 - 3. Underground, Interior: 1-inch trade size.
- E. Where conduit size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.

2.03 GALVANIZED STEEL RIGID METAL CONDUIT (RMC)

- A. Description: NFPA 70, Type RMC galvanized steel rigid metal conduit complying with ANSI C80.1 and listed and labeled as complying with UL 6.
- B. Fittings:
 - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.04 GALVANIZED STEEL INTERMEDIATE METAL CONDUIT (IMC)

- A. Description: NFPA 70, Type IMC galvanized steel intermediate metal conduit complying with ANSI C80.6 and listed and labeled as complying with UL 1242.
- B. Fittings:
 - 1. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 1242.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use threaded type fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.

2.05 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B. Fittings:
 - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.

2.06 STAINLESS STEEL ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT stainless steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797A.
- B. Fittings:
 - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Connectors and Couplings: Use compression/gland or set-screw type.

2.07 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.

2.08 REINFORCED THERMOSETTING RESIN CONDUIT (RTRC)

- A. Description: NFPA 70, Type RTRC reinforced thermosetting resin conduit complying with NEMA TC 14 (SERIES).
- B. Supports: As recommended by manufacturer.
- C. Fittings: Same type and manufacturer as conduit to be connected.

END OF SECTION 260533.13

SECTION 260533.16 - BOXES FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Outlet and device boxes up to 100 cubic inches, including those used as junction and pull boxes.
- B. Cabinets and enclosures, including junction and pull boxes larger than 100 cubic inches.
- C. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 083100 - Access Doors and Panels: Panels for maintaining access to concealed boxes.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260533.13 - Conduit for Electrical Systems:
 - 1. Additional requirements for locating boxes to limit conduit length and/or number of bends between pulling points.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 262726 - Wiring Devices:
 - 1. Wall plates.
 - 2. Additional requirements for locating boxes for wiring devices.
- G. Section 271000 - Structured Cabling: Additional requirements for communications systems outlet boxes.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B. NECA 130 - Standard for Installing and Maintaining Wiring Devices.
- C. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- D. NEMA OS 1 - Sheet-Steel Outlet Boxes, Device Boxes, Covers, and Box Supports.
- E. NFPA 70 - National Electrical Code.
- F. UL 514A - Metallic Outlet Boxes.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:

1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
3. Coordinate minimum sizes of boxes with the actual installed arrangement of conductors, clamps, support fittings, and devices, calculated according to NFPA 70.
4. Coordinate minimum sizes of pull boxes with the actual installed arrangement of connected conduits, calculated according to NFPA 70.
5. Coordinate the placement of boxes with millwork, furniture, devices, equipment, etc. installed under other sections or by others.
6. Coordinate the work with other trades to preserve insulation integrity.
7. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted boxes where indicated.
8. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cabinets and enclosures, boxes for hazardous (classified) locations, floor boxes, and underground boxes/enclosures.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 BOXES

- A. General Requirements:
 1. Do not use boxes and associated accessories for applications other than as permitted by NFPA 70 and product listing.
 2. Provide all boxes, fittings, supports, and accessories required for a complete raceway system and to accommodate devices and equipment to be installed.
 3. Provide products listed, classified, and labeled as suitable for the purpose intended.
 4. Where box size is not indicated, size to comply with NFPA 70 but not less than applicable minimum size requirements specified.
 5. Provide grounding terminals within boxes where equipment grounding conductors terminate.
- B. Outlet and Device Boxes Up to 100 cubic inches, Including Those Used as Junction and Pull Boxes:
 1. Use sheet-steel boxes for dry locations unless otherwise indicated or required.

2. Use cast iron boxes or cast aluminum boxes for damp or wet locations unless otherwise indicated or required; furnish with compatible weatherproof gasketed covers.
 3. Use 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: 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 1-1/2 inch deep (100 by 38 mm) trade size.
 - b. Communications Systems Outlets: Comply with Section 271000.
 - c. Ceiling Outlets: 4 inch octagonal or square by 1-1/2 inch deep (100 by 38 mm) trade size.
 13. Wall Plates: Comply with Section 262726.
- 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.
 3. Junction and Pull Boxes Larger Than 100 cubic inches:
 - a. Provide screw-cover or hinged-cover enclosures unless otherwise indicated.
 - b. Boxes 6 square feet and Larger: Provide sectionalized screw-cover or hinged-cover enclosures.
 4. Finish for Painted Steel Enclosures: Manufacturer's standard grey unless otherwise indicated.

2.02 ACCESSORIES

- A. Flashing Panels for Exterior Wall Penetrations: Premanufactured components and accessories as required to preserve integrity of building envelope; suitable for boxes and facade materials 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 boxes.

- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install boxes in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards where mounting heights are not indicated.
- C. Arrange equipment to provide minimum clearances in accordance with manufacturer's instructions and NFPA 70.
- D. Provide separate boxes for emergency power and normal power systems.
- E. Unless otherwise indicated, provide separate boxes for line voltage and low voltage systems.
- F. Flush-mount boxes in finished areas unless specifically indicated to be surface-mounted.
- G. Unless otherwise indicated, boxes may be surface-mounted where exposed conduits are indicated or permitted.
- H. Box Locations:
 - 1. Locate boxes to be accessible. Provide access panels in accordance with Section 083100 as required where approved by the Architect.
 - 2. Locate boxes as required for devices installed under other sections or by others.
 - a. Switches, Receptacles, and Other Wiring Devices: Comply with Section 262726.
 - b. Communications Systems Outlets: Comply with Section 271000.
 - 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.
 - 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 260533.13.
 - 10. Locate junction and pull boxes in the following areas, unless otherwise indicated or approved by the Architect:
 - a. Concealed above accessible suspended ceilings.
- I. Box Supports:
 - 1. Secure and support boxes in accordance with NFPA 70 and Section 260529 using suitable supports and methods approved by the authority having jurisdiction.
 - 2. Provide independent support from building structure except for cast metal boxes (other than boxes used for fixture support) supported by threaded conduit connections in accordance with NFPA 70. Do not provide support from piping, ductwork, or other systems.

- 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. Install permanent barrier between ganged wiring devices when voltage between adjacent devices exceeds 300 V.
- N. Install firestopping to preserve fire resistance rating of partitions and other elements, using materials and methods specified in Section 078400.
- O. Close unused box openings.
- P. Install blank wall plates on junction boxes and on outlet boxes with no devices or equipment installed or designated for future use.
- Q. Provide grounding and bonding in accordance with Section 260526.
- R. Identify boxes in accordance with Section 260553.

3.03 CLEANING

- A. Clean interior of boxes to remove dirt, debris, plaster and other foreign material.

3.04 PROTECTION

- A. Immediately after installation, protect boxes from entry of moisture and foreign material until ready for installation of conductors.

END OF SECTION 260533.16

SECTION 260536 - CABLE TRAYS FOR ELECTRICAL SYSTEMS

PART 2 PRODUCTS

1.01 CABLE TRAY SYSTEM - GENERAL REQUIREMENTS

- A. Provide new cable tray system consisting of all required components, fittings, supports, accessories, etc. as necessary for a complete system.
- B. Provide products listed, classified, and labeled as suitable for the purpose intended.
- C. Do not use cable tray for applications other than as permitted by NFPA 70 and product listing/classification.
- D. Provide cable tray system and associated components suitable for use at indicated span/load ratings under the service conditions at the installed location.
- E. Unless otherwise indicated, specified span/load ratings are based on safety factor of 1.5 and working load only (no additional concentrated static load), with ratings for metal cable tray systems in accordance with NEMA VE 1.
- F. Unless otherwise indicated, specified load/fill depths and inside widths are nominal values, with values for metal cable tray systems in accordance with NEMA VE 1 including applicable allowable tolerances.

END OF SECTION 260536

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Vibration isolation requirements.
- B. Seismic control requirements.
 - 1. Includes requirements for seismic qualification of equipment not specified in this section.
- C. External seismic snubber assemblies.
- D. Seismic restraint systems.

1.02 RELATED REQUIREMENTS

- A. Section 014533 - Code-Required Special Inspections and Procedures.

1.03 DEFINITIONS

- A. Electrical Component: Where referenced in this section in regards to seismic controls, applies to any portion of the electrical system subject to seismic evaluation in accordance with applicable codes, including distributed systems (e.g., conduit, cable tray).
- B. Seismic Restraint: Structural members or assemblies of members or manufactured elements specifically designed and applied for transmitting seismic forces between components and the seismic force-resisting system of the structure.

1.04 REFERENCE STANDARDS

- A. ASCE 19 - Structural Applications of Steel Cables for Buildings.
- B. ASHRAE (HVAC) - ASHRAE Handbook - HVAC Applications.
- C. ASTM E580/E580M - Standard Practice for Installation of Ceiling Suspension Systems for Acoustical Tile and Lay-in Panels in Areas Subject to Earthquake Ground Motions.
- D. FEMA 413 - Installing Seismic Restraints for Electrical Equipment.
- E. FEMA E-74 - Reducing the Risks of Nonstructural Earthquake Damage.
- F. ICC-ES AC156 - Acceptance Criteria for Seismic Certification by Shake-Table Testing of Nonstructural Components.
- G. MFMA-4 - Metal Framing Standards Publication.
- H. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- I. NFPA 70 - National Electrical Code.
- J. SMACNA (SRM) - Seismic Restraint Manual Guidelines for Mechanical Systems.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Design Documents: Prepare and submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, details, and calculations.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for products, including materials, fabrication details, dimensions, and finishes.
 - 1. Seismic Controls: Include seismic load capacities.
- D. Shop Drawings - Seismic Controls:
 - 1. Include dimensioned plan views and sections indicating proposed electrical component locations and distributed system routing, with locations and details of gravity supports and seismic restraints and associated attachments.
 - 2. Identify mounting conditions required for equipment seismic qualification.
 - 3. Identify anchor manufacturer, type, minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
 - 4. Indicate proposed arrangement of distributed system trapeze support groupings.
 - 5. Indicate proposed locations for distributed system flexible fittings and/or connections.
 - 6. Indicate locations of seismic separations where applicable.
 - 7. Include point load drawings indicating design loads transmitted to structure at each attachment location.
- E. Seismic Design Data:
 - 1. Compile information on project-specific characteristics of actual installed electrical components necessary for determining seismic design forces required to design appropriate seismic controls, including but not limited to the following.
 - 2. Include structural calculations, stamped or sealed by seismic controls designer, demonstrating suitability of seismic controls for seismic design forces.
- F. 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.
- G. Manufacturer's detailed field testing and inspection procedures.
- H. Field quality control test reports.

1.06 QUALITY ASSURANCE

- A. Comply with NFPA 70.
- B. Comply with applicable building code.
- C. Seismic Controls Designer Qualifications: Registered professional engineer licensed in the State in which the Project is located and with minimum five years experience designing seismic restraints for nonstructural components.
- D. Manufacturer Qualifications: Company specializing in manufacturing the products specified in this section with minimum three years documented experience.

PART 2 PRODUCTS

2.01 SEISMIC CONTROL REQUIREMENTS

- A. Design and provide electrical component restraints, supports, and attachments suitable for seismic loads determined in accordance with applicable codes, as well as gravity and operating loads and other structural design considerations of the installed location. Consider wind loads for outdoor electrical components.
- B. Seismic Design Criteria: As indicated on drawings.
- C. Component Importance Factor (Ip): Electrical components to be assigned a component importance factor (Ip) of 1.5 unless otherwise indicated.
- D. Seismic Qualification of Equipment:
 - 1. Provide special certification for electrical equipment furnished under other sections and assigned a component importance factor (Ip) of 1.5, certifying that equipment will remain operable following a design level earthquake.
 - 2. Seismic qualification to be by shake table testing in accordance with recognized testing standard procedure, such as ICC-ES AC156, acceptable to authorities having jurisdiction.
 - 3. Notify Engineer of Record and obtain direction where mounting restrictions required by conditions of seismic certification conflict with specified requirements.
 - 4. Seismically qualified equipment to be furnished with factory-installed labels referencing certificate of compliance and associated mounting restrictions.
- E. Seismic Restraints:
 - 1. Provide seismic restraints for electrical components except where exempt according to applicable codes and specified seismic design criteria, as approved by authorities having jurisdiction.
 - 2. Seismic Restraint Exemptions:
 - a. Raceway Exemptions, All Seismic Design Categories:
 - 1) Conduits less than 2-1/2 inch trade size.
 - 2) Trapeze supported raceways weighing less than 10 pounds per foot.
 - 3) Hanger supported raceways where each hanger in the raceway run is 12 inches or less in length from the raceway support to the supporting structure; rod hangers, where used, to be equipped with swivels.
 - b. Lighting Exemptions, All Seismic Design Categories:
 - 1) Suspended luminaires where attachments are designed to accommodate 1.4 times the operating weight acting in both the vertical and horizontal directions and connections to structure allow for 360 degree range of motion in the horizontal plane; arrange to prevent impact between luminaires and the structure or other nonstructural components.
 - 2) Lay-in luminaires weighing less than 56 pounds secured to ceiling grid and provided with safety wires in accordance with ASTM E580/E580M.
 - 3. Comply with applicable general recommendations of the following, where not in conflict with applicable codes, seismic design criteria, or other specified requirements:
 - a. ASHRAE (HVACA).
 - b. FEMA 413.
 - c. FEMA E-74.
 - d. SMACNA (SRM).

4. Seismic restraint capacities to be verified by a Nationally Recognized Testing Laboratory (NRTL) or certified by an independent third-party registered professional engineer acceptable to authorities having jurisdiction.
5. External Seismic Snubber Assemblies:
 - a. Provide quantity and arrangement of external seismic snubber assemblies as required to restrain equipment in all directions (both lateral and vertical).
 - b. Do not use external seismic snubber assemblies that restrain equipment only in one or more lateral directions (but not vertical) except where uplift forces are zero or are addressed by other restraints.
6. Seismic Restraint Systems:
 - a. Except where otherwise restricted, use of either cable or rigid restraints is permitted.
 - b. Use only cable restraints to restrain vibration-isolated electrical components, including distributed systems.
 - c. Use only one restraint system type for a given electrical component or distributed system (e.g., conduit, cable tray) run; mixing of cable and rigid restraints on a given component/run is not permitted.
 - d. Size restraint elements, including anchorage, to resist seismic loads as necessary to restrain electrical component in all lateral directions; consider bracket geometry in anchor load calculations.
 - e. Use rod stiffener clips to attach bracing to hanger rods as required to prevent rod buckling from vertical (upward) compressive load introduced by cable or rigid restraints loaded in tension, in excess of downward tensile load due to supported electrical component weight.
 - f. Select hanger rods and associated anchorage as required to accommodate vertical (downward) tensile load introduced by rigid restraints loaded in compression, in addition to downward tensile load due to supported electrical component weight.
 - g. Clevis hangers may only be used for attachment of transverse restraints; do not use for attachment of longitudinal restraints.
 - h. Where seismic restraints are attached to clevis hangers, provide clevis bolt reinforcement accessory to prevent clevis hanger deformation.
 - i. Do not introduce lateral loads on open bar joist chords or the weak axis of beams, or loads in any direction at other than panel points unless approved by project Structural Engineer of Record.

F. Seismic Attachments:

1. Attachments to be bolted, welded, or otherwise positively fastened without consideration of frictional resistance produced by the effects of gravity.
2. Post-Installed Concrete and Masonry Anchors: Evaluated and recognized by ICC Evaluation Service, LLC (ICC-ES) or qualified evaluation service acceptable to authorities having jurisdiction for compliance with applicable building code, and qualified for seismic applications; concrete anchors to be qualified for installation in both cracked and uncracked concrete.
3. Do not use power-actuated fasteners.
4. Do not use friction clips (devices that rely on mechanically applied friction to resist loads). Beam clamps may be used for supporting sustained loads where provided with restraining straps.
5. Comply with anchor minimum embedment, minimum spacing, minimum member thickness, and minimum edge distance requirements.
6. Concrete Housekeeping Pads:
 - a. Increase size of pad as required to comply with anchor requirements.

- b. Provide pad reinforcement and doweling to ensure integrity of pad and connection and to provide adequate load path from pad to supporting structure.
- G. Seismic Interactions:
 - 1. Include provisions to prevent seismic impact between electrical components and other structural or nonstructural components.
 - 2. Include provisions such that failure of a component, either essential or nonessential, does not cause the failure of an essential component.
- H. Seismic Relative Displacement Provisions:
 - 1. Use suitable fittings or flexible connections to accommodate:
 - a. Relative displacements at connections between components, including distributed systems (e.g., conduit, cable tray); do not exceed load limits for equipment utility connections.
 - b. Relative displacements between component supports attached to dissimilar parts of structure that may move differently during an earthquake.
 - c. Design displacements at seismic separations.
 - d. Anticipated drifts between floors.

2.02 EXTERNAL SEISMIC SNUBBER ASSEMBLIES

- A. Description: Steel snubbing assemblies designed for external attachment to both equipment and supporting structure that, as part of a complete system, restrain equipment motion in all directions during a seismic event while maintaining vibration isolation during normal operation.
- B. Seismic Snubbing Elements:
 - 1. Air Gap: Between 0.125 inches and 0.25 inches unless otherwise indicated.
 - 2. Points of Contact: Cushioned with resilient material, minimum 0.25 inch thick; capable of being visually inspected for damage and replaced.

2.03 SEISMIC RESTRAINT SYSTEMS

- A. Description: System components and accessories specifically designed for field assembly and attachment of seismic restraints.
- B. Cable Restraints:
 - 1. Comply with ASCE 19.
 - 2. Cables: Pre-stretched, galvanized steel wire rope with certified break strength.
 - 3. Cable Connections: Use only swaged end fittings. Cable clips and wedge type end fittings are not permitted in accordance with ASCE 19.
 - 4. Use protective thimbles for cable loops where potential for cable damage exists.
- C. Rigid Restraints: Use MFMA-4 steel channel (strut), steel angle, or steel pipe for structural element; suitable for both compressive and tensile design loads.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as shown on the drawings.

- B. Verify that mounting surfaces are ready to receive vibration isolation and/or seismic control components and associated attachments.
- C. Verify that conditions are satisfactory for installation prior to starting work.

3.02 CODE-REQUIRED SPECIAL INSPECTIONS

- A. Arrange work to accommodate tests and/or inspections performed by Special Inspection Agency employed by Owner or Engineer of Record in accordance with Section 014533 and statement of special inspections as required by applicable building code.
- B. Frequency of Special Inspections: Where special inspections are designated as continuous or periodic, arrange work accordingly.
 - 1. Continuous Special Inspections: Special Inspection Agency to be present in the area where the work is being performed and observe the work at all times the work is in progress.
 - 2. Periodic Special Inspections: Special Inspection Agency to be present in the area where work is being performed and observe the work part-time or intermittently and at the completion of the work.
- C. Prior to starting work, Contractor to submit written statement of responsibility to authorities having jurisdiction and to Owner acknowledging awareness of special requirements contained in the statement of special inspections.
- D. Special Inspection Agency services do not relieve Contractor from performing inspections and testing specified elsewhere.

3.03 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install products in accordance with applicable requirements of NECA 1 (general workmanship).
- C. Install anchors and fasteners in accordance with ICC Evaluation Services, LLC (ICC-ES) evaluation report conditions of use where applicable.
- D. Secure fasteners according to manufacturer's recommended torque settings.
- E. Install flexible conduit and cable connections to provide sufficient slack for vibration isolation and/or seismic relative displacements as indicated or as required.
- F. Seismic Controls:
 - 1. Provide specified snubbing element air gap; remove any factory-installed spacers, debris or other obstructions.
 - 2. Use only specified components, anchorage, and hardware evaluated by seismic design. Comply with conditions of seismic certification where applicable.
 - 3. Where mounting hole diameter exceeds bolt diameter by more than 0.125 inch, use epoxy grout, elastomeric grommet, or welded washer to reduce clearance to 0.125 inch or less.
 - 4. Equipment with Sheet Metal Housings:
 - a. Use Belleville washers to distribute stress over a larger surface area of the sheet metal connection interface as approved by manufacturer.
 - b. Attach additional steel as approved by manufacturer where required to transfer loads to structure.

- c. Where mounting surface is irregular, do not shim housing; reinforce housing with additional steel as approved by manufacturer.
- 5. Concrete Housekeeping Pads:
 - a. Size in accordance with seismic design to meet anchor requirements.
 - b. Install pad reinforcement and doweling in accordance with seismic design to ensure integrity of pad and associated connection to slab.
- 6. Seismic Restraint Systems:
 - a. Do not attach seismic restraints and gravity supports to dissimilar parts of structure that may move differently during an earthquake.
 - b. Install restraints within permissible angles in accordance with seismic design.
 - c. Install cable restraints straight between component/run and structural attachment; do not bend around other nonstructural components or structural elements.
 - d. Install cable restraints for vibration-isolated components slightly slack to prevent short-circuiting of isolation.
 - e. Install hanger rod stiffeners where indicated using only specified clamps; do not weld stiffeners to hanger rod.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 2 PRODUCTS

1.01 IDENTIFICATION REQUIREMENTS

- A. Identification for Equipment:
 - 1. Use identification nameplate to identify each piece of electrical distribution and control equipment and associated sections, compartments, and components.
 - 2. 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.
- B. Identification for Conductors and Cables:
 - 1. Color Coding for Power Conductors 600 V and Less: Comply with Section 260519.
 - 2. Use identification nameplate or identification label to identify color code for ungrounded and grounded power conductors inside door or enclosure at each piece of feeder or branch-circuit distribution equipment when premises has feeders or branch circuits served by more than one nominal voltage system.

1.02 IDENTIFICATION NAMEPLATES AND LABELS

- A. Identification Nameplates:
 - 1. Materials:
- B. Identification Labels:
 - 1. Materials: Use self-adhesive laminated plastic labels; UV, chemical, water, heat, and abrasion resistant.
 - 2. Text: Use factory pre-printed or machine-printed text. Do not use handwritten text unless otherwise indicated.

1.03 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.

END OF SECTION 260553

SECTION 260573 - POWER SYSTEM STUDIES

PART 1 GENERAL

1.01 REFERENCE STANDARDS

- A. NEMA MG 1 - Motors and Generators.
- B. NFPA 70 - National Electrical Code.

1.02 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.
 - 2. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- 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 Engineer of Record.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Study reports, stamped or sealed and signed by study preparer.

1.04 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: 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. 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.

1.05 QUALITY ASSURANCE

- A. Computer Software for Study Preparation: Use the latest edition of commercially available software utilizing specified methodologies.

END OF SECTION 260573

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Occupancy sensors.
- B. Outdoor motion sensors.
- C. Time switches.
- D. Outdoor photo controls.
- E. Daylighting controls.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems
- C. Section 260533.16 - Boxes for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 262726 - Wiring Devices: Devices for manual control of lighting, including wall switches, wall dimmers, and fan speed controllers.
- F. Section 265100 - Interior Lighting.
- G. Section 265600 - Exterior Lighting.

1.03 REFERENCE STANDARDS

- A. ANSI C136.24 - American National Standard for Roadway and Area Lighting Equipment - Nonlocking (Button) Type Photocontrols.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NECA 130 - Standard for Installing and Maintaining Wiring Devices.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- E. NFPA 70 - National Electrical Code.
- F. UL 773A - Nonindustrial Photoelectric Switches for Lighting Control.
- G. UL 916 - Energy Management Equipment.
- H. UL 917 - Clock-Operated Switches.

1.04 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 Engineer of Record of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:

1. Do not install lighting control devices until final surface finishes and painting are complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Include ratings, configurations, standard wiring diagrams, dimensions, colors, service condition requirements, and installed features.
 1. Occupancy Sensors: Include detailed motion detection coverage range diagrams.
- C. Field Quality Control Reports.
- D. Manufacturer's Installation Instructions: Include application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Operation and Maintenance Data: Include detailed information on device programming and setup.
- F. Project Record Documents: Record actual installed locations and settings for lighting control devices.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Store products in a clean, dry space in original manufacturer's packaging in accordance with manufacturer's written instructions until ready for installation.

1.08 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for all occupancy sensors.
- C. Provide two year manufacturer warranty for all daylighting controls.

PART 2 PRODUCTS

2.01 LIGHTING CONTROL DEVICES - GENERAL REQUIREMENTS

- A. Provide products listed, classified, and labeled as suitable for the purpose intended.
- B. Unless specifically indicated to be excluded, provide all required conduit, wiring, connectors, hardware, components, accessories, etc. as required for a complete operating system.

2.02 OCCUPANCY SENSORS

- A. Manufacturers:
 - 1. Hubbell Incorporated; _____: www.hubbell.com/#sle.
 - 2. Lutron Electronics Company, Inc; _____: www.lutron.com/#sle.
 - 3. Sensor Switch Inc; _____: www.sensorswitch.com/#sle.
 - 4. WattStopper; _____: www.wattstopper.com/#sle.
 - 5. Source Limitations: Furnish products produced by a single manufacturer and obtained from a single supplier.
- B. 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. Sensor Technology:
 - a. Passive Infrared/Ultrasonic Dual Technology Occupancy Sensors: Designed to detect occupancy using a combination of both passive infrared and ultrasonic technologies.
 - 3. Provide LED to visually indicate motion detection with separate color LEDs for each sensor type in dual technology units.
 - 4. 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.
 - 5. Dual Technology Occupancy Sensors: Field configurable turn-on and hold-on activation with settings for activation by either or both sensing technologies.
 - 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. Load Rating for Line Voltage Occupancy Sensors: As required to control the load indicated on drawings.
- C. 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. Unless otherwise indicated or required to control the load indicated on drawings, provide line voltage units with self-contained relay.
 - c. 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.
 - d. Finish: Match finishes specified for wiring devices in Section 262726, unless otherwise indicated.
 2. Passive Infrared/Ultrasonic Dual Technology Wall Switch Occupancy Sensors: Capable of detecting motion within an area of 900 square feet.
- 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. Occupancy sensor to be field selectable as either manual-on/automatic-off or automatic on/off.
 - d. Finish: White unless otherwise indicated.
 2. Passive Infrared/Ultrasonic Dual Technology Ceiling Mounted Occupancy Sensors:
 - a. Standard Range Sensors: Capable of detecting motion within an area of 450 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
 - b. Extended Range Sensors: Capable of detecting motion within an area of 1,200 square feet at a mounting height of 9 feet, with a field of view of 360 degrees.
- 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.

2.03 OUTDOOR MOTION SENSORS

- A. Description: Factory-assembled wet location listed device suitable for wall or ceiling/eave mounting, with integral swivel for field adjustment of coverage, capable of detecting motion for automatic control of load indicated.
- B. Sensor Technology: Passive Infrared (PIR) designed to detect occupancy by sensing movement of thermal energy between zones.
- C. Operation: Unless otherwise indicated, motion sensor to turn load on when motion is detected and to turn load off when no motion is detected during an adjustable turn-off delay time interval.
- D. Turn-Off Delay: Field adjustable, with time delay settings available up to 15 minutes.
- E. Integral Photocell: For dusk to dawn operation.

- F. Manual Override: Activated by switching power off to unit and then back on.
- G. Load Rating: 1,000 W incandescent and fluorescent load at 120 V ac.
- H. Coverage: Capable of detecting motion within a distance of 50 feet at a mounting height of 8 feet, with a field of view of 270 degrees.

2.04 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: Four 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 indicated on the drawings.
 - 8. Output Switch Contact Ratings: As required to control the load indicated on drawings.
 - 9. Provide lockable enclosure; environmental type per NEMA 250 as specified for the following installation locations:

2.05 OUTDOOR PHOTO CONTROLS

- A. Stem-Mounted Outdoor Photo Controls:
 - 1. Description: Direct-wired photo control unit with threaded conduit mounting stem and field-adjustable swivel base, listed and labeled as complying with UL 773A.
 - 2. Housing: Weatherproof, impact resistant polycarbonate.
 - 3. Photo Sensor: Cadmium sulfide.
 - 4. Provide external sliding shield for field adjustment of light level activation.
 - 5. Light Level Activation: 1 to 5 footcandles turn-on and 3 to 1 turn-off to turn-on ratio with delayed turn-off.
 - 6. Voltage: As required to control the load indicated on the drawings.
 - 7. Failure Mode: Fails to the on position.
 - 8. Load Rating: As required to control the load indicated on the drawings.
 - 9. Provide accessory wall-mounting bracket where indicated or as required to complete installation.
- B. 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 DAYLIGHTING CONTROLS

- A. Manufacturers:
 1. Hubbell Control Solutions; _____: www.hubbell.com/hubbellcontrolsolutions/en/#sle. Hubbell Control Solutions; _____: www.hubbell.com/hubbellcontrolsolutions/en/#sle. Hubbell Control Solutions; _____: www.hubbell.com/hubbellcontrolsolutions/en/#sle.
 2. Lutron Electronics Company, Inc; _____: www.lutron.com/#sle.
 3. Sensor Switch Inc; _____: www.sensorswitch.com/#sle.
 4. WattStopper; _____: www.wattstopper.com/#sle.
- B. System Description: Control system consisting of photo sensors and compatible control modules and power packs, contactors, or relays as required for automatic control of load indicated according to available natural light; capable of integrating with occupancy sensors and manual override controls.
- C. Daylighting Control Photo Sensors: Low voltage class 2 photo sensor units with output signal proportional to the measured light level and provision for zero or offset based signal.
 1. Sensor Type: Filtered silicon photo diode.
 2. Sensor Range:
 - a. Indoor Photo Sensors: 5 to 100 footcandles.
 - b. Outdoor Photo Sensors: 5 to 250 footcandles.
 - c. Open Loop Photo Sensors: 3 to 6,000 footcandles.
 3. Finish: White unless otherwise indicated.
- D. Daylighting Control Switching Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors, for switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
 1. Operation: Unless otherwise indicated, load to be turned on when light level is below selected low set point and load to be turned off when light level is above selected high set point, with a no switching dead band between set points to prevent unwanted cycling.
 2. Input Delay: To prevent unwanted cycling due to intermittent light level fluctuations.
 3. Control Capability:
- E. Daylighting Control Dimming Modules for Low Voltage Sensors: Low voltage class 2 control unit compatible with specified photo sensors and with specified dimming ballasts, for both continuous dimming of compatible dimming ballasts and switching of compatible power packs, contactors, or relays in response to changes in measured light levels according to selected settings.
 1. Operation: Unless otherwise indicated, specified load to be continuously brightened as not enough daylight becomes available and continuously dimmed as enough daylight becomes available.
 2. Control Capability: Capable of controlling up to three separately programmable channels, with up to 50 ballasts per channel.
 3. Dimming and Fade Rates: Adjustable from 5 to 60 seconds.
 4. Cut-Off Delay: Selectable and adjustable from 0 to 20 minutes.

- F. Power Packs for Low Voltage Daylighting Control Modules:
 - 1. Description: Plenum rated, self-contained low voltage class 2 transformer and relay compatible with specified low voltage daylighting control modules for switching of line voltage loads. Provide quantity and configuration of power and slave packs with all associated wiring and accessories as required to control the load indicated on drawings.
 - 2. Input Supply Voltage: Dual rated for 120/277 V ac.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that openings for outlet boxes are neatly cut and will be completely covered by devices or wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to lighting control devices.
- F. Verify that the service voltage and ratings of lighting control devices are appropriate for the service voltage and load requirements at the location to be installed.
- G. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install lighting control devices in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of lighting control devices provided under this section.
- C. Install lighting control devices in accordance with manufacturer's instructions.
- D. Unless otherwise indicated, connect lighting control device grounding terminal or conductor to branch circuit equipment grounding conductor and to outlet box with bonding jumper.
- E. Install lighting control devices plumb and level, and held securely in place.
- F. Where required and not furnished with lighting control device, provide wall plate in accordance with Section 262726.
- G. Provide required supports in accordance with Section 260529.
- H. Where applicable, install lighting control devices and associated wall plates to fit completely flush to mounting surface with no gaps and rough opening completely covered without strain on wall plate. Repair or reinstall improperly installed outlet boxes or improperly sized rough openings. Do not use oversized wall plates in lieu of meeting this requirement.

- I. Occupancy Sensor Locations:
 - 1. Location Adjustments: Within the design intent, reasonably minor adjustments to locations may be made in order to optimize coverage and avoid conflicts or problems affecting coverage.
 - 2. Locate ultrasonic and dual technology passive infrared/ultrasonic occupancy sensors a minimum of 4 feet from air supply ducts or other sources of heavy air flow and as per manufacturer's recommendations, in order to minimize false triggers.
- J. 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.
- K. 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.
- L. Daylighting Control Photo Sensor Locations:
 - 1. Location Adjustments: Locations indicated are diagrammatic and only intended to indicate which rooms or areas require devices. Provide quantity and locations as required for proper control of respective room or area based on manufacturer's recommendations for installed devices.
 - 2. Unless otherwise indicated, locate photo sensors for closed loop systems to accurately measure the light level controlled at the designated task location, while minimizing the measured amount of direct light from natural or artificial sources such as windows or pendant luminaires.
 - 3. Unless otherwise indicated, locate photo sensors for open loop systems to accurately measure the level of daylight coming into the space, while minimizing the measured amount of lighting from artificial sources.
- M. Lamp Burn-In: Operate lamps at full output for minimum of 100 hours or prescribed period per manufacturer's recommendations prior to use with any dimming controls. Replace lamps that fail prematurely due to improper lamp burn-in.
- N. Unless otherwise indicated, install power packs for lighting control devices above accessible ceiling or above access panel in inaccessible ceiling near the sensor location.
- O. Unless otherwise indicated, install switches on load side of power packs so that switch does not turn off power pack.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each lighting control device for damage and defects.
- C. Test occupancy sensors to verify proper operation, including time delays and ambient light thresholds where applicable. Verify optimal coverage for entire room or area. Record test results in written report to be included with submittals.
- D. Test time switches to verify proper operation.
- E. Test outdoor photo controls to verify proper operation, including time delays where applicable.

- F. Test daylighting controls to verify proper operation, including light level measurements and time delays where applicable. Record test results in written report to be included with submittals.
- G. Correct wiring deficiencies and replace damaged or defective lighting control devices.

3.04 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.
- B. Adjust occupancy sensor settings to minimize undesired activations while optimizing energy savings, and to achieve desired function as indicated or as directed by Engineer of Record.
- C. Adjust position of directional occupancy sensors and outdoor motion sensors to achieve optimal coverage as required.
- D. Where indicated or as directed by Architect, install factory masking material or adjust integral blinders on passive infrared (PIR) and dual technology occupancy sensor lenses to block undesired motion detection.
- E. Adjust time switch settings to achieve desired operation schedule as indicated or as directed by Engineer of Record. Record settings in written report to be included with submittals.
- F. Adjust external sliding shields on outdoor photo controls under optimum lighting conditions to achieve desired turn-on and turn-off activation as indicated or as directed by Engineer of Record.
- G. Adjust daylighting controls under optimum lighting conditions after all room finishes, furniture, and window treatments have been installed to achieve desired operation as indicated or as directed by Architect. Record settings in written report to be included with submittals. Readjust controls calibrated prior to installation of final room finishes, furniture, and window treatments that do not function properly as determined by Engineer of Record.

3.05 COMMISSIONING

- A. See Section 019113 - General Commissioning Requirements for commissioning requirements.

3.06 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. Training: Train Owner's personnel on operation, adjustment, programming, and maintenance of lighting control devices.
 - 1. Use operation and maintenance manual as training reference, supplemented with additional training materials as required.
 - 2. Provide minimum of two hours of training.
 - 3. Instructor: Qualified contractor familiar with the project and with sufficient knowledge of the installed lighting control devices.
 - 4. Location: At project site.

END OF SECTION 260923

SECTION 262413 - 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 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 262300 - Low-Voltage Switchgear.
- F. Section 264300 - Surge Protective Devices.

1.03 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
- B. IEEE C57.13 - IEEE Standard Requirements for Instrument Transformers.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- D. NECA 400 - Standard for Installing and Maintaining Switchboards.
- E. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- F. NEMA PB 2 - Deadfront Distribution Switchboards.
- G. NEMA PB 2.1 - General Instructions for Proper Handling, Installation, Operation, and Maintenance of Deadfront Distribution Switchboards Rated 600 Volts or Less.
- H. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- I. NFPA 70 - National Electrical Code.
- J. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- K. UL 891 - Switchboards.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances 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. Coordinate with manufacturer to provide shipping splits suitable for the dimensional constraints of the installation.
 - 5. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for switchboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. 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.
- D. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- E. Field Quality Control Test Reports.
- F. Project Record Documents: Record actual installed locations of switchboards and final equipment settings.
- G. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.06 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.

1.07 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. Eaton Corporation; _____: www.eaton.com/#sle.
 - 2. Schneider Electric; Square D Products: www.schneider-electric.us/#sle.
 - 3. 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. Rear-Connected Switchboards:
 - 1. Arrangement: Rear accessible, front and rear aligned.
 - 2. Rear Access: Bolted covers.
- E. 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.
- F. Short Circuit Current Rating:
 - 1. Minimum Rating: 65,000 rms symmetrical amperes.
 - 2. Label equipment utilizing series ratings as required by NFPA 70.
- G. Selectivity: Where the requirement for selectivity is indicated, furnish products as required to achieve selective coordination.

- H. 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.
- I. 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: Copper.
 - 4. Ground Bus Material: Copper.
- J. 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.
- K. 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.
- L. Future Provisions:
 - 1. Prepare designated spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- M. 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.
- N. 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 where indicated.
 - b. 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.
 - c. Electronic Trip Circuit Breakers: Furnish solid state, microprocessor-based, true rms sensing trip units.
 - d. 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.
 - 2) Pad-Lock Provision: For locking circuit breaker handle in OFF position.
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 electrically operated circuit breakers where indicated.
 - c. Construction:
 - 1) Provide fixed-mount circuit breakers unless otherwise indicated.
 - d. Minimum Interrupting Capacity:
 - 1) 42,000 rms symmetrical amperes at 240 VAC or 208 VAC.
 - 2) 65,000 rms symmetrical amperes at 480 VAC.
 - e. Trip Units: Solid state, microprocessor-based, true rms sensing.
 - 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.

2.04 SOURCE QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. 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 260529.
- F. Install switchboards plumb and level.
- G. Unless otherwise indicated, mount switchboards on properly sized 4 inch high concrete pad constructed in accordance with Section 033000.
- H. Provide grounding and bonding in accordance with Section 260526.
- 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. Provide filler plates to cover unused spaces in switchboards.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Before energizing switchboard, perform insulation resistance testing in accordance with NECA 400 and NEMA PB 2.1.
- C. Inspect and test in accordance with NETA ATS, except Section 4.
- D. Perform inspections and tests listed in NETA ATS, Section 7.1.
- E. 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.
- F. 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.
- G. Test shunt trips to verify proper operation.

- H. 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. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. 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. Location: At project site.

3.07 PROTECTION

- A. Protect installed switchboards from subsequent construction operations.

END OF SECTION 262413

SECTION 262416 - PANELBOARDS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Power distribution panelboards.
- B. Lighting and appliance panelboards.
- C. Load centers.
- D. Overcurrent protective devices for panelboards.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete: Concrete equipment pads.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260529 - Hangers and Supports for Electrical Systems.
- D. Section 260548 - Vibration and Seismic Controls for Electrical Systems.
 - 1. Includes requirements for the seismic qualification of equipment specified in this section.
- E. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- F. Section 260573 - Power System Studies: Additional criteria for the selection and adjustment of equipment and associated protective devices specified in this section.
- G. Section 264300 - Surge Protective Devices.

1.03 REFERENCE STANDARDS

- A. FS W-C-375 - Circuit Breakers, Molded Case; Branch Circuit and Service.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NECA 407 - Standard for Installing and Maintaining Panelboards.
- D. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- E. NEMA PB 1 - Panelboards.
- F. NEMA PB 1.1 - General Instructions for Proper Installation, Operation and Maintenance of Panelboards Rated 600 Volts or Less.
- G. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- H. NFPA 70 - National Electrical Code.
- I. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.

- J. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- K. UL 67 - Panelboards.
- L. UL 489 - Molded-Case Circuit Breakers, Molded-Case Switches and Circuit Breaker Enclosures.
- M. UL 943 - Ground-Fault Circuit-Interrupters.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other trades to avoid placement of ductwork, piping, equipment, or other potential obstructions within the dedicated equipment spaces and working clearances for electrical equipment required by NFPA 70.
 - 2. Coordinate arrangement of electrical equipment with the dimensions and clearance requirements of the actual equipment to be installed.
 - 3. Coordinate the work with other trades to provide walls suitable for installation of flush-mounted panelboards where indicated.
 - 4. Verify with manufacturer that conductor terminations are suitable for use with the conductors to be installed.
 - 5. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for panelboards, enclosures, overcurrent protective devices, and other installed components and accessories.
- C. Shop Drawings: Indicate outline and support point dimensions, voltage, main bus ampacity, overcurrent protective device arrangement and sizes, short circuit current ratings, conduit entry locations, conductor terminal information, and installed features and accessories.
 - 1. Identify mounting conditions required for equipment seismic qualification.
- D. Manufacturer's equipment seismic qualification certification.
- E. Project Record Documents: Record actual installed locations of panelboards and actual installed circuiting arrangements.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store panelboards in accordance with manufacturer's instructions and NECA 407.
- B. Store in a clean, dry space. Maintain factory wrapping or provide an additional heavy canvas or heavy plastic cover to protect units from dirt, water, construction debris, and traffic.

- C. Handle carefully in accordance with manufacturer's written instructions to avoid damage to panelboard internal components, enclosure, and finish.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. ABB/GE; _____: www.electrification.us.abb.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. Seismic Qualification: Provide panelboards and associated components suitable for application under the seismic design criteria specified in Section 260548 where required. Include certification of compliance with submittals.
- C. Unless otherwise indicated, provide products suitable for continuous operation under the following service conditions:
 - 1. Altitude: Less than 1000 ft.
 - 2. Ambient Temperature:
 - a. Panelboards Containing Circuit Breakers: Between 23 degrees F and 104 degrees F.
- D. 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 260573.
- E. Mains: Configure for top or bottom incoming feed as indicated or as required for the installation.
- F. Branch Overcurrent Protective Devices: Replaceable without disturbing adjacent devices.
- G. 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.
- H. Conductor Terminations: Suitable for use with the conductors to be installed.
- I. 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.
- 2. Boxes: Galvanized steel unless otherwise indicated.
 - a. Provide wiring gutters sized to accommodate the conductors to be installed.
- 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.
- 4. Lockable Doors: All locks keyed alike unless otherwise indicated.
- J. Future Provisions: Prepare all unused spaces for future installation of devices including bussing, connectors, mounting hardware and all other required provisions.
- K. Surge Protective Devices: Where factory-installed, internally mounted surge protective devices are provided in accordance with Section 264300, list and label panelboards as a complete assembly including surge protective device.
- L. Load centers are not acceptable.

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: Copper.
 - 2. Ground Bus Material: Copper.
- D. Circuit Breakers:
 - 1. Provide bolt-on type or plug-in type secured with locking mechanical restraints.
- E. Enclosures:
 - 1. Provide surface-mounted enclosures unless otherwise indicated.
 - 2. Fronts: Provide lockable hinged door with concealed hinges for access to overcurrent protective device handles without exposing live parts.
 - 3. Provide clear plastic circuit directory holder mounted on inside of door.

2.04 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. 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:
 - b. Fully Rated Systems: Provide circuit breakers with interrupting capacity not less than the short circuit current rating indicated.
 - 3. Conductor Terminations:
 - a. 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.
 - 5. Multi-Pole Circuit Breakers: Furnish with common trip for all poles.
 - 6. 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.
 - 7. 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.

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 260529.
- F. Install panelboards plumb.
- G. Install flush-mounted panelboards so that trims fit completely flush to wall with no gaps and rough opening completely covered.
- H. Mount panelboards such that the highest position of any operating handle for circuit breakers or switches does not exceed 79 inches above the floor or working platform.
- I. Provide minimum of six spare 1 inch trade size conduits out of each flush-mounted panelboard stubbed into accessible space above ceiling and below floor.
- J. Provide grounding and bonding in accordance with Section 260526.
- K. Install all field-installed branch devices, components, and accessories.
- L. Provide filler plates to cover unused spaces in panelboards.
- M. Provide circuit breaker lock-on devices to prevent unauthorized personnel from de-energizing essential loads where indicated. Also provide for the following:
 - 1. Emergency and night lighting circuits.
 - 2. Fire detection and alarm circuits.
- N. Identify panelboards in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect and test in accordance with NETA ATS, except Section 4.
- C. Molded Case Circuit Breakers: Perform inspections and tests listed in NETA ATS, Section 7.6.1.1 for all main circuit breakers and circuit breakers larger than _____ amperes. Tests listed as optional are not required.
- D. Test GFCI circuit breakers to verify proper operation.

- E. Test shunt trips to verify proper operation.
- F. Correct deficiencies and replace damaged or defective panelboards or associated components.

3.04 ADJUSTING

- A. Adjust tightness of mechanical and electrical connections to manufacturer's recommended torque settings.
- B. Adjust alignment of panelboard fronts.
- C. Load Balancing: For each panelboard, rearrange circuits such that the difference between each measured steady state phase load does not exceed 20 percent and adjust circuit directories accordingly. Maintain proper phasing for multi-wire branch circuits.

3.05 CLEANING

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

END OF SECTION 262416

SECTION 262416 – POWER DISTRIBUTION PANELBOARDS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:

1. Power Distribution Panelboard - Furnish and install distribution panelboard(s) as specified herein and where shown on the associated schedules

1.2 DEFINITIONS :

The panelboard(s) and circuit breaker(s) referenced herein are designed and manufactured according to the latest revision of the following specifications.

- A. NEMA PB 1 - Panelboards
- B. NEMA PB 1.1 - Instructions for Safe Installation, Operation and Maintenance of Panel boards Rated 600 Volts or Less.
- C. NEMA AB 1 - Molded Case Circuit Breakers
- D. UL 50 - Enclosures for Electrical Equipment
- E. UL 67 - Panelboards
- F. UL 489 - Molded-Case Circuit Breakers and Circuit Breaker Enclosures
- G. CSA Standard C22.2 No. 29-M1989 - Panelboards and Enclosed Panelboards
- H. CSA Standard C22.2 No. 5-M91 - Molded Case Circuit Breakers
- I. Federal Specification W-P-115C - Type I Class 1
- J. Federal Specification W-C-375B/Gen - Circuit Breakers, Molded Case, Branch Circuit And Service.
- K. Federal Specification W-C-865C - Fusible Switches
- L. NFPA 70 - National Electrical Code (NEC)
- M. ASTM - American Society of Testing Materials
- N. IBC – International Building Code – Seismic compliance requirements
- O. NFPA 5000 – NFPA Building Code – Seismic compliance requirements
- P. ASCE 7 – American Society of Civil Engineers, Minimum Design Loads for Buildings and

Q. SPD: Surge protective device.

1.3 ACTION SUBMITTALS

A. Product Data: For each type of panelboard.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details.
2. Detail enclosure types including mounting and anchorage, environmental protection, knockouts, corner treatments, covers and doors, gaskets, hinges, and locks.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Include evidence of NRTL listing for series rating of installed devices.
6. Include evidence of NRTL listing for SPD as installed in panelboard.
7. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
8. Include wiring diagrams for power, signal, and control wiring.
9. Key interlock scheme drawing and sequence of operations.
10. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards.

1.4 INFORMATIONAL SUBMITTALS

A. Panelboard schedules for installation in panelboards.

1.5 CLOSEOUT SUBMITTALS

A. Operation and maintenance data.

1.6 FIELD CONDITIONS

A. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet.

1.7 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboards that fail in materials or workmanship within specified warranty period.

1. Panelboard Warranty Period: 12 months from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 PANELBOARDS COMMON REQUIREMENTS

- A. Shall be Square D Company I-LINE – Class 2110
- B. Substitutions must be submitted in writing three weeks prior to original bid date with supporting documentation demonstrating that the alternate manufacturer meets all aspects of the specification herein.

2.2 POWER DISTRIBUTION PANELBOARDS

A. I-LINE Circuit Breaker Distribution Panelboard

- 1. Interior
 - a. Shall be Square D I-LINE type rated 600 Vac or 250 Vdc maximum. Continuous main current ratings as indicated on associated schedules not to exceed 1200 amperes maximum. Panelboard bus current ratings shall be determined by heat-rise tests conducted in accordance with UL 67.
 - b. Provide UL Listed short circuit current ratings (SCCR) as indicated on the associated schedules not to exceed the lowest interrupting capacity rating of any circuit breaker installed with a maximum of 200,000 RMS symmetrical amperes. Main lug and main breaker panelboards shall be suitable for use as Service Equipment when application requirements comply with UL 67 and NEC Articles 230.VI and VII.
 - c. The panelboard interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.
 - d. The bussing shall be fully rated with sequentially phased branch distribution. Panelboard bussing rated 100 through 600 amperes shall be plated copper. Bus bar plating shall run the entire length of the bus bar. The entire interleaved assembly shall be contained between two (2) U-shaped steel channels, permanently secured to a galvanized steel-mounting pan by fasteners.
 - e. Interior trim shall be of dead-front construction to shield user from all energized parts. Main circuit breaker and main lug interiors shall be field convertible for top or bottom incoming feed.
 - f. A solidly bonded copper equipment ground bar shall be provided.
 - g. Solid neutral shall be equipped with a full capacity bonding strap for service entrance applications. UL Listed panelboards with 200% rated solid neutrals shall have plated copper neutral bus for non-linear load applications. Gutter-mounted neutral will not be acceptable.
 - h. Nameplates shall contain system information and catalog number or factory order number. Interior wiring diagram, neutral wiring diagram, UL Listed label, and Short Circuit Current Rating shall be displayed on the interior or in a booklet format. Leveling provisions shall be provided for flush mounted applications. Circuit breaker(s) shall be group mounted plug-on with mechanical restraint on a common pan or rail assembly.
 - i. The interior shall have three flat bus bars stacked and aligned vertically with glass reinforced polyester insulators laminated between phases. The molded polyester insulators shall support and provide phase isolation to the entire length of bus.

- j. Circuit breakers equipped with line terminal jaws shall not require additional external mounting hardware. Circuit breakers shall be held in mounted position by a self-contained bracket secured to the mounting pan by fasteners. Circuit breakers of different frame sizes shall be capable of being mounted across from each other.
- k. Line-side circuit breaker connections are to be jaw type. All unused spaces provided, unless otherwise specified, shall be fully equipped for future devices, including all appropriate connectors and mounting hardware.

B. Molded Case Circuit Breakers

- a. Circuit breakers shall be constructed using glass reinforced insulating material. Current carrying components shall be completely isolated from the handle and the accessory mounting area.
- b. Circuit breakers shall have an over center, trip free, toggle operating mechanism which will provide quick-make, quick-break contact action. The circuit breaker shall have common tripping of all poles.
- c. The circuit breaker handle shall reside in a tripped position between ON and OFF to provide local trip indication. Circuit breaker escutcheon shall be clearly marked ON and OFF in addition to providing International I/O markings.
- d. The maximum ampere rating and UL certification standard with applicable voltage systems and corresponding interrupting ratings shall be clearly marked on face of circuit breaker.
- e. Each circuit breaker shall be equipped with a push-to-trip button, located on the face of the circuit breaker to mechanically operate the circuit breaker tripping mechanism for maintenance and testing purposes.
- f. Circuit breakers shall be factory sealed with a hologram quality mark and shall have date code on face of circuit breaker.
- g. Circuit breakers shall be equipped with UL Listed electrical accessories as noted on the associated [schedule], [drawing] or they may be field-installable.
- h. Circuit breaker handle accessories shall provide provisions for locking handle in the ON and OFF position.
- i. All circuit breakers with permanent trip units shall be UL Listed for reverse connection without restrictive line and load markings and be suitable for mounting in any position.
- j. Circuit breakers shall be I-LINE - up to 1200 Amp maximum construction with factory installed mechanical lugs. All circuit breakers shall be UL Listed to accept field installable/removable [mechanical type] lugs (except type QB/QD/QG/QJ). All lugs shall be UL Listed to accept solid (not larger than #8 AWG) and/or stranded copper conductors only]. Lugs shall be suitable for 60° C rated wire - on 125 A circuit breakers and below 75° C rated wire or 90° C rated wire, sized according to the 75° C temperature rating in the National Electrical Code.

C. Electronic Trip Breakers

- 1. Electronic Trip Circuit Breakers for all breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Digital display of settings, trip targets, and indicated metering displays.
 - d. Multi-button keypad to access programmable functions and monitored data.

- e. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - f. Integral test jack for connection to portable test set or laptop computer.
 - g. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.
- D. 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.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.
- G. Enclosures: Surface mounted, dead-front cabinets.
 - 1. Rated for environmental conditions at installed location.
 - a. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Height: 84 inches (2.13 m) maximum.
 - 3. Front: Secured to box with concealed trim clamps. For surface-mounted fronts, match box dimensions; for flush-mounted fronts, overlap box. Trims shall cover all live parts and shall have no exposed hardware.
 - 4. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover. Trims shall cover all live parts and shall have no exposed hardware.
- H. NRTL Label: Panelboards shall be labeled by an NRTL acceptable to authority having jurisdiction for use as service equipment with one or more main service disconnecting and overcurrent protective devices. Panelboards shall have meter enclosures, wiring, connections, and other provisions for utility metering. Coordinate with utility company for exact requirements.
- I. Future Devices: Panelboards shall have mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- J. Panelboard Short-Circuit Current Rating: Rated for series-connected system with integral or remote upstream overcurrent protective devices and labeled by an NRTL. Include label or manual with size and type of allowable upstream and branch devices listed and labeled by an NRTL for series-connected short-circuit rating.
- K. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals. Assembly listed by an NRTL for 100 percent interrupting capacity.

2.3 Performance Requirements

- A. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD .

- B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
 - 1. Fuses and Spare-Fuse Cabinet: Comply with requirements specified in Section 262813 "Fuses."

2.4 Identification

- A. Panelboard Label: Manufacturer's name and trademark, voltage, amperage, number of phases, and number of poles shall be located on the interior of the panelboard door.
- B. Breaker Labels: Faceplate shall list current rating, UL and IEC certification standards, and AIC rating.
- C. Circuit Directory: Directory card inside panelboard door, mounted in transparent card holder metal frame with transparent protective cover.

2.5 Accessory Components and Features

- A. Portable Test Set: For testing functions of solid-state trip devices without removing from panelboard. Include relay and meter test plugs suitable for testing panelboard meters and switchboard class relays.

PART 3 - EXECUTION

3.1 Installation

- A. Comply with NECA 1.
- B. Install panelboards and accessories according to NECA 407.
- C. Comply with mounting and anchoring requirements specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- D. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- E. Mount panelboard cabinet plumb and rigid without distortion of box.
- F. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- G. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- H. Make grounding connections and bond neutral for services and separately derived systems to ground. Make connections to grounding electrodes, separate grounds for isolated ground bars, and connections to separate ground bars.

- I. Install filler plates in unused spaces.
- J. Arrange conductors in gutters into groups and bundle and wrap with wire ties.

3.2 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Handwritten directories are not acceptable. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in power panelboards with a nameplate complying with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- E. Install warning signs complying with requirements in Section 260553 "Identification for Electrical Systems" identifying source of remote circuit.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- C. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test for low-voltage air circuit breakers stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- D. Panelboards will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results, with comparisons of the two scans. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

END OF SECTION 262416

SECTION 262726 - WIRING DEVICES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Wall switches.
- B. Receptacles.
- C. Wall plates.

1.02 RELATED REQUIREMENTS

- A. Section 260519 - Low-Voltage Electrical Power Conductors and Cables: Manufactured wiring systems for use with access floor boxes with compatible pre-wired connectors.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260533.16 - Boxes for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 260923 - Lighting Control Devices: Devices for automatic control of lighting, including occupancy sensors, in-wall time switches, and in-wall interval timers.

1.03 REFERENCE STANDARDS

- A. FS W-C-596 - Connector, Electrical, Power, General Specification for.
- B. FS W-S-896 - Switches, Toggle (Toggle and Lock), Flush Mounted (General Specification).
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- D. NECA 130 - Standard for Installing and Maintaining Wiring Devices.
- E. NEMA WD 1 - General Color Requirements for Wiring Devices.
- F. NEMA WD 6 - Wiring Devices - Dimensional Specifications.
- G. NFPA 70 - National Electrical Code.
- H. UL 20 - General-Use Snap Switches.
- I. UL 498 - Attachment Plugs and Receptacles.
- J. UL 514D - Cover Plates for Flush-Mounted Wiring Devices.
- K. UL 943 - Ground-Fault Circuit-Interruptioners.
- L. UL 1310 - Class 2 Power Units.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Coordinate the placement of outlet boxes with millwork, furniture, equipment, etc. installed under other sections or by others.
2. Coordinate wiring device ratings and configurations with the electrical requirements of actual equipment to be installed.
3. Coordinate the placement of outlet boxes for wall switches with actual installed door swings.
4. Coordinate the installation and preparation of uneven surfaces, such as split face block, to provide suitable surface for installation of wiring devices.
5. Notify Engineer of Record of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

B. Sequencing:

1. Do not install wiring devices until final surface finishes and painting are complete.

1.05 SUBMITTALS

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

B. Product Data: Provide manufacturer's catalog information showing dimensions, colors, and configurations.

C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.

D. Operation and Maintenance Data:

1. Wall Dimmers: Include information on operation and setting of presets.
2. GFCI Receptacles: Include information on status indicators.

E. Project Record Documents: Record actual installed locations of wiring devices.

F. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.

1. See Section 016000 - Product Requirements, for additional provisions.
2. Extra Wall Plates: Two of each style, size, and finish.

1.06 QUALITY ASSURANCE

A. Comply with requirements of NFPA 70.

B. Products: Listed, classified, and labeled as suitable for the purpose intended.

1.07 DELIVERY, STORAGE, AND PROTECTION

A. Store in a clean, dry space in original manufacturer's packaging until ready for installation.

PART 2 PRODUCTS

2.01 WIRING DEVICE APPLICATIONS

- A. Provide wiring devices suitable for intended use and with ratings adequate for load served.
- B. For single receptacles installed on an individual branch circuit, provide receptacle with ampere rating not less than that of the branch circuit.
- C. Provide weather resistant GFCI receptacles with specified weatherproof covers for receptacles installed outdoors or in damp or wet locations.
- D. Provide GFCI protection for receptacles installed within 6 feet of sinks.
- E. Provide GFCI protection for receptacles serving electric drinking fountains.
- F. Unless noted otherwise, do not use combination switch/receptacle devices.

2.02 WIRING DEVICE FINISHES

- A. Provide wiring device finishes as described below unless otherwise indicated.
- B. Wiring Devices, Unless Otherwise Indicated: White with white nylon wall plate.
- C. Wiring Devices Installed in Finished Spaces: White with white nylon wall plate.
- D. Wiring Devices Installed in Unfinished Spaces: Gray with stainless steel wall plate.
- E. Wiring Devices Installed in Wet or Damp Locations: Gray with specified weatherproof cover.
- F. Wiring Devices Installed in mechanical/electrical and similar rooms: Gray with _____ stainless steel wall plate.

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 and screw actuated binding clamp for back wiring with separate ground terminal screw.
- C. Standard Wall Switches: Industrial specification grade, 20 A, 120/277 V with standard toggle type switch actuator and maintained contacts; single pole single throw, double pole single throw, three way, or four way as indicated on the drawings.
- D. 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 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.
 4. Source Limitations: Where wall controls are furnished as part of lighting control system, provide accessory matching receptacles and wallplates by the same manufacturer in locations indicated.
- B. Receptacles - General Requirements: Self-grounding, complying with NEMA WD 1 and NEMA WD 6, and listed as complying with UL 498, and where applicable, FS W-C-596; types as indicated on the drawings.
1. Wiring Provisions: Terminal screws for side wiring or screw actuated binding clamp for back wiring with separate ground terminal screw.
 2. NEMA configurations specified are according to NEMA WD 6.
- C. Convenience Receptacles:
1. Standard Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R; single or duplex as indicated on the drawings.
 2. Weather Resistant Convenience Receptacles: Industrial 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: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type; single or duplex as indicated on the drawings.
 4. Tamper Resistant and Weather Resistant Convenience Receptacles: Industrial specification grade, 20A, 125V, NEMA 5-20R, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations; single or duplex as indicated on the drawings.
- D. GFCI Receptacles:
1. GFCI Receptacles - General Requirements: Self-testing, with feed-through protection and light to indicate ground fault tripped condition and loss of protection; listed as complying with UL 943, class A.
 - a. Provide test and reset buttons of same color as device.
 2. Standard GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style.
 3. Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.
 4. Tamper Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as tamper resistant type.
 5. Tamper Resistant and Weather Resistant GFCI Receptacles: Industrial specification grade, duplex, 20A, 125V, NEMA 5-20R, rectangular decorator style, listed and labeled as tamper resistant type and as weather resistant type complying with UL 498 Supplement SE suitable for installation in damp or wet locations.
- E. USB Charging Devices:
1. USB Charging Devices - General Requirements: Listed as complying with UL 1310.
 - a. Charging Capacity - Two-Port Devices: 2.1 A, minimum.
 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.

2.05 WALL PLATES

- A. Manufacturers:
 - 1. Hubbell Incorporated; _____: www.hubbell-wiring.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.
 - 4. Source Limitations: Where wall controls are furnished as part of lighting control system, provide accessory matching receptacles and wallplates by the same manufacturer in locations indicated.
- B. Wall Plates: Comply with UL 514D.
 - 1. Configuration: One piece cover as required for quantity and types of corresponding wiring devices.
 - 2. Size: Standard; _____.
 - 3. Screws: Metal with slotted heads finished to match wall plate finish.
- C. Nylon Wall Plates: Smooth finish, high-impact thermoplastic.
- D. Stainless Steel Wall Plates: Brushed satin finish, Type 302 stainless steel.
- E. Weatherproof Covers for Damp Locations: Gasketed, thermoplastic, with self-closing hinged cover and corrosion-resistant screws; listed as suitable for use in wet locations with cover closed.
- F. Weatherproof Covers for Wet Locations: Gasketed, thermoplastic, with hinged lockable cover and corrosion-resistant screws; listed as suitable for use in wet locations while in use with attachment plugs connected and identified as extra-duty type.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate devices and conductors in accordance with NFPA 70.
- C. Verify that wall openings are neatly cut and will be completely covered by wall plates.
- D. Verify that final surface finishes are complete, including painting.
- E. Verify that branch circuit wiring installation is completed, tested, and ready for connection to wiring devices.
- F. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION

- A. Perform work in accordance with NECA 1 (general workmanship) and, where applicable, NECA 130, including mounting heights specified in those standards unless otherwise indicated.
- B. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of wiring devices provided under this section.
 - 1. Mounting Heights: Unless otherwise indicated, as follows:
 - a. Wall Switches: 48 inches above finished floor.
 - b. Receptacles: 18 inches above finished floor or 12 inches above counter.
 - c. Receptacles in mechanical/electrical and similar rooms 36 inches above finished floor.
 - 2. Orient outlet boxes for vertical installation of wiring devices unless otherwise indicated.
 - 3. 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.
 - 4. 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 Engineer of Record to obtain direction prior to proceeding with work.
 - 5. 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 vertically mounted receptacles with grounding pole on top and horizontally mounted receptacles with grounding pole on left.
- L. 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.
- M. Install blank wall plates on junction boxes and on outlet boxes with no wiring devices installed or designated for future use.

- N. Identify wiring devices in accordance with Section 260553.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Inspect each wiring device for damage and defects.
- C. Operate each wall switch, wall dimmer, and fan speed controller with circuit energized to verify proper operation.
- D. Test each receptacle to verify operation and proper polarity.
- E. Test each GFCI receptacle for proper tripping operation according to manufacturer's instructions.
- F. Correct wiring deficiencies and replace damaged or defective wiring devices.

3.05 ADJUSTING

- A. Adjust devices and wall plates to be flush and level.

3.06 CLEANING

- A. Clean exposed surfaces to remove dirt, paint, or other foreign material and restore to match original factory finish.

END OF SECTION 262726

SECTION 262816.16 - ENCLOSED SWITCHES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Enclosed safety switches.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 262813 - Fuses.
- E. Section 263600 - Transfer Switches: Automatic and non-automatic switches listed for use as transfer switch equipment.

1.03 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B. NEMA 250 - Enclosures for Electrical Equipment (1000 Volts Maximum).
- C. NEMA KS 1 - Heavy Duty Enclosed and Dead-Front Switches (600 Volts Maximum).
- D. NETA ATS - Acceptance Testing Specifications for Electrical Power Equipment and Systems.
- E. NFPA 70 - National Electrical Code.
- F. UL 50 - Enclosures for Electrical Equipment, Non-Environmental Considerations.
- G. UL 50E - Enclosures for Electrical Equipment, Environmental Considerations.
- H. UL 98 - Enclosed and Dead-Front Switches.
- I. UL 869A - Reference Standard for Service Equipment.

1.04 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 Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for enclosed switches and other installed components and accessories.
- C. 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.
- D. Project Record Documents: Record actual locations of enclosed switches.
- E. Maintenance Data: Include information on replacement parts and recommended maintenance procedures and intervals.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.

1.07 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. Eaton Corporation; _____: www.eaton.com/#sle.
- B. Schneider Electric; Square D Products; _____: www.schneider-electric.us/#sle.
- C. Siemens Industry, Inc; _____: www.usa.siemens.com/#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, Class L, or Class T 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 solidly bonded equipment ground bus in each enclosed safety switch, with a suitable lug for terminating each equipment grounding conductor.
- L. 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.
- M. Provide safety interlock to prevent opening the cover with the switch in the ON position with capability of overriding interlock for testing purposes.
- N. 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.
 - a. Provide means for locking handle in the ON position where indicated.
- O. Provide the following features and accessories where indicated or where required to complete installation:

1. Hubs: As required for environment type; sized to accept conduits to be installed.

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 260529.
- 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 260526.
- H. Provide fuses complying with Section 262813 for fusible switches as indicated or as required by equipment manufacturer's recommendations.
- I. Identify enclosed switches in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - 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 7.5.1.1.
- D. 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 262816.16

SECTION 263213 - ENGINE GENERATORS

PART 2 PRODUCTS

1.01 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).
- D. Packaged Engine Generator Set:
 - 1. Type: Diesel (compression ignition).
 - 2. Power Rating: _____ kW, standby.
 - 3. 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.
- 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.

1.02 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.
- 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.
- 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.
- 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.

1.03 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.
 - 3. Voltage Regulation (with PMG excitation): Plus/minus 0.5 percent for any constant load from no load to full load.
- 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.

1.04 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).
 - 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.

END OF SECTION 263213

SECTION 263600 - TRANSFER SWITCHES

PART 2 PRODUCTS

1.01 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. Construction Type: Either "contactor type" (open contact) or "breaker type" (enclosed contact) transfer switches complying with specified requirements are acceptable.
- D. 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).
- E. Do not use double throw safety switches or other equipment not specifically designed for power transfer applications and listed as transfer switch equipment.
- F. 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.
- G. Switching Methods:
 - 1. Obtain control power for transfer operation from line side of source to which the load is to be transferred.
- H. Service Conditions: Provide transfer switches suitable for continuous operation at indicated ratings under the service conditions at the installed location.
- I. Enclosures:
 - 1. Environment Type per NEMA 250: Unless otherwise indicated, as specified for the following installation locations:
 - 2. Finish: Manufacturer's standard unless otherwise indicated.
- J. Short Circuit Current Rating:

END OF SECTION 263600

SECTION 264300 - SURGE PROTECTIVE DEVICES

PART 2 PRODUCTS

1.01 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:
- E. UL 1449 Voltage Protection Ratings (VPRs):
- 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:

END OF SECTION 264300

SECTION 265100 - INTERIOR LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Interior luminaires.
- B. Emergency lighting units.
- C. Exit signs.
- D. Ballasts and drivers.
- E. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260529 - Hangers and Supports for Electrical Systems.
- B. Section 260533.16 - Boxes for Electrical Systems.
- C. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- D. Section 260923 - Lighting Control Devices.
- E. Section 262726 - Wiring Devices: Manual wall switches and wall dimmers.
- F. Section 265600 - Exterior Lighting.

1.03 REFERENCE STANDARDS

- A. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
- B. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- D. NECA/IESNA 500 - Standard for Installing Indoor Lighting Systems.
- E. NECA/IESNA 502 - Standard for Installing Industrial Lighting Systems.
- F. NEMA LE 4 - Recessed Luminaires, Ceiling Compatibility.
- G. NFPA 70 - National Electrical Code.
- H. NFPA 101 - Life Safety Code.
- I. UL 924 - Emergency Lighting and Power Equipment.
- J. UL 1598 - Luminaires.

- K. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the installation of luminaires with mounting surfaces installed under other sections or by others. Coordinate the work with placement of supports, anchors, etc. required for mounting. Coordinate compatibility of luminaires and associated trims with mounting surfaces at installed locations.
 - 2. Coordinate the placement of luminaires with structural members, ductwork, piping, equipment, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 - 3. Coordinate the placement of exit signs with furniture, equipment, signage or other potential obstructions to visibility installed under other sections or by others.
 - 4. Notify Engineer of Record of any conflicts or deviations from Contract Documents to obtain direction prior to proceeding with work.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets including detailed information on luminaire construction, dimensions, ratings, finishes, mounting requirements, listings, service conditions, photometric performance, installed accessories, and ceiling compatibility; include model number nomenclature clearly marked with all proposed features.
 - 1. LED Luminaires:
 - a. Include estimated useful life, calculated based on IES LM-80 test data.
 - b. Include IES LM-79 test report upon request.
- C. Manufacturer's Installation Instructions: Indicate application conditions and limitations of use stipulated by product testing agency. Include instructions for storage, handling, protection, examination, preparation, and installation of product.
- D. Operation and Maintenance Data: Instructions for each product including information on replacement parts.
- E. Project Record Documents: Record actual connections and locations of luminaires and any associated remote components.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- C. Product Listing Organization Qualifications: An organization recognized by OSHA as a Nationally Recognized Testing Laboratory (NRTL) and acceptable to authorities having jurisdiction.

1.07 DELIVERY, STORAGE, AND PROTECTION

- A. Receive, handle, and store products according to NECA/IESNA 500 (commercial lighting), NECA/IESNA 502 (industrial lighting), and manufacturer's written instructions.
- B. Keep products in original manufacturer's packaging and protect from damage until ready for installation.

1.08 FIELD CONDITIONS

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

1.09 WARRANTY

- A. See Section 017800 - Closeout Submittals, for additional warranty requirements.
- B. Provide five year manufacturer warranty for LED luminaires, including drivers.

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.
- H. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.
- I. Luminaires Mounted in Continuous Rows: Provide quantity of units required for length indicated, with all accessories required for joining and aligning.

2.03 EMERGENCY LIGHTING UNITS

- A. Description: Emergency lighting units complying with NFPA 101 and all applicable state and local codes, and listed and labeled as complying with UL 924.
- B. Operation: Upon interruption of normal power source or brownout condition exceeding 20 percent voltage drop from nominal, solid-state control automatically switches connected lamps to integral battery power for minimum of 90 minutes of rated emergency illumination, and automatically recharges battery upon restoration of normal power source.
- C. Battery:
 - 1. Size battery to supply all connected lamps, including emergency remote heads where indicated.
- D. Diagnostics: Provide power status indicator light and accessible integral test switch to manually activate emergency operation.
- E. Provide low-voltage disconnect to prevent battery damage from deep discharge.
- F. Self-Diagnostics: Provide units that self-monitor functionality and automatically perform testing required by NFPA 101 where indicated; provide indicator light(s) to report test and diagnostic status.
- G. Where indicated, provide units with integral time delay to maintain emergency illumination for 15 minutes after restoration of normal power source.
- H. Accessories:
 - 1. Provide compatible accessory mounting brackets where indicated or required to complete installation.
 - 2. Where indicated, provide emergency remote heads that are compatible with the emergency lighting unit they are connected to and suitable for the installed location.

2.04 EXIT SIGNS

- A. Description: Exit signs complying with NFPA 101 and applicable state and local codes, and listed and labeled as complying with UL 924.
 - 1. Number of Faces: Single- or double-face as indicated or as required for installed location.
 - 2. Directional Arrows: As indicated or as required for installed location.

2.05 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.
- B. Dimmable LED Drivers:
 - 1. Dimming Range: Continuous dimming from 100 percent to one percent relative light output unless dimming capability to lower level is indicated, without flicker.
 - 2. Control Compatibility: Fully compatible with the dimming controls to be installed.
 - a. Wall Dimmers: See Section 262726.

- b. Daylighting Controls: See Section 260923.

2.06 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that outlet boxes are installed in proper locations and at proper mounting heights and are properly sized to accommodate conductors in accordance with NFPA 70.
- C. Verify that suitable support frames are installed where required.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to luminaires.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 PREPARATION

- A. Provide extension rings to bring outlet boxes flush with finished surface.
- B. Clean dirt, debris, plaster, and other foreign materials from outlet boxes.

3.03 INSTALLATION

- A. Coordinate locations of outlet boxes provided under Section 260533.16 as required for installation of luminaires provided under this section.
- B. Perform work in accordance with NECA 1 (general workmanship).
- C. Install products in accordance with manufacturer's instructions.
- D. Install luminaires securely, in a neat and workmanlike manner, as specified in NECA 500 (commercial lighting) and NECA 502 (industrial lighting).
- E. Provide required support and attachment in accordance with Section 260529.
- F. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- G. Suspended Ceiling Mounted Luminaires:
 - 1. Do not use ceiling tiles to bear weight of luminaires.
 - 2. Do not use ceiling support system to bear weight of luminaires unless ceiling support system is certified as suitable to do so.

3. Secure surface-mounted and recessed luminaires to ceiling support channels or framing members or to building structure.
 4. Secure pendant-mounted luminaires to building structure.
 5. Secure lay-in luminaires to ceiling support channels using listed safety clips at four corners.
 6. See appropriate Division 9 section where suspended grid ceiling is specified for additional requirements.
- H. Recessed Luminaires:
1. Install trims tight to mounting surface with no visible light leakage.
- I. 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.
 4. Unless otherwise indicated, support pendants from swivel hangers.
- J. Install accessories furnished with each luminaire.
- K. Bond products and metal accessories to branch circuit equipment grounding conductor.
- L. Emergency Lighting Units:
1. Unless otherwise indicated, connect unit to unswitched power from same circuit feeding normal lighting in same room or area. Bypass local switches, contactors, or other lighting controls.
- M. Exit Signs:
1. Unless otherwise indicated, connect unit to unswitched power from circuit indicated. Bypass local switches, contactors, or other lighting controls.
 2. Install lock-on device on branch circuit breaker serving units.
- N. Identify luminaires connected to emergency power system in accordance with Section 260553.
- O. Install lamps in each luminaire.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - 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 Engineer of Record.

3.05 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer of Record. 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 Engineer of Record 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 Engineer of Record or authority having jurisdiction.

3.06 CLEANING

- A. Clean surfaces according to NECA 500 (commercial lighting), NECA 502 (industrial lighting), and manufacturer's instructions to remove dirt, fingerprints, paint, or other foreign material and restore finishes to match original factory finish.

3.07 CLOSEOUT ACTIVITIES

- A. See Section 017800 - Closeout Submittals, for closeout submittals.

3.08 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION 265100

SECTION 265600 - EXTERIOR LIGHTING

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Exterior luminaires.
- B. Ballasts.
- C. Luminaire accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260533.16 - Boxes for Electrical Systems.
- D. Section 260923 - Lighting Control Devices.
- E. Section 265100 - Interior Lighting.

1.03 REFERENCE STANDARDS

- A. IES LM-79 - Approved Method: Optical and Electrical Measurements of Solid-State Lighting Products.
- B. IES LM-80 - Approved Method: Measuring Maintenance of Light Output Characteristics of Solid-State Light Sources.
- C. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- D. NECA/IESNA 501 - Standard for Installing Exterior Lighting Systems.
- E. NFPA 70 - National Electrical Code.
- F. UL 1598 - Luminaires.
- G. UL 8750 - Light Emitting Diode (LED) Equipment for Use in Lighting Products.

1.04 SUBMITTALS

- A. See Section 013000 - 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.
 - C. 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.
- 1.05 QUALITY ASSURANCE
- A. Comply with requirements of NFPA 70.
 - B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.
- 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 017800 - Closeout Submittals, for additional warranty requirements.
 - B. Provide five 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. Provide luminaires listed and labeled as suitable for wet locations unless otherwise indicated.

- H. LED Luminaires:
 - 1. Components: UL 8750 recognized or listed as applicable.
 - 2. Tested in accordance with IES LM-79 and IES LM-80.
 - 3. LED Estimated Useful Life: Minimum of 50,000 hours at 70 percent lumen maintenance, calculated based on IES LM-80 test data.

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.
- B. Dimmable LED Drivers:
 - 1. Dimming Range: Continuous dimming from 100 percent to one percent relative light output unless dimming capability to lower level is indicated, without flicker.
 - 2. Control Compatibility: Fully compatible with the dimming controls to be installed.

2.04 ACCESSORIES

- A. Stems for Suspended Luminaires: Steel tubing, minimum 1/2" size, factory finished to match luminaire or field-painted as directed.
- B. Threaded Rods for Suspended Luminaires: Zinc-plated steel, minimum 1/4" size, field-painted as directed.

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 260533.16 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 260529.

- E. Install luminaires plumb and square and aligned with building lines and with adjacent luminaires.
- F. Suspended Luminaires:
 - 1. Unless otherwise indicated, specified mounting heights are to bottom of luminaire.
 - 2. Install using the suspension method indicated, with support lengths and accessories as required for specified mounting height.
 - 3. Provide minimum of two supports for each luminaire equal to or exceeding 4 feet in length, with no more than 4 feet between supports.
- G. Wall-Mounted Luminaires: Unless otherwise indicated, specified mounting heights are to center of luminaire.
- H. Install accessories furnished with each luminaire.
- I. Bond products and metal accessories to branch circuit equipment grounding conductor.
- J. Install lamps in each luminaire.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - 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 Engineer of Record.

3.04 ADJUSTING

- A. Aim and position adjustable luminaires to achieve desired illumination as indicated or as directed by Engineer of Record. Secure locking fittings in place.
- B. Luminaires with Field-Rotatable Optics: Position optics according to manufacturer's instructions to achieve lighting distribution as indicated or as directed by Engineer of Record.

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. See Section 017800 - Closeout Submittals, for closeout submittals.

3.07 PROTECTION

- A. Protect installed luminaires from subsequent construction operations.

END OF SECTION 265600

SECTION 270529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Support and attachment requirements and components for equipment, conduit, cable, boxes, and other communications work.

1.02 RELATED REQUIREMENTS

- A. Section 033000 - Cast-in-Place Concrete.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 270533.13 - Conduit for Communications Systems: Additional support and attachment requirements for conduits.
- D. Section 271000 - Structured Cabling.

1.03 REFERENCE STANDARDS

- A. ASTM A123/A123M - Standard Specification for Zinc (Hot-Dip Galvanized) Coatings on Iron and Steel Products.
- B. ASTM A153/A153M - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware.
- C. ASTM B633 - Standard Specification for Electrodeposited Coatings of Zinc on Iron and Steel.
- D. BICSI ITSIMM - Information Technology Systems Installation Methods Manual (ITSIMM), 8th Edition.
- E. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition.
- F. MFMA-4 - Metal Framing Standards Publication.
- G. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- H. NFPA 70 - National Electrical Code.
- I. TIA-569 - Telecommunications Pathways and Spaces.
- J. UL 2043 - Fire Test for Heat and Visible Smoke Release for Discrete Products and Their Accessories Installed in Air-Handling Spaces.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate sizes and arrangement of supports and bases with actual equipment and components to be installed.

2. Coordinate work to provide additional framing and materials required for installation.
3. Coordinate compatibility of support and attachment components with mounting surfaces at installed locations.
4. Coordinate arrangement of supports with ductwork, piping, equipment and other potential conflicts.
5. Notify Engineer of Record of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Sequencing:

1. Do not install products on or provide attachment to concrete surfaces until concrete has cured; see Section 033000.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for cable supports, channel/strut framing systems, nonpenetrating rooftop supports, and post-installed concrete/masonry anchors.

1.06 QUALITY ASSURANCE

- A. Installer Qualifications for Powder-Actuated Fasteners: Certified by fastener system manufacturer with current operator's license.

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 SUPPORT AND ATTACHMENT COMPONENTS

A. General Requirements:

1. Comply with the following. Where requirements differ, comply with most stringent.
 - a. TIA-569.
 - b. NFPA 70.
 - c. Requirements of authorities having jurisdiction.
2. Provide required hangers, supports, anchors, fasteners, fittings, accessories, and hardware as necessary for complete installation of communications work.
3. Provide products listed, classified, and labeled as suitable for purpose intended, where applicable.
4. Where support and attachment component types and sizes are not indicated, select in accordance with manufacturer's application criteria as required for load to be supported with minimum safety factor of _____. Include consideration for vibration, equipment operation, and shock loads where applicable.
5. Do not use products for applications other than as permitted by NFPA 70 and product listing.
6. Steel Components: Use corrosion-resistant materials suitable for environment where installed.
 - a. 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. Conduit Supports: Straps and clamps suitable for conduit to be supported.
 - 1. Conduit Straps: One-hole or two-hole type; steel or malleable iron.
 - 2. Conduit Clamps: Bolted type unless otherwise indicated.
- C. Cable Supports: Suitable for cables to be supported, including but not limited to J-hooks, bridle rings, drive rings, and flexible harnesses/slings.
 - 1. Applications:
 - a. Do not exceed 5 feet between cable supports.
 - 2. Comply with TIA-569.
 - 3. Cable Supports Installed in Spaces Used for Environmental Air: Plenum rated; listed and labeled as complying with UL 2043, suitable for use in air-handling spaces.
 - 4. J-Hooks: Noncontinuous cabling support with removable top retainer clip.
 - a. Material: Use galvanized steel, factory-painted steel, or stainless steel.
 - b. Provide support surfaces with smooth, beveled edges and radius not less than minimum allowable bend radius of cables supported.
 - c. Provide multitiered J-hooks where required to support multiple cabling systems.
- D. Outlet Box Supports: Hangers and brackets suitable for boxes to be supported.
- E. Metal Channel/Strut Framing Systems:
 - 1. Description: Factory-fabricated, continuous-slot, metal channel/strut and associated fittings, accessories, and hardware required for field assembly of supports.
 - 2. Comply with MFMA-4.
 - 3. Channel Material:
 - a. Indoor Dry Locations: Use painted steel, zinc-plated steel, or galvanized steel.
- F. 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. Single Conduit up to 1-inch (27 mm) Trade Size: 1/4-inch diameter.
 - c. Single Conduit Larger than 1-inch (27 mm) Trade Size: 3/8-inch diameter.
 - d. Trapeze Support for Multiple Conduits: 3/8-inch diameter.
 - e. Outlet Boxes: 1/4-inch diameter.
- G. Anchors and Fasteners:
 - 1. Manufacturers - Mechanical Anchors:
 - a. Hilti, Inc: www.hilti.com/#sle.
 - b. ITW Red Head, a division of Illinois Tool Works, Inc: www.itwredhead.com/#sle.
 - c. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.
 - 2. Manufacturers - Powder-Actuated Fastening Systems:
 - a. Hilti, Inc: www.hilti.com/#sle.
 - b. ITW Ramset, a division of Illinois Tool Works, Inc: www.ramset.com/#sle.
 - c. Simpson Strong-Tie Company Inc: www.strongtie.com/#sle.
 - 3. Unless otherwise indicated and where not otherwise restricted, use anchor and fastener types indicated for specified applications.
 - 4. Concrete: Use preset concrete inserts, expansion anchors, or screw anchors.
 - 5. Solid or Grout-Filled Masonry: Use expansion anchors or screw anchors.
 - 6. Hollow Masonry: Use toggle bolts.
 - 7. Hollow Stud Walls: Use toggle bolts.

8. Steel: Use beam clamps, machine bolts, or welded threaded studs.
9. Sheet Metal: Use sheet metal screws.
10. Powder-actuated fasteners are not permitted.
11. Preset Concrete Inserts: Continuous metal channel/strut and spot inserts specifically designed to be cast in concrete ceilings, walls, and floors.
 - a. Manufacturer: Same as manufacturer of metal channel/strut framing system.
 - b. Comply with MFMA-4.
 - c. Channel Material: Use galvanized steel.

PART 3 EXECUTION

3.01 EXAMINATION

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

3.02 INSTALLATION

- A. Install products in accordance with manufacturer's instructions.
- B. Install hangers and supports in accordance with NECA 1, BICSI ITSIMM, and BICSI N1.
- C. Provide independent support from building structure. Do not provide support from piping, ductwork, or other systems.
- D. Unless specifically indicated or approved by Engineer of Record, do not provide support from suspended ceiling support system or ceiling grid.
- E. Unless specifically indicated or approved by Engineer of Record, do not provide support from roof deck.
- F. Do not penetrate or otherwise notch or cut structural members without approval of Structural Engineer.
- G. Equipment Support and Attachment:
 1. Use metal, fabricated supports or supports assembled from metal channel/strut to support equipment as required.
 2. Use metal channel/strut secured to studs to support equipment surface mounted on hollow stud walls when wall strength is not sufficient to resist pull-out.
 3. Use metal channel/strut to support surface-mounted equipment in wet or damp locations to provide space between equipment and mounting surface.
 4. 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 in accordance with manufacturer's recommended torque settings.
- J. Remove temporary supports.

- K. Identify independent communications component support wires above accessible ceilings, where permitted, _____ in accordance with NFPA 70.

3.03 FIELD QUALITY CONTROL

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

END OF SECTION 270529

SECTION 270533.13 - CONDUIT FOR COMMUNICATIONS SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Galvanized steel rigid metal conduit (RMC).
- B. Galvanized steel electrical metallic tubing (EMT).
- C. Aluminum electrical metallic tubing (EMT).
- D. Rigid polyvinyl chloride (PVC) conduit.
- E. Polyvinyl chloride (PVC) plastic utilities duct.

1.02 RELATED REQUIREMENTS

- A. Section 078400 - Firestopping.
- B. Section 260533.13 - Conduit for Electrical Systems.
- C. Section 271000 - Structured Cabling.

1.03 REFERENCE STANDARDS

- A. ANSI C80.1 - American National Standard for Electrical Rigid Steel Conduit (ERSC).
- B. ANSI C80.3 - American National Standard for Electrical Metallic Tubing -- Steel (EMT-S).
- C. BICSI ITSIMM - Information Technology Systems Installation Methods Manual (ITSIMM), 8th Edition.
- D. BICSI N1 - Installation Practices for Telecommunications and ICT Cabling and Related Cabling Infrastructure, 1st Edition.
- E. BICSI TDMM - Telecommunications Distribution Methods Manual, 14th Edition.
- F. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- G. NECA 101 - Standard for Installing Steel Conduits (Rigid, IMC, EMT).
- H. NECA 111 - Standard for Installing Nonmetallic Raceways (RNC, ENT, LFNC).
- I. NEMA FB 1 - Fittings, Cast Metal Boxes, and Conduit Bodies for Conduit, Electrical Metallic Tubing, and Cable.
- J. NEMA TC 2 - Electrical Polyvinyl Chloride (PVC) Conduit.
- K. NEMA TC 3 - Polyvinyl Chloride (PVC) Fittings for Use with Rigid PVC Conduit and Tubing.
- L. NFPA 70 - National Electrical Code.
- M. TIA-568.0 - Generic Telecommunications Cabling for Customer Premises.

- N. TIA-569 - Telecommunications Pathways and Spaces.
- O. UL 6 - Electrical Rigid Metal Conduit-Steel.
- P. UL 514B - Conduit, Tubing, and Cable Fittings.
- Q. UL 651 - Schedule 40, 80, Type EB and A Rigid PVC Conduit and Fittings.
- R. UL 797 - Electrical Metallic Tubing-Steel.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate minimum sizes of conduits with actual type and quantity of cables to be installed.
 - 2. Coordinate arrangement of conduits with structural members, ductwork, piping, equipment and other potential conflicts.
 - 3. Verify exact conduit termination locations required for boxes, enclosures, and equipment.
 - 4. Coordinate work to provide roof penetrations that preserve integrity of roofing system and do not void roof warranty.
 - 5. Notify Engineer of Record of conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Sequencing:
 - 1. Do not begin installation of communications cables until installation of conduit between termination points is complete.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittals procedures.
- B. Product Data: Provide manufacturer's standard catalog pages and data sheets for conduits and fittings.
- C. Project Record Documents: Record actual routing for conduits installed underground, conduits embedded within concrete slabs, and conduits 2-inch (53 mm) trade size and larger.

1.06 QUALITY ASSURANCE

1.07 DELIVERY, STORAGE, AND HANDLING

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

PART 2 PRODUCTS

2.01 CONDUIT APPLICATIONS

- A. Do not use conduit and associated fittings for applications other than as permitted by NFPA 70, TIA-569, BICSI ITSIMM, BICSI TDMM, manufacturers' instructions, and product listing.

- B. Unless otherwise indicated and where not otherwise restricted, use conduit types indicated for specified applications. Where more than one listed application applies, comply with most restrictive requirements. Where conduit type for particular application is not specified, use galvanized steel rigid metal conduit.
- C. Underground:
 - 1. Exterior, Direct-Buried: Use rigid PVC conduit.
- D. Embedded Within Concrete:
 - 1. Within Slab on Grade: Use rigid PVC conduit or reinforced thermosetting resin conduit (RTRC). Embed within structural slabs only where approved by Structural Engineer.
 - 2. Where rigid polyvinyl chloride (PVC) conduit is provided, transition to galvanized steel rigid metal conduit (RMC) where emerging from concrete.
- E. Concealed Above Accessible Ceilings: Use galvanized steel electrical metallic tubing (EMT).
- F. Interior, Damp or Wet Locations: Use galvanized steel rigid metal conduit (RMC).
- G. Exposed, Interior, Not Subject to Physical Damage: Use galvanized steel electrical metallic tubing (EMT).
- H. Exposed, Interior, Subject to Physical Damage: Use galvanized steel rigid metal conduit (RMC).
 - 1. Locations subject to physical damage include, but are not limited to:
 - a. Where exposed below 8 feet, except within electrical and communication rooms or closets.
- I. Exposed, Interior, Subject to Severe Physical Damage: Use galvanized steel rigid metal conduit (RMC).
 - 1. Locations subject to severe physical damage include, but are not limited to:
 - a. High traffic industrial and warehouse areas where exposed below 8 feet, except within electrical and communication rooms or closets.
- J. Corrosive Locations Above Ground: Use _____.
 - 1. Corrosive locations include, but are not limited to:
 - a. Cooling towers.

2.02 CONDUIT - GENERAL REQUIREMENTS

- A. Comply with NFPA 70 and TIA-569.
- B. Provide conduit, fittings, supports, and accessories required for complete communications pathway.
- C. Provide products listed, classified, and labeled as suitable for purpose intended.
- D. Maximum Number of Communications Outlet Boxes per Continuous Conduit Homerun: Two.
- E. Minimum Conduit Size, Unless Otherwise Indicated:
 - 1. Communications Outlet Box: 1-inch trade size.
 - 2. Continuous Conduit Homerun Serving One Communications Outlet Box: 1-inch trade size.
 - 3. Continuous Conduit Homerun Serving Two Communications Outlet Boxes: 1-inch trade size.

- F. Where conduit size is not indicated, size to comply with NFPA 70, TIA-569, and BICSI TDMM, but not less than applicable minimum size requirements specified. Where specified standards differ, comply with most stringent.

2.03 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. Nonhazardous Locations: Use fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B or UL 6.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use threaded fittings only. Threadless fittings, including set screw and compression/gland types, are not permitted.
 - 4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.04 GALVANIZED STEEL ELECTRICAL METALLIC TUBING (EMT)

- A. Description: NFPA 70, Type EMT galvanized steel electrical metallic tubing complying with ANSI C80.3 and listed and labeled as complying with UL 797.
- B. Fittings:
 - 1. Description: Fittings complying with NEMA FB 1 and listed and labeled as complying with UL 514B.
 - 2. Material: Use steel or malleable iron.
 - 3. Connectors and Couplings: Use compression/gland or set-screw type.
 - a. Do not use indenter type connectors and couplings.
 - 4. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

2.05 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.
- B. Fittings:
 - 1. Manufacturer: Same as manufacturer of conduit to be connected.
 - 2. Description: Fittings complying with NEMA TC 3 and listed and labeled as complying with UL 651; material to match conduit.
 - 3. Conduit Bodies: Use only conduit bodies specifically designed for communications cabling. Standard conduit bodies designed for electrical raceways are not permitted.
 - a. Comply with TIA-568.0 minimum bend radius requirements for fiber optic cables.

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. Install conduit in accordance with NECA 1, BICSI ITSIMM, and BICSI N1.
- C. Install galvanized steel rigid metal conduit (RMC) in accordance with NECA 101.
- D. Install galvanized steel electrical metallic tubing (EMT) in accordance with NECA 101.
- E. Install rigid polyvinyl chloride (PVC) conduit in accordance with NECA 111.
- F. Conduit Routing:
 - 1. Unless dimensioned, conduit routing indicated is diagrammatic.
 - 2. When conduit destination is indicated without specific routing, determine exact routing required.
 - 3. Conceal conduits unless specifically indicated to be exposed.
 - 4. Unless otherwise approved, do not route exposed conduits:
 - a. Across floors.
 - b. Across building exterior surfaces.
 - 5. Conduits installed underground or embedded in concrete may be routed in shortest possible manner unless otherwise indicated. Route 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 equivalent of two 90-degree bend(s) between pull points.
 - a. The equivalent of three 90-degree bends between pull points is permitted only under conditions described in BICSI TDMM.
 - 8. Arrange conduit to provide no more than 100 feet between pull points.
 - 9. Arrange conduit to prevent moisture traps. Provide drain fittings at low points and at sealing fittings where moisture may collect.
 - 10. Maintain minimum clearance of 6 inches between conduits and piping for other systems.
 - 11. Maintain minimum clearance of 12 inches between conduits and hot surfaces. This includes, but is not limited to:
 - a. Heaters.
 - b. Hot water piping.
 - c. Flues.
 - 12. Group parallel conduits in same area on common rack.
- G. Conduit Support:
 - 1. Secure and support conduits in accordance with NFPA 70 using suitable supports and methods approved by authorities 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 metal channel/strut with accessory conduit clamps to support multiple, parallel, surface-mounted conduits.
 5. Use trapeze hangers assembled from threaded rods and metal channel/strut with accessory conduit clamps to support multiple, parallel, suspended conduits.
 6. Use of wire for support of conduits is not permitted.
 - a. For securing conduits to studs in hollow stud walls.
- H. 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. Terminate threaded conduits in boxes and enclosures using threaded hubs or double lock nuts for dry locations and raintight hubs for wet locations.
 5. Provide insulating bushings, insulated throats, or listed metal fittings with smooth, rounded edges at conduit terminations to protect cables.
 6. Secure joints and connections to provide mechanical strength and electrical continuity.
- I. Penetrations:
1. Do not penetrate or otherwise notch or cut structural members, including footings and grade beams, without approval of Structural Engineer.
 2. Make penetrations perpendicular to surfaces unless otherwise indicated.
 3. Provide sleeves and/or slots for penetrations as indicated or as required to facilitate installation.
 4. Conceal bends for conduit risers emerging above ground.
 5. Where conduits penetrate waterproof membrane, seal as required to maintain integrity of membrane.
 6. 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.
 7. Install firestopping to preserve fire resistance rating of partitions and other elements; see Section 078400.
- J. Underground Installation:
1. Minimum Cover, Unless Otherwise Indicated or Required:
 - a. Underground, Exterior: 18 inches.
 - b. Under Slab on Grade: 12 inches to bottom of slab.
 2. Provide underground warning tape along entire conduit length where not concrete-encased.
- K. Embedment Within Structural Concrete Slabs (only where approved by Structural Engineer):
- L. Conduit Movement Provisions: Where conduits are subject to movement, provide expansion and expansion/deflection fittings to prevent damage to enclosed cables or connected equipment. This includes, but is not limited to:
1. Where conduits cross structural joints intended for expansion, contraction, or deflection.

2. Where calculated in accordance with NFPA 70 for rigid polyvinyl chloride (PVC) conduit installed above ground to compensate for thermal expansion and contraction.
3. Where conduits are subject to earth movement by settlement or frost.

M. Conduit Sealing:

1. Use foam conduit sealant to prevent entry of moisture and gases. This includes, but is not limited to:
 - a. Where conduits enter building from outside.
 - b. Where service conduits enter building from underground distribution system.
 - c. Where conduits enter building from underground.
 - d. Where conduits may transport moisture to contact live parts.
2. Where conduits cross barriers between areas of potential substantial temperature differential, use foam conduit sealant at accessible point near penetration to prevent condensation. This includes, but is not limited to:
 - a. Where conduits pass from outdoors into conditioned interior spaces.
 - b. Where conduits pass from unconditioned interior spaces into conditioned interior spaces.

N. Provide grounding and bonding.

O. Identify conduits.

3.03 FIELD QUALITY CONTROL

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

3.04 CLEANING

- A. Clean interior of conduits to remove moisture and foreign matter.

3.05 PROTECTION

- A. Immediately after installation of conduit, use suitable manufactured plugs to provide protection from entry of moisture and foreign material and do not remove until ready for installation of cables.

END OF SECTION 270533.13

SECTION 275116 - PUBLIC ADDRESS SYSTEMS

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Amplifier and control equipment.
- B. Input equipment.
- C. Reproducer equipment.
- D. Sound system cable.
- E. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260533.16 - Boxes for Electrical Systems.

1.03 REFERENCE STANDARDS

- A. NFPA 70 - National Electrical Code.

1.04 SYSTEM DESCRIPTION

- A. Public address system for voice and music.
- B. Input components:
 - 1. AM/FM tuner.
 - 2. Microphone.
- C. Features:
 - 1. Distribution of background music.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Indicate electrical characteristics and connection requirements. Indicate layout of equipment mounted in racks and cabinets, component interconnecting wiring, and wiring diagrams of field wiring to speakers and remote input devices.
- C. Product Data: Provide data showing electrical characteristics and connection requirements for each component.
- D. Project Record Documents: Record actual locations of speakers, control equipment, and outlets for input/output connectors.

- E. Operation Data: Include instructions for adjusting, operating, and extending the system.
- F. Maintenance Data: Include repair procedures and spare parts documentation.

1.06 QUALITY ASSURANCE

- A. Comply with requirements of NFPA 70 and Federal Communications Commission.
- B. Installer Qualifications: Authorized installer of specified manufacturer with service facilities within 100 miles of Project.
- C. Products: Listed, classified, and labeled as suitable for the purpose intended.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Bogen Communications, Inc; _____: www.bogen.com/#sle.

2.02 AMPLIFICATION AND CONTROL EQUIPMENT

- A. Microphone Inputs: Two low impedance inputs with 600 microvolt sensitivity and noise level at least 55 dB below rated output.
- B. Auxiliary Inputs: One high impedance input with 0.4 volt sensitivity and noise level at least 70 dB below rated output.
- C. System Frequency Response: 50 to 15,000 Hz, plus or minus 2 dB.
- D. System Distortion: Less than 1.5 percent, 100 to 100,000 Hz at rated power.
- E. System Output: 4 ohms 25 volts.
- F. Volume Controls: One for each input and one master volume.
- G. Bass Control: Plus 8 dB to minus 12 dB at 50 Hz.
- H. Treble Control: Plus 8 dB to minus 12 dB at 10,000 Hz.
- I. System Cabinet: Rack mounted.

2.03 COMPONENTS

- A. AM/FM Tuner: Tuner with 525 to 1605 kHz AM and 88 to 108 MHz FM tuning range.
 - 1. AM Performance:
 - 2. FM Performance:
 - a. FM Fidelity: 50 to 15,000 Hz, plus or minus 3 dB.
 - b. FM Antenna Input: 300 ohms, balanced.
- B. Microphone: Desk type low impedance microphone with push-to-talk switch.
- C. Speakers: 8 inch coaxial speaker with integral crossover circuit.
 - 1. Power Rating: 20 watts.

2. Frequency Range: 45 to 18,000 Hz.
 3. Sound Pressure Level: 95 dB at 3 feet with 1 watt input.
 4. Magnet: Ceramic; 10 ounces low frequency unit; 3 ounces high frequency unit.
 5. Dispersion: Minus 3 dB at 90 degrees, minus 5 dB at 110 degrees.
- D. Speaker Baffles and Enclosure: Square, painted steel, with uniform perforations.
1. Size: 12 inch.
 2. Finish: White.
 3. Speaker Backbox: Insulated with sound-deadening material.
- E. Matching Transformers: Tapped from 0.5 to 4 watts in 1 watt steps, with primary/secondary ratio to match amplifier to speaker impedances.
- F. Volume Pads: Transformer type rated 10 watts.
- G. Telephone Interface: 600 ohm - auxiliary input.
- H. Equipment Rack: Floor mounted equipment rack.
1. Equipment Mounting Width: 19 inch.

2.04 WIRE AND CABLE

- A. Microphone Cord: 20 AWG stranded copper conductor, 600 volt insulation, rated 60 degrees C, two conductor shielded cable with rubber jacket.
- B. Input Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together, shielded, and covered with a PVC jacket.
- C. Speaker Wire and Cable: 22 AWG copper conductor, 300 volt insulation, rated 60 degrees C, paired conductors twisted together shielded and covered with a PVC jacket.
- D. Plenum Cable for Speaker Circuits: 22 AWG copper conductor, 300 volt insulation, rated 200 degrees C, paired conductors twisted together shielded and covered with a nonmetallic jacket; suitable for use for Class 2 circuits in air handling ducts, hollow spaces used as ducts, and plenums.

2.05 ACCESSORIES

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with manufacturer's instructions.
- B. Splice cable only in accessible junction boxes or at terminal block units.
- C. Make cable shields continuous at splices and connect speaker circuit shield to equipment ground only at amplifier.
- D. Install input circuits in separate cables and raceways from output circuits.
- E. Provide protection for exposed cables where subject to damage.
- F. Use armored cable for outside speaker circuits.

- G. Support cables above accessible ceilings to keep them from resting on ceiling tiles. Use spring metal clips or plastic cable ties to support cables from structure for ceiling suspension system. Include bridle rings or drive rings.
- H. Use suitable cable fittings and connectors.
- I. Connect reproducers to amplifier with matching transformers.
- J. Ground and bond equipment and circuits in accordance with Section 260526.

3.02 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Measure and record sound power levels at designated locations.

3.03 ADJUSTING

- A. Adjust transformer taps for appropriate sound level.
- B. Adjust devices and wall plates to be flush and level.

3.04 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. Location: At project site.

3.05 MAINTENANCE

- A. Provide service and maintenance of public address and music system for one year from Date of Substantial Completion.

END OF SECTION 275116

SECTION 281000 - ACCESS CONTROL

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Access control system requirements.
- B. Access control units and software.
- C. Access control point peripherals, including readers and keypads.
- D. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 087100 - Door Hardware: Electrically operated door hardware, for interface with access control system.
- B. Section 260526 - Grounding and Bonding for Electrical Systems.
- C. Section 260533.13 - Conduit for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 271000 - Structured Cabling: Data cables for access control system IP network connections.
- F. Section 282000 - Video Surveillance: For interface with access control system.
- G. Section 284600 - Fire Detection and Alarm: For interface with access control system.

1.03 DEFINITIONS

- A. Access Control Cloud Services: Subscription-based hosted application utilizing Software as a Service (SaaS) delivery model in lieu of on-premises servers/software.

1.04 REFERENCE STANDARDS

- A. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- B. NFPA 70 - National Electrical Code.
- C. UL 294 - Access Control System Units.

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the work with other installers to provide suitable door hardware as required for both access control functionality and code compliance.

2. Coordinate the placement of readers with millwork, furniture, equipment, etc. installed under other sections or by others.
3. Coordinate the work with other installers to provide power for equipment at required locations.
4. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.

B. Access Control Cloud Services:

C. Preinstallation Meetings:

1. Conduct meeting with facility representative to review reader and equipment locations.

1.06 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Design Data: Standby battery/UPS calculations.
- E. Evidence of qualifications for manufacturer.
- F. Evidence of qualifications for installer.
- G. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- H. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
- I. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- J. Maintenance Materials: Furnish the following for Owner's use in maintenance of project.
 1. See Section 016000 - Product Requirements, for additional provisions.

1.07 QUALITY ASSURANCE

- A. Comply with the following:
 1. NFPA 70.
 2. The requirements of the local authorities having jurisdiction.
 3. Applicable TIA/EIA standards.
- B. Maintain at the project site a copy of each referenced document that prescribes execution requirements.

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

1.08 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.

1.09 FIELD CONDITIONS

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

1.10 WARRANTY

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Access Control Units - Basis of Design: Avigilon.
- B. Access Control Software - Basis of Design: Avigilon.
- C. Access Control Cloud Services - Basis of Design: Avigilon.
- D. Readers and Keypads - Basis of Design: Brivo, as indicated under product descriptions below ; www.brivo.com/#sle.
- E. Readers and Keypads - Basis of Design: Avigilon.

2.02 ACCESS CONTROL SYSTEM REQUIREMENTS

- A. Provide new access control system consisting of required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. System Battery Backup: Provide batteries/uninterruptible power supplies (UPS) as required 15 minutes.
- C. Surge Protection:
- D. Access Control Points:

1. See article "ACCESS CONTROL POINT PERIPHERALS" below for device descriptions.
- E. Computers Required:
1. See article "ACCESS CONTROL UNITS AND SOFTWARE" below for product descriptions.
 2. Server(s):
 - a. Quantity: One.
 - b. Location(s): To be determined.
 - c. Peripherals required for each server:
 - 1) Mouse and keyboard.
 - 2) Monitor(s): One.
- F. Interface with Other Systems:
1. Provide products compatible with other systems requiring interface with access control system.
 2. Interface with electrically operated door hardware as specified in Section 087100.
 - a. Capable of locking/unlocking/releasing controlled doors.
 - b. Capable of receiving input from integral door hardware switches.
 3. Interface with fire alarm system as specified in Section 284600.
- G. Provide products listed, classified, and labeled as suitable for the purpose intended.
1. Access Control Units and Readers: Listed and labeled as complying with UL 294.

2.03 ACCESS CONTROL UNITS AND SOFTWARE

- A. Provide access control units and software compatible with readers to be connected.
- B. Unless otherwise indicated, provide software and licenses required for fully operational system.
- C. Access Control Cloud Services - Basis of Design: Brivo Onair; www.brivo.com/#sle.
1. Capacity: Unlimited cardholders; unlimited doors, readers, and administrators; unlimited workstations; unlimited events (viewable for 365 days); 60 custom fields.
 2. Communication: Supports TLS1.2+ authentication with AES256 encryption.
 3. Mobile Credentials: Supports Brivo Mobile Pass mobile application.
 - a. Standard Mode: Enables user to select from list of authorized doors; supports Brivo smart readers, other compatible readers, and doors without readers.
 - b. Magic Button: Enables automatic selection of reader closest to user; supports Brivo smart readers.
 - c. Biometric Authentication: Utilizes mobile device biometric scanning capabilities.
 4. Features: Anti-passback; text/email event notifications; elevator control (up to 118 floors per reader); mobile administration application.
- D. Access Control Unit - Basis of Design: Brivo ACS6000 Control Panel (for Brivo Onair); www.brivo.com/#sle.
1. Quantity of Credentials Supported: Unlimited when connected to Brivo Onair; 250,000 when offline.
 2. Quantity of Readers Supported: Two onboard (Wiegand or RS-485 OSDP); up to 30 total utilizing up to 14 expansion door boards.
 3. Event History: 60,000 events when offline.
 4. Inputs: Eight onboard (two door position, two request-to-exit, and four auxiliary); up to 120 total utilizing up to 14 expansion boards.

5. Output Relays: Six onboard (two lock-switching and four auxiliary); up to 118 total utilizing up to 14 expansion boards.
 6. Communication: Ethernet or Wi-Fi; supports TLS1.2+ authentication with AES256 encryption.
- E. Access Control Unit - Basis of Design: Brivo ACS300 Controller (for Brivo Onair); www.brivo.com/#sle.
1. Quantity of Credentials Supported: Unlimited when connected to Brivo Onair; 250,000 when offline.
 2. Quantity of Readers Supported: Two (Wiegand or RS-485 OSDP).
 3. Event History: 60,000 events when offline.
 4. Inputs: Eight (two door position, two request-to-exit, and four auxiliary).
 5. Output Relays: Six (two lock-switching and four auxiliary).
 6. Communication: Ethernet or Wi-Fi; supports TLS1.2+ authentication with AES256 encryption.
 7. Products:
 - a. Model B-ACS300-E controller (for Brivo Onair); controller board in compact plastic mountable enclosure.
- F. Access Control Unit - Basis of Design: Brivo EP1502 Controller (for Brivo Onair); www.brivo.com/#sle.
1. Quantity of Readers Supported: Two onboard (Wiegand); up to 30 total utilizing up to 14 expansion reader interface modules.
 2. Event History: 50,000 events when offline.
 3. Inputs: Eight; two dedicated tamper and power monitor.
 4. Output Relays: Four.
 5. Communication: Ethernet; supports TLS1.1 authentication with AES128 encryption.

2.04 ACCESS CONTROL POINT PERIPHERALS

- A. Provide devices compatible with control units and software.
- B. Provide devices suitable for operation under the service conditions at the installed location.
- C. Readers and Keypads:
 1. General Requirements:
 - a. Provide readers compatible with credentials to be used.
 - b. Color: To be selected by Architect from manufacturer's available standard colors.
 - c. Contactless Smart Card Readers:
 - 1) Utilize 13.56 MHz RF communication with compatible credentials.
 - 2) Utilize 64 bit authentication keys.
 - 3) Support ISO compliant credentials.
 - 4) Support data encryption.
 - d. Proximity Readers:
 - 1) Utilize 125 kHz RF communication with compatible credentials.
- D. Door Locking Devices (Electric Strikes and Magnetic Locks): Comply with Section 087100.

2.05 ACCESSORIES

- A. Provide components as indicated or as required for connection of access control system to devices and other systems indicated.

- B. Unless otherwise indicated, credentials to be provided by Contractor.
 - 1. Provide credentials compatible with readers and control units/software to be used.
- C. Provide cables as indicated or as required for connections between system components.
 - 1. Data Cables for IP Network Connections: Unshielded twisted pair (UTP), _____ , complying with Section 271000.
- D. Provide accessory racks/cabinets as indicated or as required for equipment mounting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install access control system in accordance with NECA 1 (general workmanship).
- B. Install products in accordance with manufacturer's instructions.
- C. Wiring Method: Unless otherwise indicated, use cables (not in conduit).
 - 1. Use suitable listed cables in wet locations, including underground raceways.
 - 2. Use suitable listed cables for vertical riser applications.
 - 3. Use listed plenum rated cables in spaces used for environmental air.
 - 4. Install wiring in conduit for the following:
 - a. Where required for rough-in.
 - b. Where required by authorities having jurisdiction.
 - c. Where exposed to damage.
 - d. Where installed outside the building.
 - e. For exposed connections from outlet boxes to devices.
 - 5. Conduit: Comply with Section 260533.13.
 - 6. Conceal cables unless specifically indicated to be exposed.
 - 7. Use power transfer hinges complying with Section 087100 for concealed connections to door hardware.
 - 8. Route exposed cables parallel or perpendicular to building structural members and surfaces.
 - 9. Do not exceed manufacturer's recommended maximum cable length between components.
- D. Provide grounding and bonding in accordance with Section 260526.

- E. Identify system wiring and components in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Program system parameters according to requirements of Owner.
- D. Test for proper interface with other systems.
- E. 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. 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. Location: At project site.

3.06 PROTECTION

- A. Protect installed system components from subsequent construction operations.

3.07 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide trouble call-back service upon notification by Owner:
 - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 2. 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.

END OF SECTION 281000

SECTION 282000 - VIDEO SURVEILLANCE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Video surveillance system requirements.
- B. Video recording and viewing equipment.
- C. Cameras.
- D. Accessories.

1.02 RELATED REQUIREMENTS

- A. Section 260526 - Grounding and Bonding for Electrical Systems.
- B. Section 260529 - Hangers and Supports for Electrical Systems.
- C. Section 260533.13 - Conduit for Electrical Systems.
- D. Section 260553 - Identification for Electrical Systems: Identification products and requirements.
- E. Section 271000 - Structured Cabling: Data cables for IP video surveillance system network connections.

1.03 REFERENCE STANDARDS

- A. 47 CFR 15 - Radio Frequency Devices.
- B. NECA 1 - Standard for Good Workmanship in Electrical Construction.
- C. NECA 303 - Standard for Installing and Maintaining Closed-Circuit Television (CCTV) Systems.
- D. NFPA 70 - National Electrical Code.

1.04 ADMINISTRATIVE REQUIREMENTS

- A. Coordination:
 - 1. Coordinate the placement of cameras with structural members, ductwork, piping, equipment, luminaires, diffusers, fire suppression system components, and other potential conflicts installed under other sections or by others.
 - 2. Coordinate the work with other installers to provide power for cameras and equipment at required locations.
 - 3. Notify Engineer of Record of any conflicts with or deviations from Contract Documents. Obtain direction before proceeding with work.
- B. Preinstallation Meetings:

1. Conduct meeting with facility representative to review camera and equipment locations and camera field of view objectives.
2. Conduct meeting with facility representative and other related equipment manufacturers to discuss video surveillance system interface requirements.

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Include plan views indicating locations of system components and proposed size, type, and routing of conduits and/or cables. Include elevations and details of proposed equipment arrangements. Include system interconnection schematic diagrams. Include requirements for interface with other systems.
- C. Product Data: Provide manufacturer's standard catalog pages and data sheets for each system component. Include ratings, configurations, standard wiring diagrams, dimensions, finishes, service condition requirements, and installed features.
- D. Design Data:
 1. Video storage capacity calculations.
- E. Certify that proposed system design and components meet or exceed specified requirements.
- F. Evidence of qualifications for installer.
- G. Evidence of qualifications for maintenance contractor (if different entity from installer).
- H. 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.
- I. Project Record Documents: Record actual locations of system components and installed wiring arrangements and routing.
- J. Operation and Maintenance Data: Include detailed information on system operation, equipment programming and setup, replacement parts, and recommended maintenance procedures and intervals.
- K. Warranty: Submit sample of manufacturer's warranty and documentation of final executed warranty completed in Owner's name and registered with manufacturer.
- L. Software: One copy of software not resident in read-only memory.

1.06 QUALITY ASSURANCE

- A. Comply with the following:
 1. NFPA 70.
 2. Applicable TIA/EIA standards.
- B. Installer Qualifications: Company specializing in performing the work of this section with minimum three years documented experience with video surveillance systems of similar size, type, and complexity and providing contract maintenance service as a regular part of their business; authorized manufacturer's representative.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Receive, inspect, handle, and store products in accordance with manufacturer's instructions and NECA 303.
- B. Store products in manufacturer's unopened packaging, keep dry and protect from damage until ready for installation.

1.08 FIELD CONDITIONS

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

1.09 WARRANTY

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

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Video Recording and Viewing Equipment - Basis of Design: _____.
- B. Cameras - Basis of Design: Axis Communications as indicated under product descriptions below; www.axis.com/#sle.

2.02 VIDEO SURVEILLANCE SYSTEM

- A. Provide new video surveillance system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. System Description: IP system with connection to network (IP) cameras.
 - 1. Video Storage Capacity: Suitable for storing video from all cameras for 10 days.
 - 2. System Battery Backup: Provide batteries/uninterruptible power supplies (UPS) as required for _____ minutes full operation.
 - 3. Surge Protection:
 - a. Provide surge protection for exterior cameras.
- C. Video Recording and Viewing Equipment Required:
 - 1. See article "VIDEO RECORDING AND VIEWING EQUIPMENT" below for product descriptions.
- D. Interface with Other Systems:
 - 1. Provide products compatible with other systems requiring interface with video surveillance system.
- E. Provide products listed, classified, and labeled as suitable for the purpose intended.

- F. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

2.03 VIDEO RECORDING AND VIEWING EQUIPMENT

- A. Provide video recording and viewing equipment compatible with cameras to be connected.
- B. Network Video Recorders (NVRs):
 - 1. Supports connection of network (IP) cameras.
 - 2. Supports continuous and event-based recording.
 - 3. Network Video Recorder Type _____:
- C. Computers:
 - 1. Servers: Unless otherwise indicated, server hardware not furnished by video surveillance system manufacturer to be provided by Contractor as part of work of this section, meeting video surveillance system equipment manufacturer's minimum requirements.
- D. Software:
 - 1. Unless otherwise indicated, provide all software and licenses required for fully operational system.

2.04 CAMERAS

- A. Provide cameras and associated accessories suitable for operation under the service conditions at the installed location. Provide additional components (e.g. enclosures, heaters, blowers, etc.) as required.
- B. Where not factory-installed, provide additional components (e.g. lenses, mounting accessories, etc.) as necessary for complete installation.
- C. Network (IP) Cameras:
 - 1. Signal-to-Noise Ratio: Not less than 50 dB.
 - 2. Provide the following standard features:
 - a. Automatic electronic shutter.
 - b. Automatic gain control.
 - c. Automatic white balance.
 - d. Web-based interface for remote viewing and setup.
 - e. Password protected security access.
 - 3. Network (IP) Fixed Box Camera - Basis of Design: Axis Communications P13 Series; Model P1375; www.axis.com/#sle.
 - a. Maximum Video Resolution: 1920 x 1080.
 - b. Maximum Frame Rate: 50/60 fps at 50/60 Hz.
 - c. Image Sensor Size: 1/2.8 inch.
 - d. Minimum Illumination/Light Sensitivity: 0.05 lux (color).
 - e. Lens: 2.8-8 mm, F1.2; horizontal field of view of 124-42 degrees; varifocal, P-Iris.
 - f. Features: Zipstream, audio support (two-way), forensic capture wide dynamic range, Lightfinder, local storage, 12-28 VDC and Power over Ethernet (PoE), day and night functionality, image rotation (0, 90, 180, or 270 degrees).
 - 4. Network (IP) Fixed Dome Panoramic Camera - Basis of Design: Axis Communications M30 Series; Model M3057-PLVE (Outdoor, IR illumination, Vandal-resistant); www.axis.com/#sle.

- a. Maximum Video Resolution: 2048 x 2048.
- b. Maximum Frame Rate: 50/60 fps at 50/60 Hz.
- c. Image Sensor Size: 1/1.8 inch/6 MP.
- d. Minimum Illumination/Light Sensitivity (Color): 0.16 lux.
- e. Lens: 1.6 mm, F2.0; horizontal field of view of 185 degrees, vertical field of view of 185 degrees; fixed focus, fixed iris.
- f. Features: Zipstream, forensic capture wide dynamic range, local storage, Power over Ethernet (PoE), day and night functionality, built-in IR illumination, image rotation (0, 180 degrees), HDMI output, IP66/NEMA 4X/IK10 casing.

2.05 ACCESSORIES

- A. Camera Enclosures: Where not factory-installed, provide camera enclosures suitable for operation under service conditions at installed location.
- B. Camera Mounting Supports: Where not factory installed, provide mounting supports necessary for installation.
- C. Provide components as indicated or as required for connection of video surveillance system to devices and other systems indicated.
- D. Provide components as indicated or as required for system power and network connections.
- E. Provide cables as indicated or as required for connections between system components.
 - 1. Data Cables for IP Network Connections: Unshielded twisted pair (UTP), Category 6 , complying with Section 271000.
- F. Provide accessory racks/cabinets as indicated or as required for equipment mounting.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that field measurements are as indicated.
- B. Verify that ratings and configurations of system components are consistent with the indicated requirements.
- C. Verify that mounting surfaces are ready to receive system components.
- D. Verify that branch circuit wiring installation is completed, tested, and ready for connection to system where applicable.
- E. Verify that conditions are satisfactory for installation prior to starting work.

3.02 INSTALLATION

- A. Install video surveillance system in accordance with NECA 1 (general workmanship) and NECA 303.
- B. Install products in accordance with manufacturer's instructions.
- C. Provide required support and attachment in accordance with Section 260529.

- D. Wiring Method: Unless otherwise indicated, use cables (not in conduit).
 - 1. Use suitable listed cables in wet locations, including underground raceways.
 - 2. Use suitable listed cables for vertical riser applications.
 - 3. Use listed plenum rated cables in spaces used for environmental air.
 - 4. Install wiring in conduit for the following:
 - a. Where required for rough-in.
 - b. Where required by authorities having jurisdiction.
 - c. Where exposed to damage.
 - d. Where installed outside the building.
 - e. For exposed connections from outlet boxes to cameras.
 - 5. Conduit: Comply with Section 260533.13.
 - 6. Conceal all cables unless specifically indicated to be exposed.
 - 7. Route exposed cables parallel or perpendicular to building structural members and surfaces.
- E. Provide grounding and bonding in accordance with Section 260526.
- F. Identify system wiring and components in accordance with Section 260553.

3.03 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Prepare and start system in accordance with manufacturer's instructions.
- C. Adjust cameras to provide desired field of view and produce suitable images under all service lighting conditions.
- D. Program system parameters according to requirements of Owner.
- E. Test for proper interface with other systems.
- F. 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. See Section 017800 - Closeout Submittals, for closeout submittals.
- B. See Section 017900 - Demonstration and Training, for additional requirements.
- C. Training: Train Owner's personnel on operation, 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. Location: At project site.

3.06 PROTECTION

- A. Protect installed system components from subsequent construction operations.

3.07 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide trouble call-back service upon notification by Owner:
 - 1. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 - 2. 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.

END OF SECTION 282000

SECTION 283111 - BUILDING INTRUSION DETECTION

PART 2 PRODUCTS

1.01 INTRUSION DETECTION SYSTEM REQUIREMENTS

- A. Provide new intrusion detection system consisting of all required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, system programming, etc. as necessary for a complete operating system that provides the functional intent indicated.
- B. Alarm Control Unit: New addressable alarm control panel located as indicated.
- C. Provide products listed, classified, and labeled as suitable for the purpose intended.
- D. Electromagnetic Interference/Radio Frequency Interference (EMI/RFI) Limits: Comply with FCC requirements of 47 CFR 15, for Class B, consumer application.

1.02 ALARM CONTROL UNIT

- A. Alarm Control Panel: Modular construction.
 - 1. Enclosure: Lockable; provide tamper protection.
 - 2. Power Supply:
 - a. Primary Power: 120 VAC; provide suitable transformer/power supply; supervised for loss of AC power.
 - b. Secondary Power: Standby battery; provide suitable capacity for minimum standby time required by listing requirements, applicable codes, and authority having jurisdiction, but not less than four hours; provide suitable battery charger; supervised for low battery condition; protected from accidental reversal of battery leads.
- B. Alarm Initiating Circuits: Supervised.
 - 1. Hardwired Zones: Supports both normally closed and normally open conventional (non-addressable) initiating devices.
 - 2. Addressable Zones: Supports addressable initiating devices and modules using multiplexed polling loops.
- C. Alarm Notification Circuits: Supervised.
- D. Communications Interfaces: Supervised.
 - 1. Supports system reporting to central station receivers via integral interface or accessory interface modules using:
 - a. Telephone lines.
- E. Keypads: Supervised.
- F. Peripheral Devices: Supervised; provide tamper protection.
- G. Output Relays:
 - 1. Relay Modules: Form C relays (normally open and normally closed); provide tamper protection.

2. Programmable to respond to system events, according to defined scheduling, or by manual activation from keypad.
- H. User Codes:
1. Each user code to be individually assignable to any defined authority level for configurable access to system features and functions.
- I. Scheduling:
1. Provide time/calendar-based scheduling capability for automated system control.
 2. Supports open/close schedules for control of arming/disarming and reporting.
 3. Supports timed events including, but not limited to:
 - a. Point bypass/unbypass.
 - b. Relay activate/deactivate.
- J. Event Log:
1. Stores system events including time, date, partition, zone, and user code where applicable.
 2. Supports viewing of event log on keypads.
- 1.03 KEYPADS
- A. Manufacturer: Same as manufacturer of alarm control unit.
- B. Provides interface to alarm control unit for system control and remote annunciation.
- C. Provides visual notification of system status and zone information.
- D. Provides audible notification to indicate system status, entry/exit delay, and alarm situations; provide separate distinguishable sounds for alarm and trouble conditions.
- E. Keypad Type: Only LCD or graphic touch screen keypads are acceptable. Do not use LED keypads.
- F. Graphic Touch Screen Keypads: Displays system status and zone information using plain English on graphic display; touch screen interface.
- G. LCD Keypads: Displays system status and zone information using plain English on alphanumeric display; illuminated keys.

1.04 INITIATING DEVICES

- A. Manufacturers: Same as manufacturer of alarm control units where possible.
- B. General Requirements:
1. Provide devices suitable for intended application and location to be installed.
 2. Outdoor Units: Weather resistant, suitable for outdoor use.
 3. Addressable Systems:
 - a. Addressable Devices: Individually identifiable by control unit.
 - b. Provide suitable addressable modules for connection to conventional (non-addressable) devices and other components that provide a dry closure output.

END OF SECTION 283111

SECTION 284400 - REFRIGERANT DETECTION AND ALARM

PART 2 PRODUCTS

1.01 REFRIGERANT DETECTION SYSTEMS - GENERAL REQUIREMENTS

- A. Provide new refrigerant detection systems consisting of required equipment, conduit, boxes, wiring, connectors, hardware, supports, accessories, software, and system programming as necessary for complete operating system that provides functional intent indicated.
- B. Provide products listed, classified, and labeled as suitable for purpose intended.
- C. Comply with the following:
 - 1. NFPA 70.
 - 2. Applicable state and local codes.
 - 3. Requirements of local authorities having jurisdiction.
- D. Service Conditions: Provide products suitable for operation under service conditions at installed location.
- E. Enclosures:
 - 1. NEMA 250 Environment Type or Equivalent IEC 60529 Rating: Unless otherwise indicated, as specified for following installation locations:

END OF SECTION 284400

SECTION 284500 - GAS DETECTION AND ACCESSORIES

PART 1 GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes gas detection instruments and other components necessary for an emergency gas exhaust system.
 - 1. The work to be performed in accordance with these Specifications includes engineering, final system and component configuration design, manufacture, procurement, delivery, storage, installation, equipment calibration, testing, documenting, warranting, maintenance and the placing in service of carbon monoxide and nitrogen dioxide detection system.
 - 2. The work shall include the furnishing and installation of equipment, material, conduit, cables, wiring, mounting hardware, system operating software and all appurtenances required to provide complete, coordinated and compatible operating systems with functional subsystems and elements which meet the requirements described in these Contract documents. All other materials and equipment, including items such as; samples, prototypes, cable termination allowances, packing materials, wastage of material during installation efforts and tests, demonstrations, engineering review documentation, and any other materials or services associated with the prosecution of the work or the administration of the Contract that are not listed, but are otherwise specified or necessary for full and complete operation and performance of each system, shall also be provided by the Contractor. The Contractor is responsible for a complete and operational system.
 - 3. The Gas Detection System to be provided shall be a microprocessor based, distributed control system with industry standard hardware and software to detect the presence of carbon monoxide and nitrogen dioxide in the apparatus bays.
 - 4. The system shall operate over a fault tolerant three-wire communication network loop with built-in diagnostics, programmable logic, non-volatile memory for alarm and calibration logging and accommodate a variety of other fire and gas devices. It shall be designed to ignore opens and shorts that could occur on the network. The loop configuration will ensure a single short or open on the system will not affect system communication between the field devices and the control unit. System communication will provide supervision of all addressable devices on the network and provide fault alarms in the event of system failures
- B. System Performance Requirements:
 - 1. The Gas Detection System shall continuously monitor the carbon monoxide and nitrogen dioxide levels within the spaces in which they are located. Set points for each detector shall be as follows:
 - a. Carbon monoxide: 25 PPM
 - b. Nitrogen Dioxide: 3 PPM

2. The Gas Detection System shall operate satisfactorily in the environment existing in the apparatus bay. With the exception of normal cleaning requirements, the system operation shall not be compromised and false alarms shall not be generated by detectors exposed to normal levels of dust, smoke, moisture, chemicals and fumes from petroleum distillates.
3. System trouble signal initiation shall be by one or more of the following devices or actions:
 - a. Open circuits, shorts and grounds of wiring for initiating device, signaling line, and notification-appliance circuits.
 - b. Opening, tampering, or removal of alarm-initiating and supervisory signal-initiating devices.
 - c. Loss of primary power at the Local Control Unit.
 - d. Ground or a single break in Local Control Unit internal circuits.
 - e. A break in standby battery circuitry.
 - f. Failure of battery charging.
 - g. Abnormal position of any dip switch at the devices so equipped.
4. System Trouble Signal Actions: Ring trouble bell and energize LED or lamp on the graphic annunciator panel. Sound a chime tone and display trouble alarm with description on the computer monitor. Record the event in the system historical log. Trouble alarms shall be cleared only after the system fault has been corrected and a system reset function has been completed

C. Contractor's Total System Responsibility:

1. The Contractor bears total system responsibility for the specified gas detection system (except Contract deliverables not requiring Contractor installation). The Contractor's total system responsibility includes engineering services, construction, testing, installation documentation, warranty, maintenance, and other areas of responsibility, which are subject to periodic review and acceptance by the Authority (as specified elsewhere). The Contractor has the responsibility to integrate the various necessary elements of Contract work so that overall system performance goals are met.
2. The Contractor is required to engage the services of the approved system manufacturer's engineering staff to evaluate the facilities for appropriate applications of gas detection equipment.

D. Related sections:

1. Section 230993 "Sequence of operation of HVAC controls"
2. Section 260533 "Raceways and Boxes for Electrical Systems."

1.03 ACTION SUBMITTALS

- A. Product Data: Include manufacturer's name, model numbers, data sheets, ratings, power requirements, equipment layout, device arrangement, and battery calculation charts. Show the control panel module layouts, remote annunciator panel configurations and wiring terminations.
- B. Wiring Diagrams: Complete detector system wiring point-to-point diagrams, conduit layouts (show penetrations for fire rated walls).
- C. System operation description including method of operation and supervision of each type of circuit and sequence of operations for all manually and automatically initiated system inputs and corresponding outputs.
- D. Shop Drawings:
 1. Complete drawing lists for each system.
 2. Complete installation drawings for each system.

3. System riser diagram with device addresses, conduit sizes and cable and wire types and sizes.
4. Floor Plans: Indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
5. Complete test procedures for each system and each item of equipment requiring such procedures.
6. Complete interface control details and procedures.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Contractor shall include the following information in the operations and maintenance manual:
 1. As-Built drawings for all equipment items for each system.
 2. Complete test data for each system and all equipment for which such data is approved.
 3. Other submissions listed elsewhere in these Specifications, as required by the Authority's Representative.

1.05 QUALITY ASSURANCE

- A. The manufacturer of the major components of the Gas Detection System shall have a minimum of 5 years' experience in the manufacturing of gas detection equipment. The satisfactory operation of systems previously provided shall be subject to verification. Manufacturer must be ISO 9002 certified.
- B. All major components of the Gas Detection System, including software, shall be furnished from the same manufacturer.
- C. The equipment supplier shall participate in the applications engineering, set up, testing and commissioning of the system.
- D. Non-dispersed, infrared gas detectors shall be warranted against failure by the manufacturer for a minimum of five years and require calibration only on an annual basis. The gas detectors shall permit calibration to be performed by one person.
- E. The system shall be installed by qualified electricians who have successfully completed a training course provided by the equipment supplier.
- F. Gas Detection System design, clearances, electrical and mechanical installations, and testing shall, as a minimum, be in accordance with the requirements in effect at time of Invitation for Bid for each of the following and shall include addenda and supplements:
 1. FMRC NFPA 72 - National Fire Alarm Code
 2. Fire Code of the local jurisdiction
 3. FM 6310/6320 - Combustible Gas Performance
 4. National Electrical Code (NEC).
 5. FMRC 6310/6320 Combustible Gas Detectors
 6. Building Officials and Code Administrators National Building Code (BOCA).
 7. Americans with Disabilities Act Accessibility Guidelines for Buildings and Facilities (ADAAG).
- G. The specifications are not to be construed as supplanting any code requirements.

1.06 WARRANTY

- A. Warranty Period:
 - 1. For Labor: Two years from date of Substantial Completion
 - 2. For Parts: Five years from date of Substantial Completion

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by the following:
 - 1. Honeywell (basis of design).
 - 2. As approved by the Engineer.
- B. All systems to be installed shall be furnished by the same manufacturer.

2.02 MATERIALS AND EQUIPMENT

- A. The system shall be comprised of a control unit, a programmable relay module, addressable infrared gas detectors, initiating device circuits, notification appliance circuits, and analog initiating devices with control unit(s) communicating over a high speed fault tolerant communications link to form an integrated system.
- B. All field devices shall have 3/4 inch NPT cable entry and separate terminals for incoming and outgoing field wiring. Terminals shall be sized to accept 16 to 22 AWG wire.
- C. All detector locations shall permit the separation from the transmitter for a distance up to 50 feet for carbon monoxide and nitrogen dioxide detectors. Transmitters shall have the capability to simulate and adjust the output to compensate for line loss and allow field testing. Conduit and cabling between the detector and remote transmitter shall be rated for installation in hazardous locations. The transmitter shall display Gas Concentration and Alarm Status as a minimum.
- D. Wire and cable shall be UL listed with color coded insulation appropriate for the area of installation. Cable shielding, conductor configuration and sizing shall be as recommended by the system manufacturer. All system wire and cabling installed outside of equipment enclosures and devices shall be installed in rigid galvanized steel conduit.
- E. Provide grounding of system equipment and cable shielding as recommended by the system manufacturer. Grounding shall comply with IEEE 1100.
- F. Local Control Unit:
 - 1. Honeywell model VA301C.
 - 2. Power Requirements: 17-27 Vac, 60 Hz or 24-38 Vdc, 500 mA
 - 3. Operating Temperature Range: -4°F to 122°F
 - 4. Operating Humidity Range: 0 to 95% RH (non-condensing)
 - 5. Outputs: 4 DPDT relays
 - 6. Relay Output Rating: 5A, 30 Vac
 - 7. Network Capacity: Up to 96 transmitters
 - 8. Alarm levels: 3 fully programmable alarm levels
 - 9. Communication Cable: Twisted and shielded 2-24 AWG
 - 10. Length of Communication Lines: 2000ft per channel
 - 11. Battery: 3V Lithium Battery
 - 12. Enclosure: NEMA 4X ABS polycarbonate

13. The control panel must be capable of communicating digitally with the networked transmitters and relay modules through three RS-485 Modbus communication buses. Each communication bus must be capable of accepting a combination of up to 32 addressable transmitters, relay modules, or annunciator panels at a maximum distance of 2,000 feet. The power supply shall be of either 24 Vac or 24 Vdc.
14. The controller will manage four internal DPDT relays at fully programmable alarm levels (and within programmable time delays) and be capable of activating multiple relay modules of eight relays each. The relay rating will be no lower than 5 A, 30 Vdc or 250 Vac (resistive load)
15. The controller to include a self-test function that allows for the activation/deactivation of all the programmed outputs by simulating a continuous 5% increase/decrease value until the maximum/minimum value is reached.
16. The controller to include a real-time clock that enables operation of the outputs for a specific timeframe.
17. The controller must also include an energy saving feature that allows for output operation on alarms set at the max, min or average value of a specific group of transmitters. This feature must also allow for the activation of outputs upon a certain number of a specific group ($\frac{3}{4}$, $\frac{1}{2}$, $\frac{1}{3}$ and $\frac{1}{4}$) of transmitters reaching their alarm levels. A total of 128 groups can be assigned.
18. The controller will indicate the exact concentration of gas, the gas detected, and the location of the sensor by sweeping through the network and displaying the detected levels at each point on a graphic LCD display.
19. Provide required 120V to 24 V by gas detection manufacturer for each controller.
20. Data logging:
 - a. Data logging capability to provide long-term data logging to determine trends. The controller must collect data automatically and must store it on a digital Flash media card.

G. Toxic and Combustible Gas Detector- Carbon Monoxide and Nitrogen Dioxide:

1. Honeywell model E3Point
2. Power Requirement: 24 Vac nominal or 24Vdc, 60 Hz, 0.4A
3. Relay Output: 1 DPDT relay, 5A @ 250 Vac; 5A @ 30 Vdc
4. Communications: RS485 Modbus
5. Operating Temperature: -40° to 122°F
6. Display: 8 Character, 2 line backlit LCD
7. Visual Indicator: Green LED: Power; Amber LED 1: Alarm/Fault; Amber LED 2: Alarm/Fault
8. Accuracy: +/- 3% of full scale
9. Gases Detected: Carbon Monoxide (CO), Nitrogen Dioxide (NO₂)
10. Relative humidity range operating range: of 5-95%
11. Operating Temperature: -4° F to 104° F (-20° C to 40° C)
12. Enclosure: Polycarbonate
13. Transmitter to be powered by the control panel power supply rated at 24 Vac or 24 Vdc. Fully addressable gas transmitter must be capable of communicating digitally with controller through an RS-485 communication port. Gas transmitters must be installed in a true daisy chain with an end of the line resistor on the last transmitter. The gas transmitter will incorporate an electrochemical cell for toxic gas monitoring and catalytic bead sensor for combustible gases. Unit sensing cell must compensate for variations in relative humidity and temperature to maintain high levels of accuracy
14. When placed in a network configuration the transmitter to be capable of transmitting gas concentrations through the controller. For local activation of fans or louvers (or other equipment) an on-board DPDT relay 5 A, 30 Vdc or 250 Vac (resistive load) to be

- activated at programmable set points (and programmable time delays) through the control panel. An LCD display to provide gas concentration readings.
15. Unit will be certified to ANSI/UL 61010-1 label and CAN/CSA-C22.2 No. 61010-1. Transmitter must be manufactured in an ISO 9001-2000 production environment.
 16. The transmitter should have a plug-in capability for a gas cartridge with a smart sensor capable of self-testing.
 17. Provide splash guard enclosure (Honeywell ECLAB or approved equal) within wash down areas.
 18. Provide detector guards (Honeywell E3PT-Guard or approved equal)
 - a. Grid to be made of a 9-gauge steel wire. The guard must be designed to allow calibration without removing the guards.
- H. System Relay Module:
1. Honeywell model VA301R8.
 2. Fully compatible with the 301C Controller.
 3. Capable of 8 additional DPDT relays, 5A, 30Vdc or 250Vac.
 4. Easy daisy chain installation (RS-485).
 5. LED visual indication of status next to each relay.
 6. Connects into a single output of the 301C Controller.
 7. Operating Temperature: 32° to 104°F.
 8. Humidity Range: 0-95% RH, non-condensing.
 9. Power Requirements: 17-27Vac, 24-28Vdc
 10. communication port. Relay module will have eight relays rated at no lower than 5A, 30 Vdc or 250 Vac (resistive load).

PART 3 EXECUTION

3.01 INSTALLATION

- A. All equipment installation shall comply with applicable codes and shall be performed with a degree of workmanship acceptable to Precision Strip. Final terminations of Gas Detectors, Transmitters, Receivers/Controllers and Supervisory System must be performed by factory authorized and trained service personnel.
- B. Control equipment shall be located at locations shown on contract drawings. Control equipment enclosures and cabinets shall be wall mounted at a height with the top of the enclosure or cabinet not exceeding six feet above the floor. Install all items in accordance with manufacturer's instructions Equipment located within 18 inches below the ceiling shall comply with requirements for areas with hazardous classification per NFPA.
- C. Carbon monoxide detectors shall be located at 12-inches and 60-inches above floor.
- D. Nitrogen dioxide detectors shall be located between 1 foot and 3 feet below underside of roof deck.
- E. Install wiring in conduit. Refer to section 260533 "Raceways and Boxes for Electrical Systems."
- F. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace and train conductors to terminal points with no excess. Connect conductors that are terminated or interrupted in any enclosure associated with the gas

detection and alarm system to terminal blocks. Label each terminal and wire according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- G. Cable Terminations: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- H. Color-Coding: Color-code Gas Detection System conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and a different color-code for supervisory circuits.
- I. All wiring used for communication over Ethernet network shall be shielded.

3.02 TESTING

- A. Contractor shall engage a factory-authorized service representative to assist in inspecting, testing, and adjusting components, assemblies, and equipment installations, including connections. Report results in writing.
- B. Component Level Tests and Inspections:
 - 1. The contractor shall prepare detailed pre-test check sheets, test plans, procedures, data entry forms and test reports for the testing of each component.
 - 2. The test plans shall provide objectives, approach, pass/fail criteria, requirements and schedule for each test.
 - 3. Test and adjust all controls and safeties.
 - 4. Verify each component is installed at the correct height indicated.
 - 5. Verify each component is installed securely.
 - 6. Verify electrical connections to each component are correct and secure.
 - 7. Test all functions within each individual components control.
 - 8. Test alarms on each component
 - 9. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- C. System Level Tests and Inspections:
 - 1. The contractor shall prepare detailed pre-test check sheets, test plans, procedures, data entry forms and test reports for the testing of the entire gas detection system.
 - 2. The test plans shall provide objectives, approach, pass/fail criteria, requirements and schedule for each test.
 - 3. Test and adjust all controls and safeties.
 - 4. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 5. Test all conductors for short circuits utilizing an insulation-testing device.
 - 6. With each circuit pair, short circuit at the far end of the circuit and measure the circuit resistance with an ohmmeter. Record the circuit resistance of each circuit.
 - 7. Verify the control unit is in the normal condition as detailed in the manufacturers operating and maintenance manuals.
 - 8. Test each detector for operation and proper response at the control unit. Test detectors with actual carbon monoxide and nitrogen dioxide as appropriate for each detector.
 - 9. Test the system for all specified functions according to the manufacturer's operating and maintenance manual. Systematically initiate specified functional performance items at

each station including making all possible alarm and monitoring initiations and using all communications options. For each item, observe related performance at all devices required to be affected by the item under all system sequences. Observe indicating lights, displays, signal tones, and annunciator indications.

10. Verify that all HVAC equipment is functioning properly with the detection control unit.
 11. Verify all relays are performing correctly to start-up HVAC equipment and open garage doors.
 12. Test Reports: Prepare a written report to record the following:
 - a. Test procedures used.
 - b. Test results that comply with requirements.
 - c. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Furnish equipment required to perform all tests. Test each component installation and system in accordance with the approved procedures.
- E. The Contractor shall notify the owner a minimum of two working days prior to commencing any tests that are to be witnessed by the owner.
- F. The Contractor shall furnish personnel, tools and test equipment as required to satisfactorily complete the tests. Test equipment used in performing the tests shall be in current calibration. Factory authorized service personnel shall provide all programming and verification of each Gas Detector, Transmitter, Receiver/Controller, Annunciator Panel and Supervisory System and the Factory authorized service personnel shall provide final test and verification of overall system performance.
- G. Repair or replace malfunctioning units and retest as specified above.
- H. Prepare and submit certified test reports for each equipment installation test indicating the results of all tests and remedial measures implemented to enable equipment to pass the tests.
- I. System Performance Test (30 day): After completion and inspection of all work, and following placement of the gas detection and alarm system in service, the contractor shall perform a 30-day performance test. The performance test shall include an end-to-end test of all function of the system.
1. All detection, alarm and interface functions operate as intended in the event of an actual buildup of carbon monoxide, nitrogen dioxide or the release of compressed natural gas.
 2. No false alarms
 3. No system trouble or fault alarms
 4. If the system, or any part of it, fails to meet any criteria of the performance test, the contractor shall make corrections at no additional cost to the owner. More than three failures during the thirty (30) day test will result in a restart of the test period.

3.03 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain gas detection devices and equipment. Training shall be a minimum duration of 4 hours and contractor shall provide all training materials and equipment.

END OF SECTION 284500

SECTION 284600 - FIRE DETECTION AND ALARM

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Fire alarm system design and installation, including all components, wiring, and conduit.
- B. Transmitters for communication with supervising station.
- C. Circuits from protected premises to supervising station, including conduit.
- D. Maintenance of fire alarm system under contract for specified warranty period.

1.02 REFERENCE STANDARDS

- A. 36 CFR 1191 - Americans with Disabilities Act (ADA) Accessibility Guidelines for Buildings and Facilities; Architectural Barriers Act (ABA) Accessibility Guidelines.
- B. ADA Standards - Americans with Disabilities Act (ADA) Standards for Accessible Design.
- C. IEEE C62.41.2 - IEEE Recommended Practice on Characterization of Surges in Low-Voltage (1000 V and less) AC Power Circuits.
- D. NFPA 70 - National Electrical Code.
- E. NFPA 72 - National Fire Alarm and Signaling Code.
- F. NFPA 101 - Life Safety Code.

1.03 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Proposal Documents: Submit the following with cost/time proposal:
 - 1. NFPA 72 "Record of Completion", filled out to the extent known at the time.
 - 2. Manufacturer's detailed data sheet for each control unit, initiating device, and notification appliance.
 - 3. Certification by Contractor that the system design will comply with Contract Documents.
 - 4. Proposed maintenance contract.
- C. Drawings must be prepared as reproducible drawings.
 - 1. Owner will provide floor plan drawings for Contractor's use; verify all dimensions on Owner-provided drawings.
- D. Evidence of designer qualifications.
- E. Design Documents: Submit all information required for plan review and permitting by authorities having jurisdiction, including but not limited to floor plans, riser diagrams, and description of operation:
 - 1. Copy (if any) of list of data required by authority having jurisdiction.
 - 2. NFPA 72 "Record of Completion", filled out to the extent known at the time.

3. Clear and concise description of operation, with input/output matrix similar to that shown in NFPA 72 Appendix A-7-5-2.2(9), and complete listing of software required.
 4. System zone boundaries and interfaces to fire safety systems.
 5. Location of all components, circuits, and raceways; mark components with identifiers used in control unit programming.
 6. Circuit layouts; number, size, and type of raceways and conductors; conduit fill calculations; spare capacity calculations; notification appliance circuit voltage drop calculations.
 7. List of all devices on each signaling line circuit, with spare capacity indicated.
 8. Manufacturer's detailed data sheet for each component, including wiring diagrams, installation instructions, and circuit length limitations.
 9. Description of power supplies; if secondary power is by battery include calculations demonstrating adequate battery power.
 10. Certification by either the manufacturer of the control unit or by the manufacturer of each other component that the components are compatible with the control unit.
 11. Certification by the manufacturer of the control unit that the system design complies with Contract Documents.
 12. Certification by Contractor that the system design complies with Contract Documents.
- F. Evidence of installer qualifications.
- G. Evidence of instructor qualifications; training lesson plan outline.
- H. Evidence of maintenance contractor qualifications, if different from installer.
- I. Inspection and Test Reports:
1. Submit inspection and test plan prior to closeout demonstration.
 2. Submit documentation of satisfactory inspections and tests.
 3. Submit NFPA 72 "Inspection and Test Form," filled out.
- J. Operating and Maintenance Data: See Section 017800 for additional requirements; revise and resubmit until acceptable; have one set available during closeout demonstration:
1. Complete set of specified design documents, as approved by authority having jurisdiction.
 2. Additional printed set of project record documents and closeout documents, bound or filed in same manuals.
 3. Contact information for firm that will be providing contract maintenance and trouble call-back service.
 4. List of recommended spare parts, tools, and instruments for testing.
 5. Replacement parts list with current prices, and source of supply.
 6. Detailed troubleshooting guide and large scale input/output matrix.
 7. Preventive maintenance, inspection, and testing schedule complying with NFPA 72; provide printed copy and computer format acceptable to Owner.
 8. Detailed but easy to read explanation of procedures to be taken by non-technical administrative personnel in the event of system trouble, when routine testing is being conducted, for fire drills, and when entering into contracts for remodeling.
- K. Project Record Documents: See Section 017800 for additional requirements; have one set available during closeout demonstration:
1. Complete set of floor plans showing actual installed locations of components, conduit, and zones.
 2. "As installed" wiring and schematic diagrams, with final terminal identifications.

3. "As programmed" operating sequences, including control events by device, updated input/output chart, and voice messages by event.

L. Closeout Documents:

1. Certification by manufacturer that the system has been installed in compliance with manufacturer's installation requirements, is complete, and is in satisfactory operating condition.
2. NFPA 72 "Record of Completion", filled out completely and signed by installer and authorized representative of authority having jurisdiction.
3. Certificate of Occupancy.
4. Maintenance contract.

1.04 QUALITY ASSURANCE

- A. Designer Qualifications: NICET Level III or IV (3 or 4) certified fire alarm technician or registered fire protection engineer, employed by fire alarm control panel manufacturer, Contractor, or installer, with experience designing fire alarm systems in the jurisdictional area of the authorities having jurisdiction.
- B. Installer Qualifications: Firm with minimum 3 years documented experience installing fire alarm systems of the specified type and providing contract maintenance service as a regular part of their business.
 1. Authorized representative of control unit manufacturer; submit manufacturer's certification that installer is authorized; include name and title of manufacturer's representative making certification.
 2. Installer Personnel: At least 2 years of experience installing fire alarm systems.
 3. Supervisor: NICET level III or IV (3 or 4) certified fire alarm technician; furnish name and address.
- C. Maintenance Contractor Qualifications: Same entity as installer or different entity with specified qualifications.
- D. Instructor Qualifications: Experienced in technical instruction, understanding fire alarm theory, and able to provide the required training; trained by fire alarm control unit manufacturer.

1.05 WARRANTY

- A. Provide control panel manufacturer's warranty that system components other than wire and conduit are free from defects and will remain so for 1 year after date of Substantial Completion.
- B. Provide installer's warranty that the installation is free from defects and will remain so for 1 year after date of Substantial Completion.

PART 2 PRODUCTS

2.01 MANUFACTURERS

- A. Fire Alarm Control Units and Accessories - Other Acceptable Manufacturers:
 1. Honeywell Security & Fire Solutions/Gamewell-FCI; _____: www.gamewell-fci.com/#sle.
 2. Honeywell Security & Fire Solutions/Notifier; _____: www.notifier.com/#sle.
 3. Simplex, a brand of Johnson Controls; _____: www.simplex-fire.com/#sle.

4. Provide control units made by the same manufacturer.

B. Initiating Devices and Notification Appliances:

1. Same manufacturer as control units.
2. Provide initiating devices and notification appliances made by the same manufacturer, where possible.

2.02 FIRE ALARM SYSTEM

A. Fire Alarm System: Provide a new automatic fire detection and alarm system:

1. Provide all components necessary, regardless of whether shown in Contract Documents or not.
2. Protected Premises: Entire building shown on drawings.
3. Comply with the following; where requirements conflict, order of precedence of requirements is as listed:
 - a. ADA Standards.
 - b. The requirements of the local authority having jurisdiction, which is City of Niagara Falls.
 - c. Applicable local codes.
 - d. Contract Documents (drawings and specifications).
 - e. NFPA 72; where the word "should" is used consider that provision mandatory; where conflicts between requirements require deviation from NFPA 72, identify deviations clearly on design documents.
4. Evacuation Alarm: Multiple smoke zones; allow for evacuation notification of any individual zone or combination of zones, in addition to general evacuation of entire premises.
5. Voice Notification: Provide emergency voice/alarm communications with multichannel capability; digital.
6. General Evacuation Zones: Each smoke zone is considered a general evacuation zone unless otherwise indicated, with alarm notification in all zones on the same floor, on the floor above, and the floor below.
7. Program notification zones and voice messages as directed by Owner.
8. Fire Command Center: Location indicated on drawings.
9. Fire Alarm Control Unit: New, located at fire command center.

B. Supervising Stations and Fire Department Connections:

1. Public Fire Department Notification: By on-premises supervising station.
2. On-Premises Supervising Station: Existing proprietary station operated by Owner, located at _____.
3. Means of Transmission to On-Premises Supervising Station: Directly connected noncoded system.
4. Means of Transmission to Remote Supervising Station: Digital alarm communicator transmitter (DACT), 2 telephone lines.

C. Circuits:

1. Initiating Device Circuits (IDC): Class A, Style D.
2. Signaling Line Circuits (SLC) Within Single Building: Class A, Style 2.
3. Notification Appliance Circuits (NAC): Class A, Style Z.

D. Spare Capacity:

1. Initiating Device Circuits: Minimum 100 percent spare capacity.
2. Notification Appliance Circuits: Minimum 100 percent spare capacity.

3. Speaker Amplifiers: Minimum 100 percent spare capacity.
4. Fire Alarm Control Units: Capable of handling all circuits utilized to capacity without requiring additional components other than plug-in control modules.

E. Power Sources:

1. Primary: Dedicated branch circuits of the facility power distribution system.
2. Secondary: Storage batteries.
3. Capacity: Sufficient to operate entire system for period specified by NFPA 72.
4. Each Computer System: Provide uninterruptible power supply (UPS).

2.03 FIRE SAFETY SYSTEMS INTERFACES

A. Supervision: Provide supervisory signals in accordance with NFPA 72 for the following:

1. Sprinkler water control valves.
2. Dry-pipe sprinkler system pressure.
3. Dry-pipe sprinkler valve room low temperature.
4. Fire pump(s).
5. Elevator shut-down control circuits.

B. Alarm: Provide alarm initiation in accordance with NFPA 72 for the following:

1. Sprinkler water flow.
2. Elevator lobby, elevator hoistway, and elevator machine room smoke detectors.

C. Elevators:

1. Elevator lobby, hoistway, and machine room smoke detectors: Elevator recall for fire fighters' service.
2. Elevator Machine Room Heat Detector: Shut down elevator power prior to hoistway sprinkler activation.
3. Sprinkler pressure or waterflow: Shut down elevator power prior to hoistway sprinkler activation.

D. HVAC:

1. Duct Smoke Detectors: Close dampers indicated; shut down air handlers indicated.

2.04 COMPONENTS

A. General:

1. Provide flush mounted units where installed in finish areas; in unfinished areas, surface mounted unit are acceptable.
2. Provide legible, permanent labels for each control device, using identification used in operation and maintenance data.

B. Fire Alarm Control Units: Analog, addressable type; listed, classified, and labeled as suitable for the purpose intended.

C. Addressable Fire Alarm Control Unit - Basis of Design: Simplex - Johnson Controls Company.

D. Master Control Unit: As specified for Basis of Design above, or equivalent.

E. Remote Annunciators: Simplex - Johnson Controls Company.

F. Initiating Devices:

1. Addressable Systems:

- a. Addressable Devices: Individually identifiable by addressable fire alarm control unit.
 - b. Provide suitable addressable interface modules as indicated or as required for connection to conventional (non-addressable) devices and other components that provide a dry closure output.
- G. Notification Appliances:
 - 1. Speakers: _____.
 - 2. Strobes: _____.
- H. Circuit Conductors: Copper or optical fiber; provide 200 feet extra; color code and label.
- I. Surge Protection: In accordance with IEEE C62.41.2 category B combination waveform and NFPA 70; except for optical fiber conductors.
- J. Locks and Keys: Deliver keys to Owner.
- K. Instruction Charts: Printed instruction chart for operators, showing steps to be taken when a signal is received (normal, alarm, supervisory, and trouble); easily readable from normal operator's station.
 - 1. Frame: Stainless steel or aluminum with polycarbonate or glass cover.
 - 2. Provide one for each control unit where operations are to be performed.
 - 3. Obtain approval of Owner prior to mounting; mount in location acceptable to Owner.
 - 4. Provide extra copy with operation and maintenance data submittal.

PART 3 EXECUTION

3.01 INSTALLATION

- A. Install in accordance with applicable codes, NFPA 72, NFPA 70, and Contract Documents.
- B. Conceal all wiring, conduit, boxes, and supports where installed in finished areas.
- C. Obtain Owner's approval of locations of devices, before installation.
- D. Install instruction cards and labels.

3.02 INSPECTION AND TESTING FOR COMPLETION

- A. Notify Owner 7 days prior to beginning completion inspections and tests.
- B. Notify authorities having jurisdiction and comply with their requirements for scheduling inspections and tests and for observation by their personnel.
- C. Provide the services of the installer's supervisor or person with equivalent qualifications to supervise inspection and testing, correction, and adjustments.
- D. Prepare for testing by ensuring that all work is complete and correct; perform preliminary tests as required.
- E. Provide all tools, software, and supplies required to accomplish inspection and testing.
- F. Perform inspection and testing in accordance with NFPA 72 and requirements of local authorities; document each inspection and test.

- G. Correct defective work, adjust for proper operation, and retest until entire system complies with Contract Documents.

3.03 Owner PERSONNEL INSTRUCTION

- A. Provide the following instruction to designated Owner personnel:
 - 1. Hands-On Instruction: On-site, using operational system.
 - 2. Classroom Instruction: Owner furnished classroom, on-site or at other local facility.
- B. Administrative: One-hour session(s) covering issues necessary for non-technical administrative staff; classroom:
 - 1. Initial Training: 1 session pre-closeout.
- C. Basic Operation: One-hour sessions for attendant personnel, security officers, and engineering staff; combination of classroom and hands-on:
 - 1. Initial Training: 1 session pre-closeout.
- D. Furnish the services of instructors and teaching aids; have copies of operation and maintenance data available during instruction.

3.04 CLOSEOUT

- A. Closeout Demonstration: Demonstrate proper operation of all functions to Owner.
 - 1. Be prepared to conduct any of the required tests.
 - 2. Have at least one copy of operation and maintenance data, preliminary copy of project record drawings, input/output matrix, and operator instruction chart(s) available during demonstration.
 - 3. Have authorized technical representative of control unit manufacturer present during demonstration.
 - 4. Demonstration may be combined with inspection and testing required by authority having jurisdiction; notify authority having jurisdiction in time to schedule demonstration.
 - 5. Repeat demonstration until successful.
- B. Substantial Completion of the project cannot be achieved until inspection and testing is successful and:
 - 1. Approved operating and maintenance data has been delivered.
 - 2. All aspects of operation have been demonstrated to Owner.
 - 3. Final acceptance of the fire alarm system has been given by authorities having jurisdiction.
 - 4. Occupancy permit has been granted.
 - 5. Specified pre-closeout instruction is complete.

3.05 MAINTENANCE

- A. See Section 017000 - Execution and Closeout Requirements, for additional requirements relating to maintenance service.
- B. Provide to Owner, at no extra cost, a written maintenance contract for entire manufacturer's warranty period, to include the work described below.
- C. Perform routine inspection, testing, and preventive maintenance required by NFPA 72, including:

1. Maintenance of fire safety interface and supervisory devices connected to fire alarm system.
 2. Repairs required, unless due to improper use, accidents, or negligence beyond the control of the maintenance contractor.
 3. Record keeping required by NFPA 72 and authorities having jurisdiction.
- D. Provide trouble call-back service upon notification by Owner:
1. Provide on-site response within 2 hours of notification.
 2. Include allowance for call-back service during normal working hours at no extra cost to Owner.
 3. Owner will pay for call-back service outside of normal working hours on an hourly basis, based on actual time spent at site and not including travel time; include hourly rate and definition of normal working hours in maintenance contract.
- E. Provide a complete description of preventive maintenance, systematic examination, adjustment, cleaning, inspection, and testing, with a detailed schedule.
- F. Maintain a log at each fire alarm control unit, listing the date and time of each inspection and call-back visit, the condition of the system, nature of the trouble, correction performed, and parts replaced. Submit duplicate of each log entry to Owner's representative upon completion of site visit.
- G. Comply with Owner's requirements for access to facility and security.

END OF SECTION 284600

SECTION 31000 – SITE EARTHWORK

PART 1 – GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 01 – General Requirements which are hereby made a part of the Specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.
- D. Work of this Section, as shown or specified, shall be in accordance with the requirements of the Contract Documents.

1.2 SECTION INCLUDES

- A. The Work of this Section includes all labor, materials, equipment and services necessary to complete site earthwork as shown on the drawings and specified herein, including but is not necessarily limited to the following:
 - 1. Lay out and stake all lines and levels.
 - 2. Protection and safeguards.
 - 3. Earth open excavation for pavement subgrades.
 - 4. Trench earth excavation for utilities.
 - 5. Backfilling utility trenches.
 - 6. Embankment for pavement subgrade.
 - 7. Aggregate base course for asphalt and concrete pavement.
 - 8. Disposal of unsuitable and excess excavated materials.
 - 9. Preparation of sub-grade for walks, pavements and landscape areas to receive topsoil, seeding, and planting.
 - 10. Dewatering of utility trenches.
 - 11. Shoring and bracing of utility trenches.
 - 12. Protection of adjacent existing structures, utilities and other facilities against damage from the Work.

1.3 RELATED SECTIONS

- A. Division 31 Section “Site Clearing and Demolition”.
- B. Division 31 Section “Cement Concrete Pavement”.
- C. Division 31 Section “Asphalt Paving”.
- D. Division 32 Section “Planting Soils”.
- E. Division 33 Section “Water Distribution”.
- F. Division 33 Section “Sanitary Sewerage”.
- G. Division 33 Section “Storm Sewerage”.

1.4 FIELD MEASUREMENTS

- A. Verify that survey benchmark and intended elevations for the Work are as indicated.

1.5 REFERENCES

- A. ASTM D6938-17 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
- B. 16 NYCRR Part 753 – Protection of Underground Facilities.
- C. New York State Department of Transportation - Standard Specifications, Construction and Materials latest edition.

1.6 DEFINITIONS

- A. Trench Rock Excavation: Removal of solid mineral material or obstruction that cannot be excavated with a modern track-mounted power shovel equivalent to Caterpillar Model No. 318C L Hydraulic Excavator, and rated at not less than 125 HP net flywheel power and 45,500 pound draw-bar pull and equipped with a short stick and 42 inch wide short tip radius rock bucket rated at 0.92 cubic yard capacity. Trenches in excess of 10 feet width are defined as unclassified excavation.
- B. Unclassified Excavation: Removal of obstructions visible on the surface, topsoil, earth, and all other subsoil materials encountered that are not defined as trench rock.
- C. Subgrade Surface: The undisturbed earth or the compacted soil layer immediately below granular subbase, base of structure, or topsoil materials.
- D. Structure: Buildings, foundations, slabs, tanks, manholes, or other constructed or manufactured stationary features occurring above or below ground surface.
- E. Utility: Any buried pipe or conduit.
- F. Pavement: Any compacted granular, asphalt concrete or portland cement concrete section, either existing or proposed, constructed above the subgrade surface for the purpose of supporting pedestrian or vehicular traffic.

1.7 REGULATORY REQUIREMENTS

- A. Submit to Owner a signed fill agreement or property owner release for deposit of any unsuitable and excess excavation materials disposed of off site.
- B. Comply with 29 CFR Part 1926, OSHA, Subpart P, Excavations for work of this section.

1.8 SUBMITTALS

- A. Materials Source: Submit name and address of imported aggregate materials suppliers. Provide materials from same source throughout the Work. Change of source requires Engineer approval.
- B. Test Reports: Submit the following reports directly to Owner from the testing services, with copy to Engineer.
 - 1. Analysis of aggregate materials performed in accordance with ASTM C136/C136M-14. Testing shall be performed within twelve months of the submittal date.
 - 2. Modified Proctor test in accordance with ASTM D1557 for all subbases and/or structural fills. Testing shall be performed within twelve months of the submittal date.

1.9 PROJECT CONDITIONS

- A. Existing Utilities: Locate, identify, and protect utilities that remain, from damage. Be assured as to the location and position of gas, water, sewer, electric, telephone services and mains, culverts and other conduits that may be affected by the construction and notify the respective authorities in charge of same of the work in the vicinity. CALL Dig Safely New York (former

Underground Facilities Protective Organization) 811 BEFORE STARTING EXCAVATION OPERATIONS. The Contractor will be held strictly responsible for the cost of repairs or replacement of all utilities and other conduits damaged directly by his forces or indirectly by failure to provide proper protection or support of the same. The Contractor will also be held responsible for damages to others caused by utility lines damaged either directly or indirectly by his operations. Comply with all rules and regulations cited in 16 NYCRR Part 753 – Protection of Underground Facilities.

- B. If uncharted, or incorrectly charted, piping or other utilities are encountered during excavation, consult utility authority and Owner immediately for direction. Cooperate with Owner and utility authority to keep their respective services and facilities in operation.
- C. Dust Control
 - 1. Use all means necessary to control dust on or near the work.
 - 2. Thoroughly moisten all surfaces as required to prevent dust being a nuisance to the public, neighbors, and performance of other work on the site.
- D. Protection
 - 1. Barricade open excavations occurring as part of this work and post with warning lights. Operate warning lights as recommended by authorities having jurisdiction.
 - 2. Provide the necessary safeguards to prevent accidents, to avoid all unnecessary hazards and protect the public, the work and the property at all times, including Saturdays, Sundays and holidays.
 - 3. Be responsible for any and all damages which may arise or occur to any party whatsoever by reason of the neglect in providing proper lights, guards, barriers, or any other safeguards to prevent damage to property, life and limb.
 - 4. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout and other hazards created by earthwork operations.
- E. Use of explosives is not permitted.

PART 2 - PRODUCTS

2.1 AGGREGATE MATERIALS

- A. Structural Fill: Bank-run sand and gravel conforming to the following limits of gradation:

| <u>Percent Passing by Weight</u> | <u>Sieve Size</u> |
|----------------------------------|-------------------|
| 100 | 4 inch |
| 30 to 95 | 1/4-inch |
| 10 to 70 | No. 40 |
| 0 to 10 | No. 200 |

- B. Select Granular Material: NYSDOT Subbase Course Type 4 - Item 733.0404 conforming to the following limits of gradation:

| <u>Percent Passing by Weight</u> | <u>Sieve Size</u> |
|----------------------------------|-------------------|
| 100 | 2 inch |
| 30 to 65 | 1/4-inch |
| 5 to 40 | No. 40 |
| 0 to 10 | No. 200 |

- C. Subbase Course Material, Type 2: Naturally or artificially graded crushed ledge rock or crushed native cobbles which is sound, durable, and free of organic and other deleterious materials conforming to N.Y.S.D.O.T. Material Designation 733.0402. Material to have 20 percent or less loss after 4 cycles of N.Y.S.D.O.T. Magnesium Sulfate Soundness Test.

- D. Subbase Course Material, Type 4: Naturally or artificially graded crushed bank-run gravel which is sound, durable, and free of organic and other deleterious materials conforming to the limits of gradation for N.Y.S.D.O.T. Material Designation 733.0404.
- E. Bedding Stone: Clean, sound, durable, round stone of uniform quality and conforming to NYSDOT Specification 703-0201, Size Designation No. 1 or 1A.
- F. Drainage Stone: Clean, washed, sound, durable, sharp-angled fragments of crushed stone of uniform quality and conforming to NYSDOT Specification 703-0201, Size Designation No. 2.
- G. Cushion Sand: Clean, hard, durable, uncoated particles, free from lumps of clay and all deleterious substances conforming to NYSDOT Specification 703-06 and the following limits of gradation when dry:
- | Percent Passing by Weight | Sieve Size |
|---------------------------|------------|
| 100 | 1/4 inch |
| 0 to 35 | No. 50 |
| 0 to 10 | No. 100 |
- H. Select Fill: Imported or excavated on-site sand, loam, or clay material free from organic material and debris. Unfrozen and containing only small amounts of rock not exceeding four inches in the largest dimension.
- I. Rip-Rap: Sharp-angled fragments of rock of uniform quality and conforming to NYSDOT Tables 733-21A and -21B, Stone Filling Gradation and Stone Filling Approximate Shape. Nominal spherical dimensions as shown on the Drawings.

2.2 GEOTEXTILE MATERIALS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated in the work include, but are not limited to, the following:
1. Propex Geosolutions
 2. Carthage Mills
 3. TenCate Geosynthetics America
- B. Soil Stabilization Fabric for Medium Duty Pavements: Provide a woven or nonwoven fabric consisting of continuous chain polymeric filaments or yarns of polyester; similar to Mirafi 500X; with the following certifiable property values:
- | Property | Minimum Value | Test Method |
|-----------------------------|---------------------------|-------------|
| CBR Puncture Strength | 700 lbs. | ASTM D6241 |
| Trapezoid Tear Strength | 75 lbs. | ASTM D4533 |
| Grab Tensile Strength | 200 lbs. | ASTM D4632 |
| Apparent Opening Size (AOS) | 40 US Sieve | ASTM D4751 |
| Flow Rate | 4 gal/min/ft ² | ASTM D4491 |
- C. Drainage Fabric: Nonwoven geotextile, specifically manufactured as a drainage geotextile; similar to Mirafi 140N; made from polyolefins, polyesters, or polyamides; and with the following certifiable property values:

| Property | Minimum Value | Test Method |
|-----------------------------|-----------------------------|-------------|
| CBR Puncture Strength | 310 lbs. | ASTM D6241 |
| Trapezoid Tear Strength | 50 lbs. | ASTM D4533 |
| Grab Tensile Strength | 120 lbs. | ASTM D4632 |
| Apparent Opening Size (AOS) | 70 US Sieve | ASTM D4751 |
| Flow Rate | 135 gal/min/ft ² | ASTM D4491 |

2.3 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. Provide tape colors to utilities 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
- B. Tracer Wire: No. 12 THHN Green coated solid copper.

2.4 EROSION AND SEDIMENT CONTROLS

- A. Stabilized Construction Entrance Aggregate: Clean, sound, durable, sharp-angled fragments of rock of uniform quality and 3-inch nominal spherical dimension.

2.5 SOURCE QUALITY CONTROL

- A. Provide and pay for tests and analysis of aggregate material performed in accordance with ASTM C136/C136M-14.
- B. If tests indicate materials do not meet specified requirements, change materials and retest.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify location of existing underground utilities before excavating.

3.2 PREPARATION

- A. Identify required lines, levels, contours, and datum. Layout the Work in accordance with baseline data shown on Drawings.
- B. Protect vegetation, lawns, and other features remaining as a portion of final landscaping.
- C. Protect all temporary benchmarks, control points, property monuments, existing structures and fences, from excavation equipment and vehicular traffic.
- D. Saw-cut existing pavements in straight lines in advance of excavation.

3.3 EXAMINATION

- A. Verify that grades and elevations of pavement subgrade are correct prior to requesting proof rolling observation.
- B. Provide minimum of 48-hour notice to Engineer for proof rolling the pavement subgrade. Verify that Engineer has observed proof rolling and that testing agency has completed compaction tests prior to placing aggregate courses.

3.4 AGGREGATE STOCKPILING

- A. Stockpile materials on site adjacent to areas of work.
- B. Stockpile in sufficient quantities to meet project schedule and requirements.
- C. Separate differing materials with dividers or stockpile apart to prevent mixing.
- D. Direct surface water away from stockpile site so as to prevent erosion or deterioration of materials.

3.5 EXCAVATION

- A. Excavation is unclassified and includes excavation to subgrade elevations indicated, regardless of character of materials and obstructions encountered.
- B. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimension without specific direction of Geotechnical Engineer. Unauthorized excavation, as well as remedial work directed by Geotechnical Engineer, shall be at Contractor's expense.
 - 1. Under footings, foundation bases, or retaining walls, fill unauthorized excavation by extending indicated bottom elevation of footing or base to excavation bottom, without altering required top elevation. Lean concrete fill may be used to bring elevations to proper position, when acceptable to Geotechnical Engineer.
 - 2. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classifications, unless otherwise directed by Geotechnical Engineer.
- C. Additional Excavation: When excavation has reached required subgrade elevations, notify Geotechnical Engineer who will make an inspection of conditions.
 - 1. If unsuitable bearing materials are encountered at required subgrade elevations, carry excavations deeper and replace excavated material as directed by the Geotechnical Engineer. Excavation of unsuitable material must extend laterally beyond the edge of the footing or slab for a distance equal to or greater than the required depth of the excavation.
 - 2. Removal of unsuitable material and its replacement as directed will be paid on basis of contract conditions relative to changes in work.
- D. Perform excavation with drip line of large trees to remain by hand, and protect the root system from damage or dryout to the greatest extent possible. Maintain moist condition for root system and cover exposed roots with burlap. Paint root cuts of one (1) diameter and larger with emulsified asphalt tree paint.
- E. Stability of Excavations: Slope sides of excavations to comply with local codes and ordinances having jurisdiction. Shore and brace where sloping is not possible because of space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling.
- F. Shoring and Bracing: Provide materials for shoring and bracing, such as sheet piling, uprights, stringers, and cross braces, in good serviceable condition.
 - 1. Establish requirements for trench shoring and bracing to comply with local codes and authorities having jurisdiction.
 - 2. Maintain shoring and bracing in excavations regardless of time period excavations will be open. Carry down shoring and bracing as excavation progresses.
- G. Dewatering: Prevent surface water and subsurface or ground water from flowing into excavations and from flooding project site and surrounding area.
 - 1. Do not allow water to accumulate in excavations. Remove water to prevent softening of foundation bottoms, undercutting footings, and soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations. Maintain water levels below base of excavation to control hydrostatic pressure on subgrade soils.
 - 2. Establish and maintain temporary drainage ditches and other diversion outside excavation limits to convey rain water and water removed from excavations to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.
 - 3. Do not discharge sediment laden water into the adjoining storm or sanitary sewer system or open swales. Pump sediment laden water from excavations into a portable sediment tank or

a high-strength, non-woven geotextile fabric bag. Size portable sediment tanks in accordance with the New York Guidelines for Urban Erosion and Sediment Control.

- H. Material Storage: Stockpile satisfactory excavated materials where directed until required for backfill or fill. Place, grade and shape stockpiles for proper drainage.
 - 1. Locate and retain soil materials away from edge of excavations. Do not store within drip line of trees indicated to remain.
 - 2. Dispose of excess soil material and waste materials not re-used.

3.6 OPEN EXCAVATION

- A. Excavate topsoil from areas to be further excavated or re-graded.
 - 1. Stockpile topsoil in area designated on-site to be reused.
- B. Excavate subsoil required to accommodate site and roadway grades.
- C. Machine slope banks to angle of repose or less, until shored.
- D. Grade top perimeter of excavation to prevent surface water from draining into excavation.
- E. Notify Geotechnical Engineer of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- F. Correct areas over-excavated with structural fill.
- G. Pile excavated material in manner that will not endanger the Work and that will avoid obstructing drives, temporary ditches or natural water courses, or create erosion or landslide hazards.
- H. Remove all excess excavated materials from the site.

3.7 TRENCH EXCAVATION

- A. Excavate topsoil from trench area to be further excavated.
 - 1. Stockpile topsoil to be reused in a designated area on-site.
- B. Excavate subsoil to full depth and grade to accommodate the laying of utilities and setting structures.
- C. Cut trenches sufficiently wide to enable installation of trench box, shoring, forms, utilities, and to allow inspection. Provide ample trench width to permit placing of fittings and thrust blocking. Maximum and minimum trench width for utilities in accordance with Drawings.
- D. Provide uniform surface of solid and undisturbed subgrade for placement of utility or bedding material. Hand trim excavation for bell and spigot pipe joints. Remove loose matter.
- E. Excavate to depth required below pipe invert.
- F. Remove ledge rock, boulders, and large stones greater than 6-inch diameter, to provide clearance of 6 inches below and 8 inches on each side of all utility pipes and fittings.
- G. Correct areas of utility trench over-excavated with compacted structural fill.
- H. Provide bedding material of the type and depth specified for the utility and in accordance with the Drawings.
- I. Remove all excess excavated materials from the site.

3.8 SITE GRADING

- A. General: Uniformly grade areas within project limits including adjacent transition areas. Smooth finished surface within specified tolerances, compact with uniform levels or slopes between points where elevations are indicated, or between such points and existing grades.
- B. Grading Outside Building Lines: Establish subgrade adjacent to building lines to drain away from structures and to prevent ponding.
 - 1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 1-1/2" above or below required subgrade elevations.

3.9 BACKFILLING TRENCHES AND UTILITY STRUCTURES

- A. Backfill excavated areas under existing and proposed pavements, including driveways to subgrade elevations with structural fill. Place backfill from top of bedding material to pavement subgrade in maximum 8-inch lifts, each lift compacted at or above 95 percent maximum density.
- B. Backfill excavated areas adjoining structures up to subgrade elevation with structural fill unless shown otherwise on Drawings. Place backfill in maximum 6-inch lifts, each lift compacted at or above 95 percent maximum density.
- C. Backfill excavated areas under lawns or improved areas to topsoil subgrade with select fill. Place backfill from top of bedding material to topsoil subgrade in maximum 12-inch lifts, each lift compacted at or above 95 percent maximum density.
- D. Employ placement and compaction methods that do not disturb or damage adjacent work.
- E. Maintain optimum moisture content of backfill material to attain required compaction density.
- F. Do not backfill with frozen material or where the material already in the excavation is frozen.
- G. Remove surplus backfill materials from site.

3.10 EMBANKMENT FOR PROPOSED PAVEMENT SUBGRADE

- A. Ground Surface Preparation: Remove vegetation, debris, unsatisfactory soil materials, obstructions, and deleterious materials from ground surface prior to placement of fills. Plow, strip, or break up sloped surfaces steeper than one (1) vertical to four (4) horizontal so that fill material will bond with existing surface.
 - 1. When existing ground surface has a density less than that specified break up ground surface, pulverize, moisture condition to optimum moisture content, and compact to required depth and percentage of maximum density. Place embankment fill material in maximum 6-inch horizontal lifts. Spread wet embankment fill in 8-inch loose lift and disc to expedite air drying. Remove rock particles larger than 4 inches.
- B. Adjust moisture content of embankment fill material to within 2 percent of optimum by either air drying or addition of water prior to compaction.
- C. Compact embankment fill with a smooth drum compactor weighing at least 30 tons and operating in the vibratory mode.

3.11 AGGREGATE COURSES FOR PAVEMENTS

- A. Verify that subgrade has been compacted to specified density and tested prior to placing geotextile.
- B. Place soil stabilization fabric on prepared subgrade in accordance with manufacturer's instructions. Remove rocks and other objectionable material that could puncture the fabric.

- C. Maintain grades, elevations and cross-slopes of aggregate base courses for proposed pavements, as shown on the Drawings.
- D. For proposed asphalt concrete pavements, construct base course to the compacted thickness shown on the Drawings with Type 2 Subbase.
- E. For proposed portland cement concrete pavements, construct base course to the compacted thickness shown on the Drawings with Type 2 Subbase.
- F. Place aggregate materials in layers of uniform thickness conforming to indicated cross-section and thickness. Maintain optimum moisture content for compacting base course during placement.
- G. Compact aggregate materials with a smooth drum compactor weighing at least 30 tons and operating in the vibratory mode. When a base course is more than 6 inches thick, place material in equal layers, except no single layer more than 6 inches or less than 3 inches in thickness when compacted.
- H. Use mechanical tamping equipment in areas inaccessible to drum compactor.
- I. Test roll aggregate base course with fully-loaded, ten-wheeled dump truck weighting at least 18 tons prior to placing asphalt concrete pavements.

3.12 PREPARATION OF SUBGRADE FOR LANDSCAPED AREAS

- A. Limit preparation to areas that will be planted in immediate future.
- B. Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1-1/2 inches in any dimension and sticks, roots, and rubbish.
- C. Provide subgrade with an even, smooth surface ready to receive topsoil.

3.13 COMPACTION

- A. General: Control soil compaction during construction providing minimum percentage of density specified for each area classification indicated below.
- B. Percentage of Maximum Density Requirements: Compact soil to not less than the following percentages of maximum dry density as determined in accordance with ASTM D1557.
 - 1. Pavements: Compact top twelve (12) inches of subgrade and each layer of backfill or fill material to ninety-five (95) percent maximum dry density, at +/- 2% of its optimum moisture content.
 - 2. Landscape areas: Compact top twelve (12) inches of subgrade and each layer of backfill or fill material to ninety (90) percent maximum dry density.
- C. Moisture Control: Where subgrade or layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer or soil material, to prevent free water appearing on surface during or subsequent to compaction operations.
 - 1. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.
 - a. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry. Assist drying by discing, harrowing or pulverizing until moisture content is reduced to within + 2% of its optimum moisture content.

3.14 DISPOSAL OF UNSUITABLE AND EXCESS EXCAVATED MATERIAL

- A. Load, remove, and dispose of all unsuitable and excess excavated material. Cover all loads leaving the site and using public highways.

- B. Construction debris, trash, and any other objectionable solid waste regulated by 6 NYCRR Part 360, will not be permitted to be buried on the project site.

3.15 TOLERANCES

- A. Excavation for Utility Structures and Trenches: Within plus or minus 2 inches.
- B. Top Surface of Backfilling: Within plus or minus 1 inch.
- C. Top Surface of Aggregate Base Course: Within 1/2 inch. Cross-slope within 1/4 inch when measured with a 10-foot straightedge.

3.16 PROTECTION

- A. Protect excavations by methods required to prevent cave-in or loose soil from falling into excavation.
- B. Protect bottom of excavations and soil adjacent to and beneath structures, from freezing.
- C. Protect, support and maintain all underground and surface structures to remain and other obstructions encountered. Restore structures which may have been disturbed.
- D. Encase all existing underground gas, electric, telephone, and cable utilities exposed during construction in cushion sand during backfilling of excavated areas.
- E. Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, reshape and compact to required density prior to further construction.
- F. Where settling is measurable or observable at excavated areas during warranty period, remove surface, add backfill material, compact and replace surface treatment.

END OF SECTION 310000

SECTION 310519 - GEOSYNTHETICS FOR EARTHWORK

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Geotextile for separation.
- B. Geotextile for filtration.

1.02 RELATED REQUIREMENTS

- A. Section 311000 - Site Clearing.
- B. Section 312316 - Excavation.
- C. Section 312323 - Fill.

1.03 REFERENCE STANDARDS

- A. AASHTO M 288 - Standard Specification for Geosynthetic Specification for Highway Applications.
- B. ASTM D4355/D4355M - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc-Type Apparatus.
- C. ASTM D4491/D4491M - Standard Test Methods for Water Permeability of Geotextiles by Permittivity.
- D. ASTM D4533/D4533M - Standard Test Method for Trapezoid Tearing Strength of Geotextiles.
- E. ASTM D4632/D4632M - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.
- F. ASTM D4751 - Standard Test Methods for Determining Apparent Opening Size of a Geotextile.
- G. ASTM D4833/D4833M - Standard Test Method for Index Puncture Resistance of Geomembranes and Related Products.
- H. ASTM D4873/D4873M - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
- I. ASTM D5199 - Standard Test Method for Measuring the Nominal Thickness of Geosynthetics.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements for submittal procedures.
- B. Product Data: Manufacturer's data on each product to be used, including physical properties, seaming materials, and installation instructions.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. See Section 016000 - Product Requirements for additional requirements.
- B. Identify, store, and handle geosynthetic rolls and samples according to ASTM D4873/D4873M.
- C. Protect materials from sunlight and other ultraviolet light sources during storage.
- D. Handle geosynthetics with care and prevent dragging, dropping, or imbalanced lifting.

1.07 FIELD CONDITIONS

- A. Temperature Requirements: Do not place geosynthetic when ambient air or base surface temperature is less than 40 degrees F or above 140 degrees F (60 degrees C).
- B. Surface Requirements: Do not place geosynthetic when the receiving surface is saturated or has ponded water.
- C. Follow recommendations of geosynthetic manufacturer.

PART 2 PRODUCTS

2.01 GEOSYNTHETIC

- A. Provide geosynthetic in largest size sheets as possible to minimize field joining.
- B. Uniform thickness according to ASTM D5199.
- C. Resistant to mildew, chemicals in soil, stable under freeze-thaw cycles, will not shrink or expand under wet conditions, and will not unravel or become clogged during use.
- D. Ultraviolet Stability: 65 percent, minimum, when tested in accordance with ASTM D4355/D4355M.

2.02 Geotextile

- A. General:
 - 1. Material: Polyethylene consisting of 5 percent maximum regrind and free of contaminants.
 - 2. AASHTO M 288.
 - 3. Elongation: 35 percent, minimum, when tested in accordance with ASTM D4632/D4632M.
- B. Geotextile for Separation: Capable of restricting adjacent material mixing.
 - 1. Type: Woven.
 - 2. Seams: Loose laid.
 - a. Overlap: According to manufacturer.

- 1) 12 inches (300 mm), minimum, in all directions.
 3. Grab Strength: 300 lb (1.3 kN), minimum, when tested in accordance with ASTM D4632/D4632M.
 4. Puncture Strength: 450 lb (2.0 kN), minimum, when tested in accordance with ASTM D4833/D4833M.
 5. Trapezoid Tear Strength: 100 lb (0.4 kN), minimum, when tested in accordance with ASTM D4533/D4533M.
- C. Geotextile for Filtration: Capable of allowing liquid passage while restricting solids.
1. Type: Nonwoven.
 2. Seams: Mechanically sewn.
 - a. Overlap: 3 inches (7.6 cm).
 - b. Stitch: Flat; continuous; tied off at ends.
 - c. Strength: 85 percent of grab, minimum, according to ASTM D4632/D4632M.
 3. Grab Strength: 300 lb (1.3 kN), minimum, when tested in accordance with ASTM D4632/D4632M.
 4. Permittivity: 0.5 per second, minimum, ASTM D4491/D4491M.
 5. Apparent Opening Size: No.40 (0.425 mm), maximum, when tested in accordance with ASTM D4751.
 6. Sewn Seam Strength: 275 lb (1.25kN), minimum, when tested in accordance with ASTM D4632/D4632M.
 7. Trapezoid Tear Strength: 100 lb (0.4 kN), minimum, when tested in accordance with ASTM D4533/D4533M.
 8. Puncture Strength: 450 lb (2.0 kN), minimum, when tested in accordance with ASTM D4833/D4833M.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify the receiving surface is smooth, without ruts or protrusions, and grades are according to design drawings.
- B. Verify the receiving surface is unsaturated and free of ponded water.
- C. Verify the geosynthetic is free of defects or flaws that may degrade physical performance.

3.02 PREPARATION

- A. Remove vegetation, boulders, and rocks larger than 3/4 inch in size and other sharp objects in accordance with Section 311000.
- B. Remove unsuitable materials in accordance with Section 312316.
- C. Fill in holes, including stake holes, backfill, and fill in accordance with Section 312323.

3.03 INSTALLATION

- A. General:
 1. Prevent surface drainage from eroding under geosynthetic. Repair undermined areas prior to backfill.

2. Position geosynthetic smooth and wrinkle free on prepared surface; unroll or unfold carefully, avoiding stretching.
3. Perform seaming in adequate lighting. Seam each geosynthetic member immediately after final placement. Clean sheets of dust, dirt, and other foreign matter prior to seaming.
4. Follow manufacturer's recommended installation procedures.

B. Separation:

1. Install geotextile according to manufacturer's recommendations.
2. Lay sheets in the direction of construction.
3. Repairs: Remove damaged portion of geotextile and seam an additional layer to cover the affected area in all directions.

C. Filtration:

1. Install geotextile according to manufacturer's recommendations.
2. Lay sheets in the direction of construction.
3. Repairs: Remove damaged portion of geotextile and seam an additional layer to cover the affected area in all directions. Replace geotextile where surface runoff contamination has occurred.

3.04 BACKFILL

- A. Backfill in a manner to prevent damage to geosynthetic. Repair geosynthetic damaged during backfill operations.
- B. Cover geosynthetic in the installed direction in accordance with Section 312323.

3.05 PROTECTION

- A. Do not exceed geosynthetic manufacturer's recommended exposure to UV radiation.
- B. Prevent surface water runoff from contaminating geosynthetic.
- C. Do not use pins or staples where risk of damaging underlying geosynthetic layer is present.
- D. Erect barricades to prevent traffic over geosynthetic before it is filled.

END OF SECTION 310519

SECTION 311000 – SITE CLEARING AND DEMOLITION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 01 – General Requirements which are hereby made a part of the Specifications.
- B. Examine all Drawings and other Sections of the Specification for requirements therein affecting the work of this section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure the steady progress of all work under the Contract.

1.2 SECTION INCLUDES

- A. Remove trees, shrubs, and other vegetation.
- B. Remove root system of trees and shrubs.
- C. Demolition and disposal of asphalt concrete pavements.
- D. Demolition, removal and abandoning of existing utilities.
- E. Pruning operations and tree protection.
- F. Temporary chain link fencing and gates.

1.3 RELATED SECTIONS

- A. Division 01 Section "Temporary Facilities and Controls" for temporary utilities, temporary construction and support facilities, temporary security and protection facilities.
- B. Division 01 Section "Stormwater Pollution Prevention Plan" for temporary erosion and sedimentation control requirements.
- C. Division 01 Section "Execution" for verifying utility locations and for recording field measurements.
- D. Division 31 Section "Site Earthwork" for soil materials, excavating, backfilling, and site grading.
- E. Division 32 Sections "Soil Preparation," "Turf and Grasses," and "Plants" for finish grading including preparing and placing planting soil mixes and testing of topsoil material.

1.4 DEFINITIONS

- A. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of weeds, roots, and other deleterious materials.
- B. Tree Protection Zone: Area surrounding individual trees or groups of trees to be protected during construction, and defined by the drip line of individual trees or the perimeter drip line of groups of trees, unless otherwise indicated.

1.5 SUBMITTALS

- A. Predemolition Photographs or Video: Show existing conditions of adjoining construction and site improvements, including finish surfaces, that might be misconstrued as damage caused by building and site demolition operations.

1.6 MATERIALS OWNERSHIP

- A. Except for materials indicated to be stockpiled, reinstalled or to remain Owner's property, cleared materials shall become Contractor's property and shall be removed from the site.

1.7 REGULATORY REQUIREMENTS

- A. Conform to applicable Local and State codes for disposal of debris.
- B. Submit to Owner a signed fill agreement or property owner release for deposit of debris material disposed of off site.
- C. Locate, identify, and protect utilities that remain, from damage. Be assured as to the location and position of gas, water, sewer, electric, telephone services and mains, culverts and other conduits that may be affected by the construction and notify the respective authorities in charge of same of the work in the vicinity. CALL Dig Safely New York (former Underground Facilities Protective Organization) 811 BEFORE STARTING EXCAVATION OPERATIONS. The Contractor will be held strictly responsible for the cost of repairs or replacement of all utilities and other conduits damaged directly by his forces or indirectly by failure to provide proper protection or support of the same. The Contractor will also be held responsible for damages to others caused by utility lines damaged either directly or indirectly by his operations. Comply with all rules and regulations cited in 16 NYCRR Part 753 – Protection of Underground Facilities.

1.8 UTILITY INTERRUPTIONS AND CONNECTIONS

- A. Coordinate the shutdown details for all utilities with the appropriate utility company. A minimum of four weeks notice to the utility company is required for shutdown scheduling and proper notice to those effected.
- B. Water valves will only be operated by authorized utility personnel.

1.9 MAINTENANCE AND PROTECTION OF TRAFFIC

- A. Do not close or obstruct public highways without written authorization from the controlling authority.
- B. When road or lane closures are required comply with the requirements of the Manual on Uniform Traffic Control Devices for Streets and Highways, current Edition for barricades and signage
- C. Notify the Tompkins County Emergency Control Center at (607)273-7288 at the beginning and end of a restriction on any highway.
- D. Schedule work so that all travel lanes in each direction are open when the Contractor's operations are closed down or substantially closed down.

1.10 JOB CONDITIONS

- A. Condition of Structure:
 - 1. The Contractor for the work of this Section shall be held to have visited the site, examined the premises, determined the existing conditions, character of equipment and facilities needed for the performance of the work, and all matters which may in any way affect the work.
 - a. Notify the Engineer and Owner if, during the course of demolition, conditions are discovered which significantly vary from those shown on the contract documents. Do not proceed until authorized by Engineer.

2. The Contractor shall accept the condition of the site and structures as found. The Engineer and Owner assume no responsibility for condition of site or structures nor the continuation of the condition existing at time of bidding, or thereafter.

PART 2 - PRODUCTS

2.1 PIPE PLUGS

- A. Mechanical Plugs: Expandable metal or plastic plug utilizing natural rubber "O" ring with wing nut or hex nut adjustment and suitable for long-term buried applications.

2.2 CHAIN LINK FENCES AND GATES

- A. System Description:
 1. Galvanized Steel Fence Fabric: 2 inch mesh, 9 gage wire.
 2. Fence Height: 8 feet nominal.
 3. Screening: Opaque fabric secured under all conditions to the fence fabric.
 4. Line Post Spacing: Spaced equidistant in fence line at intervals not exceeding 10 feet.
- B. Steel and Iron Posts: Manufactured in accordance with ASTM A120.
 1. Line Posts: 2.375 inch galvanized standard full weight.
 2. End, Corner and Pull Posts: 2.875 inch galvanized standard full weight.
 3. Gate Posts: 4 inch galvanized standard full weight.
- C. Swing Gate: Conforming to ASTM F 900, Schedule 40 galvanized steel frame, welded fabrication. Gate height and fabric to match fence.
 1. Double Gate Latch: Drop rod or plunger bar arranged to engage the gate stop. Construct locking device so that the center drop rod or plunger bar cannot be raised when the gate is locked. Latching device to have provision for a padlock.
 2. Gate stops.
- D. Wire Ties and Tension Wire: Tension wire to meet requirements of ASTM A641, as modified herein. No. 7 gage in diameter; tensile strength at least 80,000 psi with a galvanized coating no less than 0.7 oz. per square foot of surface area. No. 9 gage aluminum wire clips for attaching fence fabric to line posts.
- E. Concrete: 2,500 psi; 28-day strength.

2.3 TREE PROTECTION FENCE

- A. Wood Fence:
 1. Fence Height: 4 feet nominal.
 2. Line Post Spacing: Spaced equidistant in fence line at intervals not exceeding 8 feet.
 3. Line Posts: 4" x 4" Timber.
 4. Rails: 2" x 6" Timber.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Site Inspection
 1. Prior to work of this Section, carefully inspect the entire site and all objects designated to be removed and to be preserved.
 2. Coordinate and complete a walk-through of the site with Landscape Architect prior to site clearing to identify and tag plant life to be protected and preserved.
 3. Locate all existing utility lines and determine all requirements for disconnecting and capping.

4. Locate all existing active utility lines traversing the site and determine the requirements for protection.
- B. Clarification
 1. The drawings do not purport to show all objects existing on the site.
 2. Before commencing work of this Section, verify by inspection all objects to be removed and all objects to be preserved.
- C. Scheduling
 1. Schedule all work in a careful manner with all necessary consideration for neighbors and the public.
 2. Avoid interference with the use of, and passage to and from, adjacent buildings and facilities.
- D. Disconnection of Utilities: Before starting site operations, disconnect or arrange for the disconnection of all utility services designated to be removed, performing all such work in accordance with the requirements of the utility authority.
- E. Sealing Openings: Seal all unused utility structure openings and pipe penetrations with concrete brick and non-shrink grout.
- F. Protection of Utilities: Preserve in operating condition all active utilities traversing the site and designated to remain.
- G. Carefully review clearing work required adjacent to existing structures and subgrade foundations.

3.2 PROTECTION

- A. Locate, identify, and protect utilities and existing improvements that remain from damage.
- B. Protect existing trees and other vegetation indicated to remain in place against unnecessary cutting, breaking, or skinning and bruising of bark, smothering of trees by stockpiling construction materials or excavated materials within drip line, excess foot or vehicular traffic, or parking of vehicles within drip line. Erect and maintain protective fencing for trees and other vegetation.
- C. Protect survey benchmarks and property pins from damage or displacement.
- D. Conduct site clearing to ensure minimum interference with adjoining roads, driveways, fences and properties.
- E. Protect existing above and below grade structures designated to remain from damage. Correct any damage at Contractor's expense.

3.3 CLEARING

- A. Clear areas required for access to site and execution of Work.
- B. Remove trees and shrubs within site from areas to be further excavated to a depth greater than 12 inches. Remove stumps and main root ball. Carefully grade around trunks and root systems of trees that can remain.
- C. Where excavation over 3" in depth or removal of a tree is to occur within the root zone area of a tree to remain, make a clean-cut, using a trenching machine, in order to minimize disturbance to the undisturbed root zone. The cut shall be a minimum of 2 feet deep, between the designated disturbed and undisturbed root zone area.
- D. Tree protection: All trees on adjacent lands shall be protected from branch, trunk and root damage by providing the maximum offsets possible between the utility and the tree.

Additionally, branches shall be moved and tied out of the construction zone for the duration of construction activities. Any branches or roots cut, broken, severed or damaged which are greater than 1" in diameter shall be clearly pruned to the next major branch, trunk or large root. Every effort to minimize compaction by reducing or eliminating the movement of heavy equipment near trees shall be made.

1. Professionally prune damaged limbs of trees, shrubs, and bushes designated to remain.
2. Use only hand methods for grubbing inside the drip line of trees indicated to remain.

3.4 FENCE INSTALLATION

- A. Drive all fence posts into the earth a minimum of 24". In hardscape areas, or as approved by the owner, architect or engineer, metal upright stands may be used to hold fence sections in place.
- B. Brace each gate and corner post to adjacent line post with horizontal center brace rail and diagonal truss rods. Install brace rail, one bay from end and gate posts.
- C. Position bottom of fabric a minimum of 1 inch and no more than 2 inches above finished grade.
- D. Fasten fabric to line posts, braces, and bottom tension wire with tie wire at maximum 15 inches on centers.
- E. Install bottom tension wire stretched taut between terminal posts.
- F. Coordinate pad lock and keying requirements with Local Fire Department.

3.5 SITE DEMOLITION

- A. Sawcut all existing asphalt concrete pavements in straight line before removal.
- B. Remove, store, and protect scheduled items for reuse.
- C. Install and maintain gravel ramps adjoining existing highways.

3.6 REMOVAL

- A. Remove surface debris, rocks, trees and shrubs, and excavated stumps and root balls, from site.

3.7 SCHEDULE

- A. Where indicated on Drawings as "REUSE", "RESET", or "RELOCATE", carefully remove indicated items, clean, and store for reinstallation:
- B. Replace all salvaged items damaged by the Contractor at the Contractor's expense.

3.8 TREE PROTECTION PREPARATION

- A. No site preparation work shall begin in areas where tree preservation and treatment measures have not been completed as designated on the drawings and specified herein.

3.9 PRUNING

- A. Pruning shall proceed using standard arboricultural procedures and shall provide clearance for vehicular traffic, structures, equipment, tree protection fencing, line-of-sight, or trenching machines during pruning operations. Pruning shall also occur at affected vegetation edge and trees with protective fencing, to remove dead and diseased wood and to cleanly remove any ripped or hanging branches. See plan for scope of work.

3.10 TREE PROTECTION

- A. Tree protection fencing shall be located as shown on the plans. The exact locations will be marked in the field by the Contractor and approved by the Landscape Architect prior to installation.

- B. No access to fenced areas shall be permitted without prior approval by the Landscape Architect. Access for tree maintenance shall be provided into fenced areas with permission by the Landscape Architect.
- C. Contractor shall provide maintenance and repair of fence during duration of this contract.

3.11 MULCHING

- A. Trees within protective fencing and selected trees within high impact areas adjacent to construction shall be mulched at a 4-inch depth with shredded, well-aged hardwood bark mulch.

3.12 WATERING

- A. Trees within protective fencing shall be watered on a weekly basis during period of construction. Provide supplemental irrigation so that a minimum of 1 inch of water per week, including natural precipitation and irrigation, is supplied over entire area within protective fencing. Hoses and irrigation equipment to be supplied by Contractor.

END OF SECTION 311000

SECTION 312316 - EXCAVATION

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Excavating for footings, slabs-on-grade, and utilities within the building.
- B. Trenching for utilities outside the building to utility main connections.
- C. Temporary excavation support and protection systems.

1.02 RELATED REQUIREMENTS

- A. Section 023200 - Geotechnical Investigation
- B. Section 310000 - Earthwork (Site)
- C. Section 312323 - Fill: Fill materials, backfilling, and compacting for the building.

1.03 REFERENCE STANDARDS

- A. 29 CFR 1926 - Safety and Health Regulations for Construction.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Field Quality Control Submittals: Document visual inspection of load-bearing excavated surfaces.

1.05 QUALITY ASSURANCE

- A. Temporary Support and Excavation Protection Plan:
 - 1. Indicate sheeting, shoring, and bracing materials and installation required to protect excavations and adjacent structures and property.
 - 2. Include drawings and calculations for bracing and shoring.
 - 3. Bracing and shoring design to meet requirements of OSHA's Excavation Standard, 29 CFR 1926, Subpart P.
- B. Designer Qualifications: For design of temporary shoring and bracing, employ a Professional Engineer experienced in design of this type of work and licensed in the State in which the Project is located.
- C. Shoring Installer Qualifications: Company specializing in performing the shoring and bracing work of this section with minimum 5 years of documented experience.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Bedding and Fill to Correct Over-Excavation:
 - 1. See Section 312323 for bedding and corrective fill materials at building excavations.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that survey bench mark and intended elevations for the work are as indicated.
- B. Survey existing adjacent structures and improvements and establish exact elevations at fixed points to act as benchmarks.
 - 1. Resurvey benchmarks during installation of excavation support and protection systems and notify Owner if any changes in elevations or positions occur or if cracks, sags, or other damage is evident in adjacent construction.
- C. Determine the prevailing groundwater level prior to excavation. If the proposed excavation extends less than 1 foot into the prevailing groundwater, control groundwater intrusion with perimeter drains routed to sump pumps, or as directed by Engineer of Record. If the proposed excavation extends more than 1 foot into the prevailing groundwater, control groundwater intrusion with a comprehensive dewatering procedures, or as directed by Geotechnical Engineer.

3.02 PREPARATION

- A. Identify required lines, levels, contours, and datum locations.
- B. Locate, identify, and protect utilities that remain and protect from damage.
- C. Grade top perimeter of excavation to prevent surface water from draining into excavation. Provide temporary means and methods, as required, to maintain surface water diversion until no longer needed, or as directed by Engineer of Record.

3.03 TEMPORARY EXCAVATION SUPPORT AND PROTECTION

- A. Excavation Safety: Comply with OSHA's Excavation Standard, 29 CFR 1926, Subpart P.
 - 1. Excavations in stable rock or in less than 5 feet in depth in ground judged as having no cave-in potential do not require excavation support and protection systems.
 - 2. Depending upon excavation depth, time that excavation is open, soil classification, configuration and slope of excavation sidewalls, design and provide an excavation support and protection system that meets the requirements of 29 CFR 1926, Subpart P:
 - a. Sloping and benching systems.
 - b. Support systems, shield systems, and other protective systems.
- B. Leave excavation support and protection systems, used as formwork or within 10 feet of existing foundations, permanently in place, unless otherwise noted.
- C. Excavation support and protection systems not required to remain in place may be removed subject to approval of Owner or Owner's Representative.

1. Remove temporary shoring and bracing in a manner to avoid harmful disturbance to underlying soils and damage to buildings, structures, pavements, facilities and utilities.

3.04 EXCAVATING

- A. Excavate to accommodate new structures and construction operations.
 1. Excavate to the specified elevations.
 2. Excavate to the length and width required to safely install, adjust, and remove any forms, bracing, or supports necessary for the installation of the work.
 3. Cut utility trenches wide enough to allow inspection of installed utilities.
 4. Hand trim excavations. Remove loose matter.
- B. Notify Engineer of Record of unexpected subsurface conditions and discontinue affected Work in area until notified to resume work.
- C. Preparation for Piling Work: Excavate to working elevations. Coordinate special requirements for piling.
- D. Do not interfere with bearing splay of foundations.
- E. Provide temporary means and methods, as required, to remove all water from excavations until directed by Engineer of Record. Remove and replace soils deemed suitable by classification and which are excessively moist due to lack of dewatering or surface water control.

3.05 SUBGRADE PREPARATION

- A. See Section 312323 for subgrade preparation at building excavations.

3.06 FILLING AND BACKFILLING

- A. See Section 312323 for fill, backfill, and compaction requirements at building excavations.

3.07 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for general requirements for field inspection and testing.

3.08 CLEANING

- A. Remove excavated material that is unsuitable for re-use from site.
- B. Remove excess excavated material from site.

3.09 PROTECTION

- A. Divert surface flow from rains or water discharges from the excavation.
- B. Prevent displacement of banks and keep loose soil from falling into excavation; maintain soil stability.
- C. Protect open excavations from rainfall, runoff, freezing groundwater, or excessive drying so as to maintain foundation subgrade in satisfactory, undisturbed condition.

- D. Protect bottom of excavations and soil adjacent to and beneath foundation from freezing.
- E. Keep excavations free of standing water and completely free of water during concrete placement.

END OF SECTION 312316

SECTION 312323 - FILL

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Filling, backfilling, and compacting for building volume below grade, footings, slabs-on-grade, and utilities within the building.

1.02 RELATED REQUIREMENTS

- A. Section 023200 - Geotechnical Investigation.
- B. Section 310519 - Geosynthetics for Earthwork.
- C. Section 310000 - Earthwork (Site)
- D. Section 312316 - Excavation: Removal and handling of soil to be re-used.

1.03 DEFINITIONS

- A. Finish Grade Elevations: Indicated on drawings.
- B. Subgrade Elevations: Indicated on drawings.

1.04 REFERENCE STANDARDS

- A. ASTM C136/C136M - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.
- B. ASTM C150/C150M - Standard Specification for Portland Cement.
- C. ASTM D1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft³ (2,700 kN m/m³)).
- D. ASTM D2487 - Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
- E. ASTM D6938 - Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).

1.05 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data for Manufactured Fill.
- C. Materials Sources: Submit name of imported materials source.
- D. Fill Composition Test Reports: Results of laboratory tests on proposed and actual materials used, including manufactured fill.

- E. Compaction Density Test Reports.

1.06 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Independent firm specializing in performing testing and inspections of the type specified in this section.
- B. Copies of Documents at Project Site: Maintain at the project site a copy of each referenced document that prescribes execution requirements.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. When necessary, store materials on site in advance of need.

PART 2 PRODUCTS

2.01 FILL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from excavations.
- B. Satisfactory Soils: Soil Classification Groups GW, GP, GM, SW, SP, and SM according to ASTM D2487, or a combination of these groups; free of rock or gravel larger than 3 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter.
- C. Unsatisfactory Soils: Soil Classification Groups GC, SC, CL, ML, OL, CH, MH, OH, and PT according to ASTM D2487, or a combination of these groups.
- D. Structural Fill - Groups GW according to ASTM D2487.
- E. Concrete for Fill: Lean concrete.
- F. Imported Structural Fill - Gravel : Pit run washed stone; free of shale, clay, friable material and debris.
 - 1. Graded in accordance with ASTM C136/C136M, within the following limits:
 - a. 2 inch sieve: 100 percent passing.
 - b. 3/4 inch sieve: 45 to 95 percent passing.
 - c. No. 4 sieve: 30 to 90 percent passing.
 - d. No. 10 sieve: 25 to 80 percent passing.
 - e. No. 40: 10 to ____ percent passing.
 - f. No. 200: 5 to 12 percent passing.

2.02 ACCESSORIES

- A. Geotextile: See Section 310519.

2.03 SOURCE QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for general requirements for testing and analysis of soil material.

- B. Where fill materials are specified by reference to a specific standard, test and analyze samples for compliance before delivery to site.
- C. If tests indicate materials do not meet specified requirements, change material and retest.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Identify required lines, levels, contours, and datum locations.
- B. Verify areas to be filled are not compromised with surface or ground water.

3.02 PREPARATION

- A. Scarify and proof roll subgrade surface to a depth of 6 inches to identify soft spots.
- B. Cut out soft areas of subgrade not capable of compaction in place. Backfill with Structural Fill.
- C. Compact subgrade to density equal to or greater than requirements for subsequent fill material.
- D. Until ready to fill, maintain excavations and prevent loose soil from falling into excavation.

3.03 FILLING

- A. Fill to contours and elevations indicated using unfrozen materials.
- B. Employ a placement method that does not disturb or damage other work.
- C. Systematically fill to allow maximum time for natural settlement. Do not fill over porous, wet, frozen or spongy subgrade surfaces.
- D. Maintain optimum moisture content of fill materials to attain required compaction density.
- E. Structural Fill: Place and compact material in equal continuous layers not exceeding 8 inches compacted depth.
- F. Correct areas that are over-excavated.
 - 1. Other areas: Use structural fill, flush to required elevation, compacted to minimum 95 percent of maximum dry density.
- G. Compaction Density Unless Otherwise Specified or Indicated:
 - 1. Under slabs-on-grade and similar construction: 95 percent of maximum dry density.
- H. Maintain temporary means and methods, as required, to remove all water while fill is being placed as required, or until directed by the Engineer of Record. Remove and replace soils deemed unsuitable by classification and which are excessively moist due to lack of dewatering or surface water control.

3.04 FILL AT SPECIFIC LOCATIONS

- A. Structural Fill: Use for foundation subbase, foundation backfill, and slab subbase:
 - 1. Maximum depth per lift: 8 inches, compacted.

2. Compact to minimum 95 percent of maximum dry density.

3.05 TOLERANCES

- A. Top Surface of General Filling: Plus or minus 1 inch from required elevations.

3.06 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for general requirements for field inspection and testing.
- B. Soil Fill Materials:
 1. Perform compaction density testing on compacted fill in accordance with ASTM D6938.
 2. Evaluate results in relation to compaction curve determined by testing uncompacted material in accordance with ASTM D1557 ("modified Proctor").
 3. If tests indicate work does not meet specified requirements, remove work, replace and retest.
 4. Frequency of Tests: Building Slab Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 1000 sq. ft. or less of building slab, but in no case fewer than three tests. 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..
 5. Proof roll compacted fill at surfaces that will be under slabs-on-grade.

3.07 CLEANING

- A. See Section 017419 - Construction Waste Management and Disposal, for additional requirements.
- B. Leave unused materials in a neat, compact stockpile.
- C. Remove unused stockpiled materials, leave area in a clean and neat condition. Grade stockpile area to prevent standing surface water.
- D. Leave borrow areas in a clean and neat condition. Grade to prevent standing surface water.

END OF SECTION 312323

SECTION 316216.13 - SHEET STEEL PILES

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Driven steel sheet piling for retaining walls and foundations.
- B. Barricades, protection, temporary access roadways, maintenance and on-site testing.

1.02 RELATED REQUIREMENTS

- A. Section 312316 - Excavation: Pre-excavation and excavating.

1.03 REFERENCE STANDARDS

- A. AISC 303 - Code of Standard Practice for Steel Buildings and Bridges.
- B. AISC 360 - Specification for Structural Steel Buildings.
- C. ASTM A328/A328M - Standard Specification for Steel Sheet Piling.
- D. ASTM A514/A514M - Standard Specification for High-Yield-Strength, Quenched and Tempered Alloy Steel Plate, Suitable for Welding.
- E. ASTM F3125/F3125M - Standard Specification for High Strength Structural Bolts and Assemblies, Steel and Alloy Steel, Heat Treated, Inch Dimensions 120 ksi and 150 ksi Minimum Tensile Strength, and Metric Dimensions 830 MPa and 1040 MPa Minimum Tensile Strength.
- F. AWS D1.1/D1.1M - Structural Welding Code - Steel.
- G. NASSPA (BP) - NASSPA Best Practices Sheet Piling Installation Guide.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Shop Drawings: Submit drawings for approval of steel sheet piles prior to start of the work or ordering materials. Include details of top protection, special reinforcing tips, tip protection, and cut-off method.
 - 1. Include member locations, plans, elevations, dimensions, shapes, and each weld.
 - 2. Show complete dimensions on drawings, including minimum section properties and details of piling and the driving sequence and location of piling.
 - 3. Include details and dimensions of templates and other temporary guide structures for installing the piling.
 - 4. Provide details of the method of handling piling to prevent permanent deflection, distortion or damage to piling interlocks.
 - 5. Anchorages: Include locations, tolerances, and details of anchorage devices to be embedded in or attached to structure or other construction.
 - 6. Include reinforcement required for sheet pile at penetrations.

7. Include relationship of sheet pile units to adjacent materials.
- C. Certificates: Submit certificates for the following:
 1. Welder qualifications.
 2. Pile driving equipment.
- D. Project Record Documents: Accurately record the following:
 1. Sizes, lengths, and locations of piles.
 2. Sequence of driving.
 3. Number of blows per foot for entire length of piles and measured set for last 10 blows.
 4. Identify piles requiring drilling, and hole diameters.
 5. Final base and top elevations.
 6. Driving force of each hammer blow.

1.05 QUALITY ASSURANCE

- A. Pile Driving Equipment: Submit descriptions of pile driving equipment to be employed in the work. Descriptive information includes manufacturer's name, model numbers, capacity, rated energy, hammer details, cushion material, helmet, templates, and jetting equipment.
- B. Welder Qualifications: Qualified within previous 12 months in accordance with AWS D1.1/D1.1M and AWS D1.4/D1.4M.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Handle piling using handling holes or lifting devices.
- B. Handle long length piles with care to prevent damage.
- C. Support on level blocks or racks spaced not more than 10 feet apart and not more than 2 feet from the ends. Provide supports between multiple lifts in a vertical plane.
- D. Protect piling to prevent damage to coatings and to prevent corrosion prior to installation.

PART 2 PRODUCTS

2.01 STEEL SHEET PILES

- A. Design: The materials used for the construction of the walls shall be designed in accordance with: AISC 303 and AISC 360.
- B. Heavy gauge hot-rolled sheet piling complying with ASTM A328/A328M.
- C. Interlocking: Free-sliding interlocks, allowing a swing angle of at least 5 degrees when threaded and maintaining continuous interlocking when installed.
- D. Sheet piling, including special fabricated sections: Provide full-length sections of the dimensions shown.
 1. Fabricated sections: Comply with requirements included in the Section and the piling manufacturer's recommendations for fabricated sections.
 2. Provide sheet piling with standard pulling holes.

2.02 STEEL PLATES

- A. Structural Steel Plates: Comply with ASTM A514/A514M Grade ____ for splices and other fabrication appurtenances.

2.03 BOLTS, NUTS, AND WASHERS

- A. High-Strength Bolts, Nuts, and Washers: ASTM F3125/F3125M, Type 1, medium carbon, galvanized.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Examine site and the areas adjacent to the site.
- B. Examine Contract Documents, data, and other available information affecting the proposals and work.
- C. Verify existing conditions, dimensions, elevations, and related details.
- D. Field verify underground utility line locations. If verified location conflicts with drawings, or undocumented underground utilities are discovered, do not proceed with the Work until conflict is resolved. Notify Engineer of Record.
- E. Do not start the excavation or purchase the materials required until the design calculations, plans, and details have been reviewed by the Owner and Engineer of Record.

3.02 PREPARATION

- A. Prevent settlements or damage to existing structures, service lines, utilities, streets, walks, and other areas

3.03 INSTALLATION

- A. Perform earthwork in accordance with Section 312316. Pre-excavation will be permitted to a maximum depth as indicated. Backfill as indicated.
- B. Install sheet piles per NASSPA (BP).
- C. Pile Hammer: Use a pile hammer having a delivered force or energy suitable for the total weight of the pile and the character of subsurface material to be encountered. Operate hammer at the rates recommended by the manufacturer throughout the entire driving period. Repair damage to piling caused by use of a pile hammer with excess delivered force or energy.
- D. Pile Protection: Use a protecting cap during driving to prevent damage to the top of the sheet piling. Use cast steel shoe to prevent damage to the tip of the sheet piling.
- E. Templates:
 - 1. Prior to driving, provide template or driving frame suitable for aligning, supporting, and maintaining sheet piling in the correct position during setting and driving. Use a system of structural framing sufficiently rigid to resist lateral and driving forces and to

- adequately support the sheet piling until design tip elevation is achieved. Provide at least two levels of support, not less than 20 feet apart.
2. Do not allow templates to move when supporting sheet piling. Fit templates with wood blocking to bear against the web of each alternate sheet pile and hold the sheet pile at the design location alignment. Provide outer template straps or other restraints as necessary to prevent the sheets from warping or wandering from the alignment. Mark template for the location of the leading edge of each alternate sheet pile. If in view, also mark the second level to assure that the piles are vertical and in position. If two guide marks cannot be seen, other means must be used to keep the sheet pile vertical along its leading edge.
 3. Accurately place the piling using templates and guide frames unless otherwise recommended in writing by the sheet piling manufacturer.
- F. Pile Driving:
1. Continuously monitor vibrations, settlements, and movements to prevent damage to permanent structures and to ensure stability of excavations and constructed slopes.
 2. Maintain piling vertical during driving. Drive piles in such a manner as to prevent damage to the piles and to provide a continuous closure. Where possible, drive Z-pile with the ball end leading. If an open socket is leading, a bolt or similar object placed in the bottom of the interlock will minimize packing material into it and ease driving for the next sheet.
 3. Incrementally sequence driving of individual piles such that the tip of any sheet pile is not more than 4 feet below that of any adjacent sheet pile.
- G. Cutting and Splicing:
1. Cut off to the required elevation any piles driven to refusal or to the point where additional penetration cannot be attained and the piles are extending above the required top elevation in excess of the specified tolerance.
 2. Extend by splicing any piles driven below the required top elevation and piles damaged by driving and cut off to permit further driving. Splice as required to reach the top elevation when directed by the Engineer of Record.
 3. If directed by the Engineer of Record, splice piles as required to drive them to depths greater than shown on drawings and extend them up to the required top elevation. Piles adjoining spliced piles shall be full length unless otherwise approved.
 - a. Remove from the site pile cut-offs, which are the property of Contractor.
 - b. Use a straightedge in cutting by burning to avoid abrupt nicks.
 - c. Drill bolt holes or burn and ream by approved methods that will not damage the surrounding metal. Make holes other than bolt holes reasonably smooth and the proper size for rods or other items to be inserted.
 - d. Make holes in piles on the wet side of cofferdams watertight by welding steel plates over the holes after the piling installation is completed.
 - e. Do not use explosives for cutting.
 4. Cut tops of sheet piling to uniform elevation at top of wall as indicated on drawings.
- H. Welding: Comply with requirements of AWS D1.1/D1.1M for shop and field welding, qualification of welding procedures, welders, and welding operators.
- I. Tolerances in Driving:
1. Drive all piles with a variation from vertical of not more than 1/16 inch per foot.
 2. Place piles so the face will not be more than 2 inches from vertical alignment at any point.
 3. Top of pile at elevation of cut-off shall be within 1/2 inch horizontally and 1-1/2 inches vertically of the location indicated.

4. Manipulation of piles to force them into position will not be permitted. Check all piles for heave. Redrive all heaved piles to the required tip elevation.
5. Align exposed faces of sheet piling to vary not more than 1 inch from a horizontal line and not more than 1:120 out of vertical alignment. If survey results indicate that any piece of steel sheet pile does not meet these requirements, it shall be removed and re-driven.

3.04 FIELD QUALITY CONTROL

- A. See Section 014000 - Quality Requirements, for additional requirements.
- B. Maintain a pile driving record for each sheet pile. Indicate on the installation record installation dates and times, type and size of hammer, rate of operation, total driving time, dimensions of driving helmet and cap used, blows required per foot for each foot of penetration, final driving resistance in blows for final 6 inches, pile locations, tip elevations, ground elevations, cut-off elevations, and any reheading or cutting of piles. Record any unusual pile driving problems during driving. Submit complete records to Engineer of Record.
- C. Perform continuous inspection during pile driving. Inspect all piles for compliance with tolerance requirements. Bring any unusual problems that may occur to the attention of Engineer of Record.
- D. Inspection of Driven Piling:
 1. Inspect the interlocks of the portion of driven piles that extend above ground. Remove and replace piles found to be out of interlock.
 2. Pulling and Redriving: Contractor may be required to pull selected piles after driving to determine the condition of the underground portions of piles. The pile pulling method must be approved by Engineer of Record. Remove and replace at Contractor's expense any pile pulled and found to be damaged to the extent that its usefulness in the structure is impaired. Redrive piles pulled and found to be in satisfactory condition.
- E. Vibration Monitoring and Limitations:
 1. Driving of steel sheet pile wall may result in vibrations causing detrimental effects on existing adjacent buildings.
 2. Testing Agency will coordinate work with their representative and install monitoring devices in existing structures to avoid damage.
- F. Testing: Conduct dynamic testing on the sheet piles (3 test minimum).

3.05 PROTECTION

- A. Provide steel sheet pile walls and all other protections required.
- B. Protect and repair excavation slopes as necessary to maintain stability.
- C. Repair and replace any damage to existing structures that are to remain by the Contractor and without cost to the Owner.
- D. Barricades and Work Protections: Comply with the requirements of OSHA and all other applicable ordinances and codes.

END OF SECTION 316216.13

SECTION 321216 – ASPHALT PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 1 – General Requirements which are hereby made a part of the Specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SUMMARY

- A. Section Includes:
 - 1. Hot-mix asphalt paving.
 - 2. Pavement markings.
- B. Related Sections:
 - 1. Division 31 Section "Earth Moving" for aggregate base courses.

1.3 DEFINITION

- A. Hot-Mix Asphalt Paving Terminology: Refer to ASTM D 8 for definitions of terms.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated. Include technical data and tested physical and performance properties.
 - 1. Job-Mix Formula: From a NYSDOT approved plant, signed by the Regional Materials Engineer with the date of signature not more than two years old. Substitutions or cross outs on the signed JMF will not be accepted.
 - 2. Plant Certification: For each day's placement, certifying that all materials are in accordance with NYSDOT standards and a total of each mix type delivered to the job site under that contract.
- B. Qualification Data: For qualified manufacturer and Installer.
- C. Material Certificates: For each paving material, from manufacturer.
- D. Material Test Reports: For each paving material.

1.5 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A paving-mix manufacturer registered with and approved by NYSDOT.
- B. Testing Agency Qualifications: Qualified according to ASTM D 3666 for testing indicated.
- C. Regulatory Requirements: Comply with materials, workmanship, and other applicable requirements of NYSDOT for asphalt paving work.
 - 1. Measurement and payment provisions and safety program submittals included in standard specifications do not apply to this Section.

1.6 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. Tack Coat: Minimum surface temperature of 60 deg F (15.6 deg C).
 - 2. Slurry Coat: Comply with weather limitations in ASTM D 3910.
 - 3. Asphalt Base Course: Minimum surface temperature of 40 deg F (4.4 deg C) and rising at time of placement.
 - 4. Asphalt Surface Course: Minimum surface temperature of 60 deg F (15.6 deg C) at time of placement.

PART 2 - PRODUCTS

2.1 AGGREGATES

- A. General: Use materials and gradations that have performed satisfactorily in previous installations.
- B. Uncured or improperly cured slag aggregates have caused serious problems. Delete slag aggregates in remaining paragraphs if not recommended for local use.
- C. Coarse Aggregate: ASTM D 692, sound; angular crushed stone, crushed gravel, or cured, crushed blast-furnace slag.
- D. Fine Aggregate: ASTM D 1073 sharp-edged natural sand or sand prepared from stone, gravel, cured blast-furnace slag, or combinations thereof.
 - 1. In subparagraph below, reduce percentage of natural sand to 10 percent if slow, heavily loaded traffic is anticipated.
 - 2. For hot-mix asphalt, limit natural sand to a maximum of 20 percent by weight of the total aggregate mass.
- E. Mineral Filler: ASTM D 242 rock or slag dust, hydraulic cement, or other inert material.

2.2 ASPHALT MATERIALS

- A. Asphalt Binder: PG 64S-22, meeting requirements of AASHTO M320:
 - 1. Use of polyphosphoric acid (PPA) to modify the PG binder properties is prohibited. This prohibition also applies to the use of PPA as a cross linking agent for polymer modification.
 - 2. The mixture designs must be developed in accordance with the criteria specified in the SUPERPAVE Hot Mix Asphalt items that are appropriate for an estimated traffic level of <30 Million 80 kN ESALs.
- B. Asphalt Cement: ASTM D 3381 for viscosity-graded material.
- C. Tack Coat: In accordance with NYSDOT SS Section 407. Diluted to .05-.06 gal/sy for new paving. Diluted to .08-.10 gal/sy for existing HMA and Portland Cement Concrete.
- D. Water: Potable.
- E. Asphalt Joint Adhesives: Used on all transverse and longitudinal joints for top course in accordance with NYSDOT SS ITEM# 418.7603

2.3 MIXES

- A. Hot-Mix Asphalt: Dense, hot-laid, hot-mix asphalt plant mixes approved by authorities having jurisdiction; designed according to procedures in AI MS-2, "Mix Design Methods for Asphalt Concrete and Other Hot-Mix Types"; and complying with the following requirements:
 - 1. Provide mixes with a history of satisfactory performance in geographical area where Project is located.
 - 2. Binder Course: 19 mm Binder HMA NYSDOT ITEM# 402.197903
 - 3. Top Course: 9.5 mm Top HMA NYSDOT ITEM# 402.097203

2.4 AUXILIARY MATERIALS

- A. Pavement-Marking Paint: For all parking spaces, stop bars, and crosswalks within parking lots. Latex, waterborne emulsion, lead and chromate free, ready mixed, complying with FS TT-P-1952, Type II, with drying time of less than three minutes.
 - 1. Color: White and blue as indicated on drawings.

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 to identify soft pockets and areas of excess yielding. Do not proof-roll wet or saturated subgrades.

1. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Landscape Architect, and replace with compacted backfill or fill as directed.
- C. Proceed with paving only after unsatisfactory conditions have been corrected.
- D. Verify that utilities and other items requiring a cut and installation beneath the asphalt surface have been completed and that asphalt surface has been repaired flush with adjacent asphalt prior to beginning installation of imprinted asphalt.

3.2 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.
- B. Tack Coat: Apply uniformly to surfaces of existing pavement at a rate of 0.05 to 0.15 gal./sq. yd. (0.2 to 0.7 L/sq. m).
 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.

3.3 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. Revise first two subparagraphs below to suit Project. AI recommends that the minimum compacted thickness of hot-mix asphalt paving lift exceed three times the maximum nominal aggregate size.
 2. Place hot-mix asphalt base course in number of lifts and thicknesses indicated.
 3. Place hot-mix asphalt surface course in single lift.
 4. Revise first subparagraph below to higher temperature if thin lifts in cool weather are likely. See National Asphalt Pavement Association recommendations.
 5. Spread mix at minimum temperature of 250 deg F (121 deg C).
 6. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 7. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. 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.

3.4 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 (150 mm).
 - 3. Offset transverse joints, in successive courses, a minimum of 24 inches (600 mm).
 - 4. Compact joints as soon as hot-mix asphalt will bear roller weight without excessive displacement.
 - 5. Compact asphalt at joints to a density within 2 percent of specified course density.

3.5 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 (85 deg C).
- 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. Revise average density and range of acceptable densities in applicable subparagraph below if required. First subparagraph refers to Marshall test method. Revise to Superpave Gyratory Compactor method to verify field compaction if using Superpave method of mix design. Second subparagraph refers to Rice test method preferred by AI.
 - 2. Average Density: 96 percent of reference laboratory density according to ASTM D 6927, but not less than 94 percent nor greater than 100 percent.
- D. Finish Rolling: Finish roll paved surfaces to remove roller marks while hot-mix asphalt is still warm.
- E. Edge Shaping: While surface is being compacted and finished, trim edges of pavement to proper alignment. Bevel edges while asphalt is still hot; compact thoroughly.
- F. 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.

3.6 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 (13 mm).
 - 2. Surface Course: Plus 1/4 inch (6 mm), 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 (3-m) straightedge applied transversely or longitudinally to paved areas:
 - 1. Base Course: 1/4 inch (6 mm).
 - 2. Surface Course: 1/8 inch (3 mm).

3.7 PAVEMENT MARKING

- A. Do not apply pavement-marking paint until layout, colors, and placement have been verified with Architect.
- B. Sweep and clean surface to eliminate loose material and dust.
- C. 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 (0.4 mm).

3.8 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: Asphalt mixtures shall be in accordance with NYSDOT SS 402-3 with the following exceptions and notations:
 - 1. Cornell will provide the Third-Party acceptance testing for the pavement density testing by nuclear density gauge. Contractors are encouraged to have their own trained and certified technicians to assure quality and to verify Third Party results.
 - 2. Pavement Density will be verified and accepted by the 70 Series Compaction Methods with all acceptance testing by the Cornell University Third Party Technician. Cornell reserves the right to take pavement cores to test for density in accordance with this section. Contractors shall work with the University to assure that the requirements of

the section are carried out with full cooperation of the paving contractor or subcontractor.

- 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.

3.9 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 – CEMENT CONCRETE PAVEMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 01 – General Requirements which are hereby made a part of the Specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SUMMARY

- A. Section includes: exterior cement concrete for the following:
 - 1. Exterior cement concrete pavement for walkways.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving” for subgrade preparation, grading, and base course.

1.3 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, expansive hydraulic cement, fly ash and other pozzolans, ground granulated blast-furnace slag, and silica fume.

1.4 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixes: For each concrete pavement mix. Submit proposed concrete design mix together with name and location of batching plant at least 28 days prior to the start of concrete work. Include alternate mix designs (subject to review by Landscape Architect) when characteristics of materials, project conditions, weather, test results, or other circumstances warrant adjustments.
 - 1. Indicate amounts of water to be withheld for later addition at Project site (generally all water shall be added to transit mixer at batch plant).
- C. Shop drawings: Submit shop drawings of proposed concrete pavement pattern and layout including expansion joint locations.
- D. Material Test Reports: From a qualified testing agency indicating and interpreting test results for compliance of the following with requirements indicated, based on comprehensive testing of current materials:
- E. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:
 - 1. Cementitious materials and aggregates.

- a. Provide brand and manufacturer's name
 - b. Provide a test performed within the previous month for Alkali-Silica Reaction in aggregates.
- 2. Form materials and form-release agents.
- 3. Fiber reinforcement.
- 4. Steel reinforcement and reinforcement accessories.
- 5. Admixtures.
- 6. Sealing compounds.
- 7. Applied finish materials.
- 8. Adhesives and epoxies.
- 9. Joint fillers.
- 10. Joint-filler strips.
- 11. Repair materials.
- 12. ADA detectable warning surface.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer who has completed pavement work similar in material, design, and extent to that indicated for this Project and whose work has resulted in construction with a record of successful in-service performance.
- B. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products complying with ASTM C 94 requirements for production facilities and equipment.
 - 1. Manufacturer must be certified according to the National Ready Mix Concrete Association's Plant Certification Program.
- C. Testing Agency Qualifications: An independent testing agency, acceptable to authorities having jurisdiction, qualified according to ASTM C 1077 and ASTM E 329 to conduct the testing indicated, as documented according to ASTM E 548.
 - 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.
- D. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant and each aggregate from one source, and each admixture from the same manufacturer.
- E. Welding: Qualify procedures and personnel according to AWS D1.4, "Structural Welding Code-Reinforcing Steel."
- F. ACI Publications: Comply with the following, unless more stringent provisions are indicated:
 - 1. ACI 301, "Specification for Structural Concrete."
 - 2. ACI 117, "Specifications for Tolerances for Concrete Construction and Materials."
- G. Concrete Testing Service: Owner to engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixes.
- H. Pre-installation Conference: Conduct conference at Project site to include Owner, Landscape Architect, General Contractor and Concrete Subcontractor.
 - 1. Before submitting design mixes, review concrete mix design and examine procedures for ensuring quality of concrete materials. Require representatives of each entity directly concerned with cast-in-place are to attend, including the following:
 - a. Contractor's superintendent.
 - b. Independent testing agency responsible for concrete design mixes.

- c. Ready-mix concrete producer.
 - d. Concrete subcontractor.
- 2. Layout of all walkways shall be reviewed to ensure alignments as demonstrated on Contract Documents.
- 3. Scoring patterns and layout shall be reviewed prior to execution.
- I. Fiber reinforcement manufacturer shall provide representative for first placement (pre-pour, on-site, or at ready-mix plant) as required.

1.6 TEST PLACEMENT SECTION

- A. Contractor shall prepare a test placement at minimum equal to 10 linear foot of sidewalk at the design width. The purpose of this test placement is to become familiar with the materials, the consistency, admixtures, fibers and other reinforcing, etc. in addition to the finishing requirements which may include consolidating, floating, broom finish, etc.
- B. The Test Placement may be included as part of the finished work at the Approval of the Owner's Representative.
- C. Subsequent placements shall be staggered such that the test section can be placed and finished to meet the Owner's requirements. Any placement prior to acceptance of the test section may be required to be removed and replaced at the Contractor's expense.
- D. Removal of test sections not approved for incorporation into the final work shall be the responsibility of the Contractor.

1.7 DELIVERY STORAGE AND HANDLING

- A. Deliver, store and handle steel reinforcement to prevent bending and damage.

1.8 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities and access to the building.

PART 2 - PRODUCTS

2.1 STEEL REINFORCEMENT

- A. Reinforcement Bars: ASTM A 615/A 615M, Grade 60 (Grade 420), deformed.
- B. Epoxy-Coated Reinforcement Bars: ASTM A 775; with ASTM A 615, Grade 60, bars.

2.1 FIBER REINFORCEMENT

- A. Synthetic Fiber: Macro-synthetic fibers shall be manufactured specifically for the reinforcement of concrete and be in accordance with ASTM 1116, Class III. Fibers shall provide temperature and shrinkage reinforcement, provide moderate benefits to reduce cracking, and increase toughness of concrete.
- B. Fibers shall be grey color, virgin polypropylene/co-polymer blend, 2" minimum length, and designed for broom finished concrete and be designed to take the place of traditional 6 x 6, W 2.9

W2.9 mesh. Use at minimum 4 pounds / cubic yard. Micro-synthetic and cellulose fibers shall not be permitted. Fiber reinforcement manufacturer shall provide representative for first placement (pre-pour, on-site, or at ready-mix plant) as required.

1. Available Products:
 - a. Forta-Ferro by Forta, Grove City, PA, (800) 245-0306, www.forta-ferro.com
 - b. ICF M Macro Plus, by ICF Concrete Additives, Warren, NJ (908) 293-8280, www.icfconcreteadditives.com
 - c. Strux by Grace Construction Products, Cambridge, MA, (877)423-6491, www.gcpat.com
 - d. Tuf-Strand by Euclid Chemical Company, Cleveland, OH, (800) 321-7628, www.euclidchemical.com
 - e. Approved equivalent.

- C. Supplier shall adjust mix at plant to account for changes in slump after addition of fibers, possibly requiring need for water reducers or other admixture to assure workability on the jobsite. Required Water Cement Ratio shall not be changed.

2.2 REINFORCEMENT ACCESSORIES

- A. Bar Supports: Bolsters, chairs, spacers, and other devices for spacing, supporting, and fastening reinforcement bars, welded wire fabric, and dowels in place. Manufacture bar supports according to CRSI's "Manual of Standard Practice" from steel wire, plastic, or precast concrete or fiber-reinforced concrete of greater compressive strength than concrete, and as follows:
 1. Equip wire bar supports with sand plates or horizontal runners where base material will not support chair legs.
- B. Epoxy Repair Coating: Liquid, two-part, epoxy repair coating; compatible with epoxy coating on reinforcement and complying with ASTM A 775/A 775M.

2.3 CONCRETE MATERIALS

- A. General: Use the same brand and type of cementitious material from the same manufacturer throughout the Project.
- B. Portland Cement: ASTM C 150, Type I or II.
 1. Fly Ash: ASTM C 618, Class F or C.
- C. Normal Weight Aggregate: ASTM C 33, uniformly graded, from a single source, as follows:
 1. Class: Severe weathering region, but not less than 3S.
 2. Nominal Maximum Aggregate Size: 1 inch (38mm) Refer to design mix.
 3. Combined Aggregate Gradation: Well graded from coarsest to finest with not more than 18 percent and not less than 10 percent retained on an individual sieve, except that less than 8 percent may be retained on sieves finer than No. 5 (0.3mm).
 4. Do not use fine or coarse aggregates containing substances that cause spalling.
- D. Water: ASTM C 94.

2.4 ADMIXTURES

- A. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures and that will not contribute water-soluble chloride ions exceeding those permitted in

hardened concrete. Do not use calcium chloride or admixtures containing calcium chloride. Refer to design mixes.

- B. Air-Entraining Admixture: ASTM C 260.
- C. High-Range, Water-Reducing Admixture: ASTM C 494, Type F.
- D. Water-Reducing and Retarding Admixture: ASTM C 494, Type A.

2.5 CURING MATERIALS

- A. Absorptive Cover: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) dry.
- B. Moisture-Retaining Cover: ASTM C 171, or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cimfilm; Axim Concrete Technologies.
 - b. Finishing Aid Concentrate; Burke Group, LLC (The).
 - c. Spray-Film; ChemMasters.
 - d. Aquafilm; Conspec Marketing & Manufacturing Co., Inc.
 - e. Sure Film; Dayton Superior Corporation.
 - f. Eucobar; Euclid Chemical Co.
 - g. Vapor Aid; Kaufman Products, Inc.
 - h. Lambco Skin; Lambert Corporation.
 - i. E-Con; L&M Construction Chemicals, Inc.
 - j. Confilm; Master Builders, Inc.
 - k. Waterhold; Metalcrete Industries.
 - l. Rich Film; Richmond Screw Anchor Co.
 - m. SikaFilm; Sika Corporation.
 - n. Finishing Aid; Symons Corporation.
- E. Other moisture loss control – for prevention of moisture loss prior to the primary method of curing:
 - 1. “The Bean” - a soybean oil based sealer/water repellant reduces surface color markings from plastic sheeting, enhances strength and durability, but does not reduce porosity.
- F. Curing Compound: NOT PERMITTED.

2.6 JOINT SEALANT

- A. Type SL Silicone Sealant for Concrete and Asphalt: Single-component, low-modulus, neutral-curing, self-leveling silicone sealant complying with ASTM D 5893 for Type SL.
 - 1. Available Products:
 - a. Crafcro Inc.; RoadSaver Silicone SL.
 - b. Dow Corning Corporation; 890-SL.

2.7 JOINT-SEALANT BACKER MATERIALS

- A. General: Provide joint-sealant backer materials that are non-staining; are compatible with joint substrates, sealants, primers, and other joint fillers; and are approved for applications indicated by joint-sealant manufacturer based on field experience and laboratory testing.
- B. Round Backer Rods for Cold- and Hot-Applied Sealants: ASTM D 5249, Type 1, of diameter and density required to control sealant depth and prevent bottom-side adhesion of sealant.

2.8 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D 1751, asphalt-saturated cellulosic fiber.
- B. Dowel alignment system:
 - 1. Products
 - a. Speed Load PSD1/2x9LT, dowel sleeve in sizes for ½" x 18" dowel bar; by Greenstreak Inc, 800-325-9504, or approved equal.
- C. Clear, Waterborne, Membrane-Forming Sealing Compound: ASTM 1315, Type 1, Class A.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. V-Seal 102 Winter Guard Penetrating Sealer
 - b. Approved equivalent.

2.9 CONCRETE MIXES

- A. Prepare design mixes, proportioned according to ACI 211.1 and ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
- B. Use a qualified independent testing agency for preparing and reporting proposed mix designs for the trial batch method.
- C. Mix Design: W.F. Saunders & Son, Inc. (Tel. 315-469-3217) or approved equivalent. Mix ID: LS51/705 (no water reducer mix)
 - 1. Proportion mixes to provide concrete with the following properties:
 - a. Compressive Strength (28 Days): 5000 psi (27.6 MPa).
 - b. ESSROC Cement Co. Low Alkali Type I/II Portland Cement: 564 #/CY.
 - c. RMS Gravel Inc., Freeville NYSDOT Concrete Sand: 11800 #/CY
 - d. Marcellus NYSDOT Limestone : #1's 3/4" (1645 #/CY)
 - e. ESSROC Cement Co. Ground Granulated Blast-Furnace Slag: 141 #/CY
 - f. Air Entrained: 6% +/- 1.5%.
 - g. MasterAir 100 BASF 0.5 oz
 - h. Water-Cement Ratio Lbs / Lb: 0.41.
 - i. Curing: Moist cure for 7 days minimum with burlene or approved equivalent
 - j. **Air entrainment dosage to be adjusted for field conditions**
- D. Cementitious Materials: Limit percentage, by weight, of cementitious materials other than portland cement according to ACI 301 requirements for concrete exposed to deicing chemicals.
- E. Limit water-soluble, chloride-ion content in hardened concrete to 0.15 percent by weight of cement.
- F. Admixtures: Use admixtures according to manufacturer's written instructions.

1. Use water reducing admixture or high-range water-reducing admixture (superplasticizer) in concrete, as required, for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
- G. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 4.0 lb/cu. yd.

2.10 FABRICATING REINFORCEMENT

- A. Fabricate steel reinforcement according to CRSI's "Manual of Standard Practice."

2.11 CONCRETE MIXING

- A. Ready-Mixed Concrete: Comply with requirements and with ASTM C 94. Furnish batch ticket information to concrete testing representative.
1. When air temperature is between 85 deg F (30 deg C) and 90 deg F (32 deg C), reduce mixing and delivery time from 1-1/2 hours to 75 minutes; when air temperature is above 90 deg F (32 deg C), reduce mixing and delivery time to 60 minutes.

2.12 ADA DETECTABLE WARNING SURFACE

- A. ADA Detectable Warning Surface: Cast Iron Detectable Warning plate with a non-slip texture on the travel surface. Material used to provide visual warning shall be an integral part of the detectable warning surface. Visual contrast to meet the existing ADAAG A4.2.9.2.
1. Detectable Warning Plate Model R-4984 by Neenah Foundry, 2121 Brooks Avenue, Neenah, WI 54956, (800) 558-5075, www.nfco.com
 2. Iron Dome by ADA Solutions, Inc., 323 Andover Street, Wilmington, MA 01887, (800)372-0519, www.adatile.com.
 3. Cast Iron Detectable Warning Tile by TufTile, 1200 Flex Court, Lake Zurich, IL 60047, (888)960-8897, www.tuftile.com

PART 3 - EXECUTION

3.1 PREPARATION

- A. Proof-roll prepared base surface to check for unstable areas and verify need for additional compaction. Proceed with pavement only after nonconforming conditions have been corrected and subgrade is ready to receive pavement.
- B. Remove loose material from compacted base surface immediately before placing concrete.

3.2 EDGE FORMS AND SCREED CONSTRUCTION

- A. Set, brace, and secure edge forms, bulkheads, and intermediate screed guides for pavement to required lines, grades, and elevations. 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.

3.3 FORMWORK

- A. Design, erect, shore, brace, and maintain formwork, according to ACI 301, to support vertical, lateral, static, and dynamic loads, and construction loads that might be applied, until structure can support such loads.
- B. Construct formwork so concrete members and structures are of size, shape, alignment, elevation, and position indicated, within tolerance limits of ACI 117.
- C. Limit concrete surface irregularities, designated by ACI 347R as abrupt or gradual, as follows:
 - 1. Class A, 1/8 inch (3mm).
- D. Construct forms tight enough to prevent loss of concrete mortar.
- E. Fabricate forms for easy removal without hammering or prying against concrete surfaces. Provide crush or wrecking plates where stripping may damage cast concrete surfaces. Provide top forms for inclined surfaces steeper than 1.5 horizontal to 1 vertical.
 - 1. Install keyways, reglets, recesses, and the like, for easy removal.
 - 2. Do not use rust-stained steel form-facing material.
- F. Set edge forms, bulkheads, and intermediate screed strips for slabs to achieve required elevations and slopes in finished concrete surfaces. Provide and secure units to support screed strips; use strike-off templates or compacting-type screeds.
- G. Provide temporary openings for cleanouts and inspection ports where interior of formwork is inaccessible. Close openings with panels tightly fitted to forms and securely braced to prevent loss on concrete mortar. Locate temporary openings in forms at inconspicuous locations.
- H. Form openings, chases, offsets, sinkages, keyways, reglets, blocking, screeds, and bulkheads required in the Work. Determine sizes and locations from trades providing such items.
- I. Clean forms and adjacent surfaces to receive concrete. Remove chips, wood, sawdust, dirt, and other debris just before placing concrete.
- J. Retighten forms and bracing before placing concrete, as required, to prevent mortar leaks and maintain proper alignment.
- K. Coat contact surfaces of forms with form-release agent, according to manufacturer's written instructions, before placing reinforcement.

3.4 REMOVING AND REUSING FORMS

- A. General: Formwork that does not support weight of concrete may be removed after cumulatively curing at not less than 50 deg F (10 deg C) for 24 hours after placing concrete, if concrete is hard enough to not be damaged by form-removal operations and curing and protection operations are maintained.
- B. Leave formwork that supports weight of concrete in place until concrete has achieved at least 70 percent of its 28-day design compressive strength.
 - 1. Determine compressive strength of in-place concrete by testing representative field or laboratory cure test specimens according to ACI 301.
 - 2. Remove forms only if shores have been arranged to permit removal of forms without loosening or disturbing shores.
- C. Clean and repair surfaces of forms to be reused in the Work. Split, frayed, delaminated, or otherwise damaged form-facing material will not be acceptable for exposed surfaces. Apply new form-release agent.

- D. When forms are reused, clean surfaces, remove fins and laitance, and tighten to close joints. Align and secure joints to avoid offsets. Do not use patched forms for exposed concrete surfaces unless approved by Landscape Architect.

3.5 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating reinforcement and with recommendations in CRSI's "Placing Reinforcing Bars" for placing and supporting reinforcement.
 - 1. Apply epoxy repair coating to uncoated or damaged surfaces of epoxy-coated reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Accurately position, support, and secure reinforcement against displacement. Locate and support reinforcement with bar supports to maintain minimum concrete cover. Do not tack weld crossing reinforcing bars.
 - 1. Shop or field weld reinforcement according to AWS D1.4, where indicated.
- D. Set wire ties with ends directed into concrete, not toward exposed concrete surfaces.
- E. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch (50-mm) overlap to adjacent mats.

3.6 JOINTS

- A. General: Construct construction, isolation, and contraction joints and tool edgings true to line with faces perpendicular to surface plane of concrete. Construct transverse joints at right angles to centerline, unless otherwise indicated.
 - 1. When joining existing pavement, place transverse joints to align with previously placed joints, unless otherwise indicated.
- B. Construction Joints: Install so strength and appearance of concrete is not impaired, at locations indicated or approved by Landscape Architect. Refer to drawings for details. Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour, unless pavement terminates at isolation joints.
 - 1. Install epoxy coated dowel bars and plastic dowel sleeves at joints.
 - 2. Continue reinforcement across construction joints, unless otherwise indicated. Do not continue reinforcement through sides of pavement strips, unless otherwise indicated.
 - 3. Use a bonding agent at locations where fresh concrete is placed against hardened or partially hardened concrete surfaces.
- C. Contraction Joints in Slabs-on-Grade: Form weakened-plane contraction joints, sectioning concrete into areas as indicated. Construct contraction joints for a depth equal to at least one-fourth of 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- (3-mm-) wide joints into concrete when cutting action will not tear, abrade, or otherwise damage surface and before developing random contraction cracks, no fewer than 7 days.

- D. Isolation Joints in Slabs-on-Grade: After removing formwork, install joint-filler strips at slab junctions with vertical surfaces, such as column pedestals, foundation walls, grade beams, and other locations, as indicated.
 - 1. Locate expansion joints at intervals of 30 feet, unless otherwise indicated.
 - 2. Extend joint-filler strips full width and depth of joint, terminating flush with finished concrete surface, unless otherwise indicated.
 - 3. Terminate full-width joint-filler strips not less than ½ inch (13 mm) or more than 1 inch (25 mm) below finished concrete surface where joint sealants are indicated.
 - 4. Install joint-filler strips in lengths as long as practicable. Where more than one length is required, lace or clip sections together.
- E. Doweled Joints: Install dowel bars and support assemblies at joints where indicated.

3.7 CONCRETE PLACEMENT FOR WALKS

- A. Inspection: Before placing concrete, inspect and complete formwork installation, reinforcement steel, and items to be embedded or cast in. Notify other trades to permit installation of their work.
- B. Remove snow, ice, or frost from subbase surface and reinforcement before placing concrete. Do not place concrete on frozen surfaces.
- C. Moisten subbase to provide a uniform dampened condition at the time concrete is placed. Do not place concrete around manholes or other structures until they are at the required finish elevation and alignment.
- D. Comply with requirements and with recommendations in ACI 304R for measuring, mixing, transporting, and placing concrete.
- E. Do not add water to concrete during delivery, at Project site, or during placement.
- F. 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.
- G. Consolidate concrete by mechanical vibrating equipment supplemented by hand-spading, rodding, or tamping. Use equipment and procedures to consolidate concrete according to recommendations in ACI 309R.
- H. Screed pavement surfaces with a straightedge and strike off. Commence initial floating using bull floats or darbies to form 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 dry-shake surface treatments.
- I. Cold-Weather Placement: Comply with ACI 306.1 and as follows. Protect concrete work from physical damage or reduced strength that could be caused by frost, freezing actions, or low temperatures.
 - 1. When air temperature has fallen to or is expected to fall below 40 deg F (4.4 deg C), uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 deg F (10 deg C) and not more than 80 deg F (27 deg C) 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 mix designs.
- J. Hot-Weather Placement: Place concrete according to recommendations in ACI 305R and as follows when hot-weather conditions exist:

1. Cool ingredients before mixing to maintain concrete temperature at time of placement below 90 deg F (32 deg C). Chilled mixing water or chopped ice may be used to control temperature, provided water equivalent of ice is calculated to total amount of mixing water. Using liquid nitrogen to cool concrete is Contractor's option.
2. Cover reinforcement steel with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
3. Fog-spray forms, reinforcement steel, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.8 CONCRETE FINISHING FOR WALKS

- A. General: Wetting of concrete surfaces during screeding, initial floating, or finishing operations is prohibited.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and the 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 broom finish: Apply nonslip medium broom finish to exterior concrete walks. Immediately after float finishing, slightly roughen concrete surface by brooming with fiber-bristle broom, perpendicular to main traffic route. Coordinate required final finish with Landscape Architect prior to application.

3.9 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and follow recommendations in ACI 305R for hot-weather protection during curing.
- B. All curing supplies shall be on project site prior to commencement of concrete placement. This shall include identification of water supply, and all curing materials.
- C. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including slabs and other surfaces.
- D. Commence curing activity as soon as concrete has set to a state where it cannot be easily marred. Conditions may require application of an evaporation retarder to keep surface from drying out during set time. Curing objective shall be to provide constant water supply for concrete hydration through means and methods of the contractor. This shall include a source of clean water available at all times. Avoid concentrated watering that may erode the fresh concrete. If using hydrant water, flush any discolored water prior to hooking up to soaker hoses or sprinkler/mister. Water can be turned off at times during cure as long as it remains wet. Wet cure for 7 days and have personnel available at all times during that period to attend to curing issues that may arise. If curing has to be cut short, due to circumstances and as directed by the University, apply specified cure and seal product on moist concrete to continue curing process for remaining time. Contractor shall submit detailed curing plan prior to planned placement.
- E. Cure concrete according to ACI 308.1, by the following method:
 1. Moisture Curing: Keep surfaces continuously moist for not less than seven days with the following materials:
 - a. Water.

- b. Absorptive cover, water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch (300-mm) lap over adjacent absorptive covers. Minimize cover contact with concrete to prevent staining.

2. Curing Compound: NOT PERMITTED

3.10 SEALER

- A. Exterior Sealer: Apply two (2) coats of specified sealer to exterior concrete slabs, walks, landings, steps, walls, ramps and curbs according to manufacturer's directions. Apply uniformly in a continuous operation by power spray or roller according to manufacturer's written instructions. Recoat areas subjected to heavy rainfall within three hours after initial application. Repeat process 24 hours later and apply a second coat. Maintain continuity of coating and repair damage during curing period. If 7 day curing period is not feasible, the VSeal 102 product can be applied to wet or moist concrete in accordance to manufacturer's recommendations.

3.11 INSTALLATION OF JOINT SEALANTS

- A. General: Comply with joint-sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
- B. Sealant Installation Standard: Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- C. Install backer materials of type indicated to support sealants during application and at position required to produce cross-sectional shapes and depths of installed sealants relative to joint widths that allow optimum sealant movement capability.
 - 1. Do not leave gaps between ends of backer materials.
 - 2. Do not stretch, twist, puncture, or tear backer materials.
 - 3. Remove absorbent backer materials that have become wet before sealant application and replace them with dry materials.
- D. Install sealants using proven techniques that comply with the following and at the same time backings are installed:
 - 1. Place sealants so they directly contact and fully wet joint substrates.
 - 2. Completely fill recesses provided for each joint configuration.
 - 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- E. Tooling of Nonsag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified below to form smooth, uniform beads of configuration indicated; to eliminate air pockets; and to ensure contact and adhesion of sealant with sides of joint.
 - 1. Remove excess sealants from surfaces adjacent to joint.
 - 2. Use tooling agents that are approved in writing by joint-sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- F. Provide joint configuration to comply with joint-sealant manufacturer's written instructions, unless otherwise indicated.
- G. Provide recessed joint configuration for silicone sealants of recess depth and at locations indicated.

3.12 CONCRETE SURFACE REPAIRS

- A. Defective Concrete: Repair and patch defective areas when approved by Landscape Architect. Remove and replace concrete that cannot be repaired and patched to Landscape Architect's approval.
- B. Repairing Formed Surfaces: Surface defects include color and texture irregularities, cracks, spalls, air bubbles, honeycombs, rock pockets, fins and other projections on the surface, and stains and other discolorations that cannot be removed by cleaning.
 - 1. Immediately after form removal, cut out honeycombs, rock pockets, and voids more than ½ inch (13 mm) in any dimension in solid concrete, but not less than 1 inch (25 mm) in depth. Make edges of cuts perpendicular to concrete surface. Clean, dampen with water, and brush-coat holes and voids with bonding agent. Fill and compact with patching mortar before bonding agent has dried. Fill form-tie voids with patching mortar or cone plugs secured in place with bonding agent.
 - 2. Repair defects on surfaces exposed to view by blending white portland cement and standard portland cement so that, when dry, patching mortar will match surrounding color. Patch a test area at inconspicuous locations to verify mixture and color match before proceeding with patching. Compact mortar in place and strike off slightly higher than surrounding surface.
 - 3. Repair defects on concealed formed surfaces that affect concrete's durability and structural performance as determined by Landscape Architect.
- C. Perform structural repairs of concrete, subject to Landscape Architect's approval, using epoxy adhesive and patching mortar.
- D. Repair materials and installation not specified above may be used, subject to Landscape Architect's approval

3.13 PAVEMENT TOLERANCES

- A. Comply with tolerances of ACI 117 and as follows:
 - 1. Elevation: 1/4 inch (6 mm).
 - 2. Thickness: Plus 3/8 inch (9 mm), minus 1/4 inch (6 mm).
 - 3. Surface: Gap below 10-foot-long, unlevelled straightedge not to exceed 1/4 inch (6 mm).
 - 4. Joint Spacing: 3 inches (75 mm).
 - 5. Contraction Joint Depth: Plus 1/4 inch (6 mm), no minus.
 - 6. Joint Width: Plus 1/8 inch (3 mm), no minus.

3.14 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified independent testing and inspection agency to sample materials, perform tests, and submit test reports during concrete placement according to requirements specified in this Article.
- B. Testing Services: Testing of composite samples of fresh concrete obtained according to ASTM C172 shall be performed according to the following requirements:
 - 1. Testing Frequency: Obtain at least one composite sample for each 100 cu. yd. (76 cu. m) 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. SLUMP TEST IS ONLY FOR CONSISTENCY, NOT FOR DETERMINATION OF ACCEPTABLE WATER CONTENT.
 3. Air Content: ASTM C 231, pressure method, for normal weight concrete; ASTM C173, volumetric method, for structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each type of air-entrained concrete.
 4. Concrete Temperature: ASTM C 1064; one test hourly when air temperature is 40 deg F (4.4 deg C) and below and when 80 deg F (27 deg C) and above, and one test for each set of compressive-strength specimens.
 5. Unit Weight: ASTM C567, fresh unit weight of structural lightweight concrete; one test for each composite sample, but not less than one test for each day's pour of each concrete mix.
 6. Compression Test Specimens: ASTM C 31/C 31M; one set of five standard cylinders for each compressive-strength test, unless otherwise indicated. Cylinders shall be molded and stored for laboratory-cured test specimens unless field-cured test specimens are required.
 7. Compressive-Strength Tests: ASTM C 39;
 - a. Test two field-cured specimens at 7 days and two at 28 days.
 - b. A compressive strength test shall average compressive strength from two specimens obtained from the same composite sample and tested at age indicated.
 8. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, current operations shall be evaluated and corrective procedures shall be provided for protecting and curing in-place concrete.
 9. Strength level of concrete will be considered satisfactory if averages of sets of three consecutive compressive-strength test results equal or exceed specified compressive strength and no individual compressive-strength test result falls below specified compressive strength by more than 500 psi (3.4 MPa).
- C. Test results shall be reported in writing to Landscape 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 agency, concrete type and class, location of concrete batch in pavement, design compressive strength at 28 days, concrete mix proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
- D. Nondestructive testing: Impact hammer, sono-scope, or other nondestructive device may be permitted by Landscape Architect but will not be used as sole basis for approval or rejection of concrete.
- E. Additional Tests: At Contractor's expense, testing agency shall make additional tests of the concrete when test results indicate slump, air entrainment, concrete strengths, or other requirements have not been met, as directed by Landscape Architect. Testing agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C 42, or by other methods as directed by Landscape Architect.

3.15 CLEANING

- A. Clean off excess sealants or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved by manufacturers of joint sealants and of products in which joints occur.

3.16 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective, or does not meet requirements in this Section.
- B. Drill test cores where directed by Landscape Architect when necessary to determine magnitude of cracks or defective areas. Fill drilled core holes in satisfactory pavement areas with portland cement concrete bonded to pavement with epoxy adhesive.
- C. Protect concrete from damage. Exclude traffic from pavement for at least 14 days after placement. When construction traffic is permitted, maintain pavement as clean as possible by removing surface stains and spillage of materials as they occur.
- D. Maintain concrete pavement free of stains, discoloration, dirt, and other foreign material. Sweep concrete pavement not more than two days before date scheduled for Substantial Completion inspections.
- E. Protect joint sealants during and after curing period from contact with contaminating substances and from damage resulting from construction operations or other causes so sealants are without deterioration or damage at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, cut out and remove damaged or deteriorated joint sealants immediately and replace with joint sealant so installations with repaired areas are indistinguishable from the original work.

END OF SECTION 32 13 13

SECTION 321640 - STONE CURBS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 01 – General Requirements which are hereby made a part of the Specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SUMMARY

- A. This Section includes:
 - 1. Granite curb.
 - 2. Flush granite curb.
- B. Related Sections include the following:
 - 1. Division 31 Section “Earth Moving” for trenching, bedding, and backfilling.
 - 2. Division 32 Section “Asphalt Paving.”
 - 3. Division 32 Section “Cement Concrete Pavement.”

1.3 SUBMITTALS

- A. Product Data: Samples of color and finish.

1.4 QUALITY ASSURANCE

- A. Codes and Standards: Provide stone curbing according to the materials, workmanship, and other applicable requirements of the New York State Department of Transportation (NYSDOT) Standard Specifications, Construction and Materials.
- B. Installer Qualifications: Engage an experienced installer who has completed stone curbing installations similar in material, design, and extent to that indicated for this Project and with a record of successful in-service performance.

- C. Single Source Responsibility: Obtain stone curbing from a single source with resources to provide products and materials of consistent quality in appearance and physical properties without delaying progress of the Work.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Protect stone curbing during storage and construction against soiling or contamination from earth and other materials.
- B. Protect grout and mortar materials from deterioration by moisture and temperature. Store in a dry location or waterproof container.

1.6 PROJECT CONDITIONS

- A. Site Information: Perform site survey and layout for curbing. Verify that straight length, radius, and drop curbing sections may be installed in compliance with drawings and referenced standards.
- B. Weather Limitations: Protect mortar material against freezing when ambient air temperature is 40 degrees F and falling. Heat materials and provide temporary protection of completed joints.
- C. Sequencing and Scheduling: Coordinate stone curbing work with location and alignment of roadways, parking lot entrances, traffic islands, walks, and drainage inlets.

PART 2 - PRODUCTS

2.1 STONE CURBING

- A. Standard Curb: Granite, complying with the requirements of NYSDOT Specifications 714-01 for Type C curb:
 - 1. Size: 5 inches wide by 16 inches deep.
 - 2. Finish: Sawn top, split face battered front.
 - 3. For radii less than 100 feet, radiused curb shall be provided.
- B. Concrete Backing and Bedding: Portland cement concrete, 3,000psi mix.
- C. Mortar: Cement mortar complying with the requirements of NYSDOT Specifications 705-20.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Do not use stone curbing with cracks, voids, discolorations, and other defects that might be visible in the finished work.

- B. Place stone curbing on a continuous concrete backing in accordance with NYSDOT Specifications 609-3.01.
- C. Set stone curb on true line and grade to provide a minimum 4- inch and maximum 6-inch reveal above final pavement elevations and fit no closer than 1/4 inch at the Aris line.
- D. Fill all joints solid with cement mortar and remove excess mortar from exposed faces of stone curbing.
- E. Backfill, after cement has properly set, with material indicated for applicable pavement section.
- F. Saw-cut transition angle from standard face curb to traversable curb per contract documents.

3.2 FIELD QUALITY CONTROL

- A. Tolerances: Provide completed stone curbing installation that does not exceed the following deviations from specifications and alignments indicated:
 - 1. Curb Reveal: Plus or minus 3/8 inch.
 - 2. Curb Grade: 1/4 inch per 10 feet.
 - 3. Horizontal Alignment: Within 2 inches.
 - 4. Elevation: Within 1/2 inch at any point.

3.3 PROTECTION

- A. Cleaning: Remove any visible stains and excess mortar from exposed surfaces, wash and scrub clean.
- B. Protect the installed curbing from chipping, staining, displacement or other damage during backfilling and paving operations.

END OF SECTION 321640

SECTION 323113 - FENCES AND GATES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all Sections of Division 01 – General Requirements which are hereby made a part of the Specification.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Chain-link fences and gates.
- B. Related Sections include the following:
 - 1. Division 31 Sections “Soils for Earthwork,” “Aggregates for Earthwork,” and “Earth Moving”
 - 2. Division 32 Section “Cement Concrete Pavement”

1.3 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide chain-link fences and gates capable of withstanding the effects of gravity loads and the following loads and stresses within limits and under conditions indicated:

1.4 SUBMITTALS

- A. Product Data: Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for chain-link fences and gates.
 - 1. Fence and gate posts, rails, and fittings.
 - 2. Chain-link fabric, reinforcements, and attachments.
 - 3. Gates and hardware.
- B. Shop Drawings: Show locations of fences, gates, posts, rails, tension wires, details of extended posts, extension arms, gate swing, or other operation, hardware, and accessories. Indicate materials, dimensions, sizes, weights, and finishes of components. Include plans, gate elevations,

sections, details of post anchorage, attachment, bracing, and other required installation and operational clearances.

- C. Qualification Data: For Installer.

1.5 QUALITY ASSURANCE

- A. References:

- 1. United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS) Conservation Practice Job Sheet RI-382(b) for Fence.

- B. Mockups: Build mockups to set quality standards for fabrication and installation.

- 1. Include 10 ft. (3 m) length of fence and gate complying with requirements.
 - a. Approval of mockups is also for other material and construction qualities specifically approved by Landscape Architect in writing.
 - b. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless such deviations are specifically approved by Landscape Architect in writing.
 - 2. Approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

- C. Preinstallation Conference: Conduct conference at Project site to comply with requirements in Division 01 Section "Project Management and Coordination."

1.1 PROJECT CONDITIONS

- D. Field Measurements: Verify layout information for fences and gates shown on Drawings in relation to property survey and existing structures. Verify dimensions by field measurements.

- E. Interruption of Existing Utility Service: Do not interrupt utility services to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:

- 1. Do not proceed with interruption of utility services without Landscape Architect's written permission.

PART 2 - PRODUCTS

2.1 CHAIN-LINK FENCE FABRIC

- A. General: Height indicated on Drawings. Provide fabric in one-piece heights measured between top and bottom of outer edge of selva knuckle or twist. Comply with ASTM A 392, CLFMI CLF 2445, and requirements indicated below:

1. Wire and mesh sizes in subparagraph and associated subparagraphs below are commonly available and are limited to certain heights depending on the usage of the fence. See ASTM standards and CLFMI CLF 2445. Delete below for aluminum wire mesh.
2. Steel Wire Fabric: Metallic-coated wire with a diameter of 0.192 inch (4.88 mm).
 - a. Mesh Size: 2 inch (50 mm).
 - b. Weight of Metallic (Zinc) Coating: ASTM A 392, Type II, Class 1, 1.2 oz./sq. ft. (366 g/sq. m) with zinc coating applied before weaving.
 - c. Coat selvage ends of fabric that is metallic coated before the weaving process with manufacturer's standard clear protective coating.
3. Selvage: Knuckled at both selvages.

2.2 INDUSTRIAL FENCE FRAMING

- A. Posts and Rails: Comply with ASTM F 1043 for framing, ASTM F 1083 for Group IC round pipe, and the following:
 1. Group: IA, round steel pipe, Schedule 40
 2. Fence Height: 6 feet
 3. Strength Requirement: Light industrial according to ASTM F 1043.
 4. Post Diameter and Thickness: According to ASTM F 1083. Mesh Size: 2 inch (50 mm).
 - a. Top Rail: 1.66 inches (42 mm).
 - b. Line Post: 2.375 inches (60 mm).
 - c. End, Corner and Pull Post: 2.875 inches (73 mm).
 - d. Swing Gate Post: 4-inch (102-mm) diameter, 8.65-lb/ft. (12.88-kg/m) weight. Retain first option in subparagraph below for fabric less than 6 feet (1.83 m) high.

2.3 INDUSTRIAL SWING GATES

- A. Comply with ASTM F 900 for double swing gate types.
 1. Metal Pipe and Tubing: Galvanized steel. Comply with ASTM F 1043 and ASTM F 1083 for materials and protective coatings.
- B. Frames and Bracing: Fabricate members from galvanized steel tubing with outside dimension and weight according to ASTM F 900 and the following:
 1. Gate Fabric Height: As indicated.
 2. Leaf Width: As indicated.
 3. Frame Members:
 - a. Tubular Steel: 2 inches (50 mm) rectangular.
- C. Frame Corner Construction:

1. Welded and 5/16-inch- (7.9-mm-) diameter, adjustable truss rods for panels 5 feet (1.52 m) wide or wider.
- D. Hardware: Latches permitting operation from both sides of gate, hinges, center gate stops and keepers for each gate leaf more than 5 feet (1.52 m) wide.
 1. Provide latches with integral eye openings for padlocking chain link gates; padlock shall be accessible from both sides of gate.

2.4 FASTENERS AND HARDWARE

- A. General: Provide fasteners of size and type complying with requirements specified for material and manufacturer.
 1. Where fasteners are exposed to weather, in ground contact, pressure-preservative treated, or in area of high relative humidity, provide hot-dip galvanized.
 - a. Galvanized fence staples.
 - b. Tension springs: Class 3 galvanized 250 lb. tension.
 - c. In-line ratchet-style tensioner.

2.5 FITTINGS

- A. General: Comply with ASTM F 626.
- B. Post and Line Caps: Provide for each post.
 1. Line post caps with loop to receive tension wire or top rail.
- C. Rail and Brace Ends: Attach rails securely to each gate, corner, pull, and end post.
- D. Rail Fittings: Provide the following:
 1. Top Rail Sleeves: Pressed-steel or round-steel tubing not less than 6 inches (152 mm) long.
 2. Rail Clamps: Line and corner boulevard clamps for connecting intermediate and bottom rails in the fence line-to-line posts.
- E. Tension and Brace Bands: Aluminum Alloy 6063.
- F. Tension Bars: Steel, length not less than 2 inches (50 mm) shorter than full height of chain-link fabric. Provide one bar for each gate and end post, and two for each corner and pull post, unless fabric is integrally woven into post.
- G. Truss Rod Assemblies: Steel, hot-dip galvanized after threading rod and turnbuckle or other means of adjustment.
- H. Tie Wires, Clips, and Fasteners: According to ASTM F 626.

1. Standard Round Wire Ties: For attaching chain-link fabric to posts, rails, and frames, complying with the following:

- a. Hot-Dip Galvanized Steel: 0.106-inch- (2.69-mm-) diameter wire; galvanized coating thickness matching coating thickness of chain-link fence fabric.

I. Finish:

1. Metallic Coating for Pressed Steel or Cast Iron: Not less than 1.2 oz. /sq. ft. (366 g /sq. m) zinc.

2.6 CAST-IN-PLACE CONCRETE

- A. Materials: Portland cement complying with ASTM C 150, Type I aggregates complying with ASTM C 33, and potable water for ready-mixed concrete complying with ASTM C 94/C 94M. Measure, batch, and mix Project-site-mixed concrete according to ASTM C 94/C 94M.

1. Concrete Mixes: Normal-weight concrete with not less than 3000-psi (20.7- MPa) compressive strength (28 days), 3-inch (75-mm) slump, and 1-inch (25-mm) maximum size aggregate.

- B. Materials: Dry-packaged concrete mix complying with ASTM C 387 for normal-weight concrete mixed with potable water according to manufacturer's written instructions.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for a verified survey of property lines and legal boundaries, site clearing, earthwork, pavement work, and other conditions affecting performance.

- 3.2 Do not begin installation before final grading is completed, unless otherwise permitted by Landscape Architect.

- 3.3 Proceed with installation only after unsatisfactory conditions have been corrected.

3.4 PREPARATION

- A. Stake locations of fence lines, gates, and terminal posts. Do not exceed intervals of 500 feet (152.5 m) or line of sight between stakes. Indicate locations of utilities, lawn sprinkler system, underground structures, benchmarks, and property monuments.

3.5 INSTALLATION, GENERAL

- A. Install chain-link fencing to comply with ASTM F 567 and more stringent requirements specified.

3.6 CHAIN-LINK FENCE INSTALLATION

- A. Post Excavation: Drill or hand-excavate holes for posts to diameters and spacings indicated, in firm, undisturbed soil.
- B. Post Setting: Set posts in concrete at indicated spacing into firm, undisturbed soil.
 - 1. Verify that posts are set plumb, aligned, and at correct height and spacing, and hold in position during setting with concrete or mechanical devices.
 - 2. Concrete Fill: Place concrete around posts to dimensions indicated and vibrate or tamp for consolidation. Protect aboveground portion of posts from concrete splatter.
 - a. Exposed Concrete: Extend 2 inches (50 mm) above grade; shape and smooth to shed water.
- C. Terminal Posts: Locate terminal end, corner, and gate posts per ASTM F 567 and terminal pull posts at changes in horizontal or vertical alignment of as indicated on Drawings.
- D. Line Posts: Space line posts uniformly at 10 feet (3 m) o.c.
- E. Post Bracing and Intermediate Rails: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Install braces at end and gate posts and at both sides of corner and pull posts.
 - 1. Locate horizontal braces at midheight of fabric 6 feet (1.83 m) or higher, on fences with top rail and at 2/3 fabric height on fences without top rail. Install so posts are plumb when diagonal rod is under proper tension.
- F. Tension Wire: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Pull wire taut, without sags. Fasten fabric to tension wire with 0.120-inch- (3.05-mm-) diameter hog rings of same material and finish as fabric wire, spaced a maximum of 24 inches (610 mm) o.c. Install tension wire in locations indicated before stretching fabric.
 - 1. Top Tension Wire: Install tension wire through post cap loops.
 - 2. Bottom Tension Wire: Install tension wire within 6 inches (150 mm) of bottom of fabric and tie to each post with not less than same diameter and type of wire.
- G. Top Rail: Install according to ASTM F 567, maintaining plumb position and alignment of fencing. Run rail continuously through line post caps, bending to radius for curved runs and terminating into rail end attached to posts or post caps fabricated to receive rail at terminal posts. Provide expansion couplings as recommended in writing by fencing manufacturer.
- H. Bottom Rails: Install, spanning between posts.

- I. Chain-Link Fabric: Apply fabric to outside of enclosing framework. Leave 2 inches (50 mm) between finish grade or surface and bottom selvage, unless otherwise indicated. Pull fabric taut and tie to posts, rails, and tension wires. Anchor to framework so fabric remains under tension after pulling force is released.
- J. Tension or Stretcher Bars: Thread through fabric and secure to end, corner, pull, and gate posts with tension bands spaced not more than 15 inches (380 mm) o.c.
- K. Tie Wires: Use wire of proper length to firmly secure fabric to line posts and rails. Attach wire at 1 end to chain-link fabric, wrap wire around post a minimum of 180 degrees, and attach other end to chain-link fabric per ASTM F 626. Bend ends of wire to minimize hazard to individuals and clothing.
 - 1. Maximum Spacing: Tie fabric to line posts at 12 inches (300 mm) o.c. and to braces at 24 inches (610 mm) o.c.
- L. Fasteners: Install nuts for tension bands and carriage bolts on the side of the fence opposite the fabric side.

3.7 GATE INSTALLATIONS

- A. Install gates according to manufacturer's written instructions, level, plumb, and secure for full opening without interference. Attach fabric as for fencing. Attach hardware using tamper-resistant or concealed means. Install ground-set items in concrete for anchorage. Adjust hardware for smooth operation and lubricate where necessary.

3.8 ADJUSTING

- A. Gates: Adjust gate to operate smoothly, easily, and quietly, free of binding, warp, excessive deflection, distortion, nonalignment, misplacement, disruption, or malfunction, throughout entire operational range. Confirm that latches and locks engage accurately and securely without forcing or binding.

END OF SECTION 323113

SECTION 32 91 13 – SOIL PREPARATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of the Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SCOPE OF WORK

- A. This Section specifies administrative and procedural requirements for planting soil including, but not limited to the following:
 - 1. Soil amendments.
 - 2. Soil preparation for imported soils including testing for conformance.
 - 3. Installation and placement of soils.
- B. Related Sections: The following Sections contain requirements that relate to this Section:
 - 1. Division 01 Section “Temporary Tree Protection” for protection of existing trees, soils and planting.
 - 2. Division 31 Section “Site Clearing” for stripping and stockpiling topsoil.
 - 3. Division 31 Section “Earthwork” for excavation, filling, rough grading, and backfill.
 - 4. Division 32 Section “Turf and Grasses” for planting soil mix placement.
 - 5. Division 32 Section “Plants” for planting soil mix placement.
- C. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to placement.

1.3 REFERENCES

- A. ANSI: American National Standards Institute.
- B. AOAC: Association of Official Agricultural Chemists.
- C. ASA: American Society of Agronomy.
- D. ASTM: American Society for Testing Materials.
- E. USDA Soil Texture System of Classification.

1.4 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Planting Soil: Stockpiled or imported topsoil mixed with soil amendments for planting trees, shrubs, ground covers and lawn.
- D. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.
- E. Subsoil: All soil beneath the topsoil layer of the site soil profile, and typified by the lack of organic matter and soil organisms. Subsoil is unsuitable for plant growth unless amended as specified.
- F. Topsoil: Natural or cultivated surface-soil layer containing organic matter and sand, silt, and clay particles; friable, pervious, and black or a darker shade of brown, gray, or red than underlying subsoil; reasonably free of subsoil, clay lumps, gravel, and other objects more than 2 inches (50 mm) in diameter; and free of subsoil and weeds, roots, toxic materials, or other non-soil materials.

1.5 SUBMITTALS

- A. Sources for Soil Components and Planting Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of planting soil mixes.
 - 1. Landscape Architect shall reserve the right to reject any soil supplier.
 - 2. Soil mix supplier shall have a minimum of five years' experience at supplying custom planting soil mixes.
 - 3. Submit supplier name, address, telephone and fax numbers and contact name.
 - 4. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project.
- B. Samples: Prior to installing soil mixes, submit representative samples to Landscape Architect for approval. Do not place any soil mixes until Landscape Architect's approval has been obtained.
 - 1. Imported sandy loam soil mix.
- C. Compost:
 - 1. Product Data: For each type of product indicated, including source.
 - 2. Certificates: Provide certificates required by authorities having jurisdiction, especially for any composted materials containing sewage sludge. Approval as EPA Type 1 "exceptional quality" is required as well as that of the State of New York.
 - 3. Testing: As described in Quality Assurance.
- D. All Other Amendments: Product Data.
- E. Subgrade Testing:
 - 1. Field percolation test results as described in Part 3 Execution. Percolation tests shall be measured in inches per hour of drainage.

- F. Planting Soil Mixes: The following testing is required of all soil mixes comprised of imported soil materials:

1. Particle Size Analysis: Include sand, silt and clay, sand size distribution, sand particle shape, pH, uniformity coefficient by hydrometer method (ASTM D-422-63).
2. Organic Matter: Percent organic matter by combustion (ASTM F-1647, Method 1).
3. Report suitability of soil mixes for turf and plant growth. Verify compliance with recommended quantities of nitrogen, phosphorus, potassium, nutrients and soil amendments to be added to produce satisfactory topsoil.
4. Test results for soil mixes must be accepted prior to placement.

1.6 QUALITY ASSURANCE

- A. Source Limitations for Topsoil and Planting Soil Mix: Obtain all topsoil and/or planting soil mix through one source that has been tested according to the requirements below. If there are any additional proposed sources, Contractor must provide topsoil analysis and testing for each source as described below.
- B. Sources for Soil Components and Planting Soil Mixes: Submit information identifying sources for all soil components and the firm responsible for mixing of planting soil mixes.
1. Landscape Architect shall have the right to reject any soil supplier.
 2. Soil mix supplier shall have a minimum of five years' experience at supplying custom planting soil mixes.
 3. Submit supplier name, address, telephone and fax numbers and contact name.
- C. Submit certification that accepted supplier is able to provide sufficient quantities of materials and mixes for the entire project.
- D. Soil-Testing Laboratory Qualifications: The Contractor shall engage an independent laboratory, recognized by the State Department of Agriculture, with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed. The following firms are acceptable testing agencies for the various components:
1. A. McNitt & SerenSoil Testing, LLC
1338 Deerfield Drive
State College, PA 16803
Tel: 610.360.5985
andy@turfsoiltesting.com
 2. Turf & Soil Diagnostics - NY
35 King Street
Trumansburg, NY 14886
855-769-4231
lab@turfdiag.com
 3. Turf & Soil Diagnostics - KS
613 E. 1st Street
Linwood, KS 66052
855-769-4231
lab@turfdiag.com

- E. Percolation Testing of Subgrade: Prior to placement of the planting soil, test the subgrade as described in this Section. Coordinate the testing of the subgrade for percolation with the Sitework Contractor, Soil Scientist, and Landscape Architect.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Material should not be handled or hauled, placed or compacted when it is wet as after a heavy rainfall or is frozen. Soil should be handled only when the moisture content is less than at field capacity. The Landscape Architect shall be consulted to determine if the soil is too wet to handle.
- B. Store and handle packaged materials in strict compliance with manufacturer's instructions and recommendations. Protect all materials from weather, damage, injury and theft.
- C. Sequence deliveries to avoid delay. On-site storage space is permissible only with written notice from Owner's Representative. Deliver materials only after preparations for placement of planting soil have been completed.
- D. Prohibit vehicular and pedestrian traffic on or around stockpiled planting soil.
- E. Soil that is to be stockpiled longer than two weeks, whether on or off site, shall be placed in mounds less than six feet high. If soil stockpiles greater than six feet high are present longer than two weeks then the contractor shall break down and disperse soil so that mounds do not exceed the six-foot height restriction for longer than two weeks.
 - 1. Provide silt fencing around topsoil mounds, and/or as directed in the Storm Water Pollution Prevention Plan (SWPPP).
- F. Soil materials shall not be handled or hauled, placed or compacted when it is wet, as after a heavy rain, nor when frozen. Soil shall be handled only when the moisture content is less than field capacity.

PART 2 - PRODUCTS

2.1 TOPSOIL

- A. Topsoil: ASTM D 5268, pH range of 6.5 to 7.2, a minimum of 4 percent organic material content; clean and screened free of deleterious materials and weeds, including but not limited to any plant listed by NYSDEC or other authority as invasive, nuisance or noxious weed species; and free of stones 1 inch (25 mm) or larger in any dimension and other extraneous materials harmful to plant growth.
 - 1. Topsoil Source: Import topsoil or manufactured topsoil from off-site sources only if required due to deficit of existing soil materials. Obtain topsoil displaced from naturally well-drained construction or mining sites where topsoil occurs at least 4 inches (100 mm) deep; do not obtain from agricultural land, bogs or marshes.

2.2 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings. The compost shall be a dark brown to black color and be capable of supporting plant growth with appropriate management practices in conjunction with addition of fertilizer and other amendments as applicable, with no visible free water or dust, with no unpleasant odor, and meeting the following criteria as reported by laboratory tests. **Debris such as metal, glass, plastic, wood (other than residual chips), asphalt or masonry shall not be visible and shall not exceed one percent dry weight.**
1. Organic Matter Content: >24% percent of dry weight. (ASTM F-1647, Method 1).
 2. The ratio of carbon to nitrogen shall be in the range of 10:1 to 25:1.
 3. One hundred percent of the material shall pass a 3/8-inch (or smaller) screen. (ASTM D-422-63).
 4. pH: The pH shall be between 5.5 to 7.5 as determined from a 1:1 soil-distilled water suspension using a glass electrode pH meter. (American Society of Agronomy *Methods of Soil Analysis*, Part 2, 1986).
 5. Salinity: Electrical conductivity of a one to two soil to water ratio extract shall not exceed 4.0 mmhos/cm (dS/m).
 6. Heavy metal contents shall conform to state and federal regulations.
 7. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Compost may be obtained at one of the following sources, provided that the test requirements are met:
1. WeCare Compost by We Care Organics, Jordan, New York, 315-689-1937
 2. Cayuga Compost (fine) by P&S Excavating, Trumansburg, New York, 607-387-6826
 3. Cornell Farm Services, Ithaca, NY: 607-257-2235
 4. CJ Krantz Organics, Clarence Center, NY, 716-741-3850
 5. Fessenden Farms, King Ferry, NY, 877-767-7280

2.3 FERTILIZER

- A. Bonemeal: Commercial, raw or steamed, finely ground; a minimum of 4 percent nitrogen and 10 percent phosphoric acid.
- B. Superphosphate: Commercial, phosphate mixture, soluble; a minimum of 20 percent available phosphoric acid.
- C. Commercial Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.
- D. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:

1. Composition: Nitrogen, phosphorous, and potassium in amounts recommended in soil reports from a qualified soil-testing agency.

2.4 PLANTING SOIL MIX

- A. Planting soil mix shall be a **sandy loam** as defined by USDA Soil Texture System of Classification created from combination of accepted sand, topsoil, and compost meeting the following criteria:
 1. Free of stones over 1/2", stumps, roots or other woody material over 2" in diameter
 2. Free of brush and seeds from noxious weeds.
 3. Sand content 50% to 70% by volume
 4. Silt 20% to 50% by volume
 5. Clay content 0% to 20% by volume
 6. Permeability >1" inch per hour
 7. pH 5.5 to 7.2
 8. Organic Matter Minimum 5.0%
 9. Magnesium 35 lbs. per acre, minimum
 10. Phosphorus (P2O5) 75 lbs. per acre, minimum
 11. Potassium (K2O) 85 lbs. per acre, minimum
 12. Soluble salts <500 ppm
- B. Provide test results from a certified soil scientist confirming that soil mix conforms to the characteristics as outlined above.
- C. Weight of Slow-Release Fertilizer per 1000 Sq. Ft. (92.9 Sq. m): As recommended by manufacturer, based on rates supplied by Soil Scientist.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Pre-Installation Examination Required: The Contractor shall examine previous work, related work, and conditions under which this work is to be performed and shall notify Landscape Architect in writing of all deficiencies and conditions detrimental to the proper completion of this work. Beginning work means Contractor accepts substrates, previous work, and conditions. The Contractor shall not place any planting or turf soil mix until all work in adjacent areas is complete and approved by the Landscape Architect.
- B. Examination of Subgrade: The subgrade shall be inspected prior to the start of soil placement for conformance with the Drawings for elevations of subgrade relative to finish grade. Subgrade shall be graded smooth and parallel to the finish grades unless otherwise noted in the Drawings.
- C. Pre-Grading Inspection: Prior to the commencement of Work, contact the Landscape Architect to provide an inspection to verify the delineation areas on the Soils Management Plan and proposed location(s) for topsoil and material stockpiling. Make corrections and adjustments as directed by the Landscape Architect prior to commencing any work.

3.2 SUBGRADE DRAINAGE TESTING

- A. Perform subgrade percolation testing at a frequency of one percolation test for every 1,000 sq. ft. of installed topsoil area and at all bioretention planting beds. Percolation tests shall be performed on a minimum of 10% of tree pits and 20% of shrub beds, and on any areas of questionable drainage or as required by Landscape Architect. Contact Landscape Architect and conduct percolation tests in his or her presence. Percolation tests shall be measured in inches per hour of drainage at the base of the plant root level.
 - 1. Excavate test pits 36" by 36" by 18" deep.
 - 2. Fill test pit with 12" minimum depth water and allow water to naturally drain out. When water has drained out, fill excavation again with 12" minimum depth water and measure rate of drainage. Drainage rate should be a minimum of 1" per hour (1 inch drop in water elevation per hour test pit).
 - 3. Should any planting areas yield a percolation test result of less than 1" of drainage per hour, stop work on these areas and obtain direction from Landscape Architect prior to installation of planting mixes and amendments.

3.3 MIXING OF SOIL MIXES

- A. General Soil Mix Preparation: Examine soil and remove foreign materials, stones over 1/2", and organic debris over 2" in length. All preparation and mixing shall be accomplished when the soil moisture content is less than field capacity.
- B. Adequate quantities of mixed planting soil materials shall be provided to attain, after compaction and natural settlement, all design finish grades.
 - 1. Minimum depths of mixed soils must be achieved per planting details. Contractor shall remove excess soils from site as needed at no additional cost.
- C. Soil mixes shall be produced with equipment that blends together each component in a thorough and uniform manner.
 - 1. Soil mixing can occur in-place or off-site.

3.4 Soil Preparation Techniques

- A. Protection of Existing Soils: Protect existing in-place soils and vegetation.
 - 1. Applicability: All areas within the Project Limit Line that are to remain undisturbed by all construction activities including topsoil stripping, grading, excavation, backfill, staging and stockpiling shall be protected by the following:
 - a. Enclose area with chain link protection fence. Fence line shall be maintained throughout the duration of the Work.
 - b. Provide continuous 3" layer of shredded bark mulch at commencement of site work. Layer of mulch shall remain undisturbed throughout the duration of the Work.
 - c. Upon completion of site work, Contractor shall rototill shredded bark mulch into soil, avoiding tree roots.
 - d. Contractor shall establish lawn or planting beds as directed in the Landscape Plan.

- B. Import topsoil and amend to achieve a sandy loam as defined by the USDA Soil Texture System of Classification.
 - 1. Applicability: All areas designated for lawns and planting beds that need additional material to achieve finish grades.
 - 2. Contractor shall manufacture planting soil mix as follows:
 - a. Contractor shall procure all soil component materials.
 - b. Contractor shall obtain laboratory testing services to determine percentages of soil component materials required to manufacture planting soil mix.
 - c. Mix in fertilizers and amendments as recommended by soil testing laboratory and as approved by the Landscape Architect. If lime is to be added, it shall be mixed with dry soil before fertilizer is added and mixed.
 - d. After component percentages are determined by the Soil Scientist, each planting soil mix shall be tested for physical and chemical analysis.
 - e. Retest mixed planting soil and adjust mix as necessary to meet project requirements.
 - 3. Placement: Scarify or till subgrade to depth needed to achieve required depth of planting or turf soil mix after amending. Entire surface shall be disturbed by scarification. Do not scarify within drip line of existing trees.
 - 4. Rake beds to fine grade and remove surface rocks larger than 2 inches in diameter.
 - a. In turf areas, roll to compact soil to 85% of maximum density and remove rocks and debris greater than 1 inch in diameter.

3.5 COORDINATION AND EXCESS MATERIALS

- A. Coordinate activities with other project contractors so that there is no soil disturbance from traffic or other construction activities subsequent to soil placement.
- B. Excess Soil Materials: Remove the excess soil materials from the site at no additional cost to the Owner unless otherwise requested.
 - 1. Owner shall reserve right of first refusal on all amended soil mixes.

3.6 Field Quality Control

- A. Post-Installation Inspection: Prior to planting, contact the Landscape Architect to provide an inspection verify that the placement of amendments and soil preparation is consistent with the Soil Management Plan.
 - 1. Contractor and Landscape Architect shall verify depth of imported planting soil placement and/or rototilled amended soil depth prior to installation of plants.
 - 2. If required depth is not achieved, Contractor shall provide additional rototilling, mixing and compost to achieve specified depth at no cost to the Owner.

END OF SECTION 32 91 13

SECTION 329200 - TURF AND GRASSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Attention is directed to the Contract and General Conditions and all sections of Division 01 - General Requirements which are hereby made a part of the specifications.
- B. Examine all Drawings and all other Sections of the Specifications for requirements therein affecting the Work of this Section.
- C. Coordinate work with that of all other trades affecting or affected by work of this Section. Cooperate with such trades to assure steady progress of all work under the Contract.

1.2 SUMMARY

- A. Section Includes:
 - 1. Seeding.
 - 2. Sodding.
 - 3. Erosion-control materials.
- B. Related Sections:
 - 1. Division 31 Section "Earthwork" for soil materials, excavating, backfilling, and site grading.
 - 2. Division 32 Section "Soil Preparation" for planting soil mix.
 - 3. Division 32 Section "Plants" for planting soil mix placement.

1.3 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Final Acceptance: At the end of Maintenance Period, Landscape Architect shall reinspect all lawn to determine whether Satisfactory Lawn has been achieved.
- C. Finish Grade: Elevation of finished surface of planting soil.
- D. Initial Acceptance: Completion of seeding, with adequacy determined by Landscape Architect. Maintenance period shall commence for 60 days after initial acceptance, until Final Acceptance.
- E. Planting Soil: Stockpiled or imported topsoil mixed with soil amendments for planting trees, shrubs and ground covers.
- F. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill.

- G. Subsoil: All soil beneath the topsoil layer of the site soil profile, and typified by the lack of organic matter and soil organisms.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name and percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.
 - 1. Certification of each seed mixture for turfgrass sod, identifying source, including name and telephone number of supplier.
- C. Qualification Data: For qualified landscape Installer.
- D. Product Certificates: For soil amendments and fertilizers, from manufacturer.
- E. Material Test Reports: For existing surface soil and imported topsoil.
- F. Planting Schedule: Indicating anticipated planting dates for each type of planting.
- G. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of lawns during a calendar year. Submit before expiration of required initial maintenance periods.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful lawn and native seed establishment.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
 - 2. Maintenance Proximity: Not more than two hours' normal travel time from Installer's place of business to Project site.
- B. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Seed: Deliver seed in original sealed, labeled, and undamaged containers.
- B. Sod: Harvest, deliver, store, and handle sod according to requirements in TPI's "Specifications for Turfgrass Sod Materials" and "Specifications for Turfgrass Sod Transplanting and Installation" in its "Guideline Specifications to Turfgrass Sodding." Deliver sod in time for planting within 24 hours of harvesting. Protect sod from breakage and drying.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
 - 1. Spring Planting: March 15 to June 30.
 - 2. Fall Planting: September 1 to November 15.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit.

1.8 MAINTENANCE SERVICE

- A. Initial Lawn and Native seed Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable lawn is established, but for not less than the following periods:
 - 1. Seeded Lawns: 60 days from date of planting completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if lawn is not fully established, continue maintenance during next planting season.

PART 2 - PRODUCTS

2.1 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Grass Seed Mix: Proprietary seed mix as follows:
 - 1. Products: Subject to compliance with requirements, provide the following:
 - a. Low Grow Fine Fescue Mix:
 - 1) 30% Nanook Hard Fescue
 - 2) 25% Marco Polo Sheep Fescue
 - 3) 25% Quattro Sheep Fescue
 - 4) 15% Intrigue Chewings Fescue
 - 5) 5% Miniclover White Clover
 - 6) Seeding Rate: 10 pounds per 1,000 square feet

2.2 TURFGRASS SOD

- A. Turfgrass Species: Sod of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. 80/20 Tall Fescue/Kentucky Bluegrass mix as follows:
 - a. 27% Cochise Tall Fescue
 - b. 27% Rambler Tall Fescue

- c. 26% 3rd Millennium Tall Fescue
- d. 20% Brooklawn Kentucky Bluegrass

2.3 TOPSOIL AND AMENDMENTS

- A. Refer to Section 329113.

2.4 PLANTING ACCESSORIES

- A. Selective Herbicides: EPA registered and approved, of type recommended by manufacturer for application.

2.5 FERTILIZER

- A. Starter Fertilizer: Commercial-grade complete fertilizer of neutral character, consisting of fast- and slow-release nitrogen, 50 percent derived from natural organic sources of urea formaldehyde, phosphorous, and potassium in the following composition:
 - 1. Composition: 18 percent nitrogen, 24 percent phosphorous, and 12 percent potassium, by weight.
 - 2. Application Rate: 5.5 pounds per 1,000 square feet (5 bags per acre).
- B. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 38 percent nitrogen, 0 percent phosphorous, and 8 percent potassium, by weight.
 - 2. Application Rate: 3.5 pounds per 1,000 square feet (3 bags per acre).

2.6 PLANTING Soil MIX

- A. Refer to Section 32 91 13 Soil Preparation.

2.7 MULCHES

- A. Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley.
- B. Fiber Mulch: Biodegradable, dyed-wood, cellulose-fiber mulch; nontoxic; free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5.
- C. Non-asphaltic Tackifier: Colloidal tackifier recommended by fiber-mulch manufacturer for slurry application; nontoxic and free of plant-growth or germination inhibitors.

2.8 EROSION CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd. (0.5 kg/sq. m), with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches (150 mm) long.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive lawns and grass for compliance with requirements and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydro-mulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.

3.3 LAWN PREPARATION

- A. Limit lawn subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: De-compact subgrade as detailed on drawings. Remove stones larger than 1-1/2 inches (38 mm) in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Apply fertilizer and amendments as detailed directly to subgrade before loosening.
 - 2. Thoroughly blend planting soil mix off-site before spreading.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - 3. Spread planting soil mix to a depth as noted in details but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
 - a. Spread approximately 1/2 the thickness of planting soil mix over loosened subgrade. Mix thoroughly into top 2 inches (50 mm) of subgrade. Spread remainder of planting soil mix.
- C. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch (13 mm) of finish elevation. Roll and rake,

remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

- D. Moisten prepared lawn areas before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- E. Before planting, restore areas if eroded or otherwise disturbed after finish grading.

3.4 PREPARATION FOR EROSION-CONTROL MATERIALS

- A. Prepare area as specified in "Lawn Preparation" Article.
- B. For erosion-control blanket or mesh, install from top of slope, working downward, and as recommended by material manufacturer for site conditions. Fasten as recommended by material manufacturer.
- C. Moisten prepared area before planting if surface is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.

3.5 SEEDING

- A. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph (8 km/h). Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- B. Sow seed at a total rate of 10 lb/1000 sq. ft.
- C. Rake seed lightly into top 1/8 inch (3 mm) of soil, roll lightly, and water with fine spray.
- D. Protect seeded areas with slopes exceeding 1:3 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
- E. Protect seeded areas with erosion-control mats where shown, installed and anchored according to manufacturer's written instructions.
- F. Protect seeded areas with slopes not exceeding 1:6 by spreading straw mulch. Spread uniformly at a minimum rate of 2 tons/acre (42 kg/92.9 sq. m) to form a continuous blanket 1-1/2 inches (38 mm) in loose depth over seeded areas. Spread by hand, blower, or other suitable equipment.
 - 1. Anchor straw mulch by crimping into soil with suitable mechanical equipment.

3.6 HYDROSEEDING

- A. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.

1. Mix slurry with non-asphaltic or fiber-mulch manufacturer's recommended tackifier.
2. Apply slurry uniformly to all areas to be seeded in a one-step process. Apply slurry at a rate so that mulch component is deposited at not less than 1500-lb/acre (15.6-kg/92.9 sq. m) dry weight, and seed component is deposited at not less than the specified seed-sowing rate.

3.7 LAWN MAINTENANCE

- A. Maintain and establish lawns by watering, fertilizing, weeding, mowing, trimming, replanting, and other operations. Roll, regrade, and replant bare or eroded areas and re-mulch to produce a uniformly smooth lawn. Provide materials and installation the same as those used in the original installation.
 1. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
- B. Watering: Provide and maintain temporary piping, hoses, and lawn-watering equipment to convey water from sources and to keep lawn uniformly moist to a depth of 4 inches (100 mm).
 1. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 2. Water lawn with fine spray at a minimum rate of 1 inch (25 mm) per week unless rainfall precipitation is adequate.
- C. Mow lawn as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain the following grass height:
 1. Mow Lawns to a height of 2 to 3 inches (50 to 75 mm).
- D. Lawn Postfertilization: Apply fertilizer after initial mowing and when grass is dry.
 1. Use fertilizer that will provide actual nitrogen of at least 1 lb/1000 sq. ft. (0.45 kg/92.9 sq. m) to lawn and native seed areas.

3.8 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris, created by work, from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after lawn and native seed are established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

3.9 INSPECTION AND ACCEPTANCE

- A. Contractor shall notify Landscape Architect to make inspection of lawn and seeded areas to determine acceptability. Contractor shall provide notification at least 10 working days before requested inspection date. Landscape Architect shall provide letter in writing stating acceptability of lawn and landscape work.
 - 1. Where inspected lawn or native seed does not comply with requirements, replace rejected work and continue specified maintenance until re-inspected by Landscape Architect and found to be acceptable. Remove rejected material and dispose of legally off Owner's property.
 - 2. Lawn may be inspected for acceptance in parts agreeable to Landscape Architect, provided work offered for inspection is complete, including maintenance.
- B. Warranty inspection of the entire project will be performed by Landscape Architect at the end of the 1-year warranty period.
 - 1. Use specified materials to reestablish lawns and native seeded areas that do not comply with requirements and continue maintenance until areas are satisfactory.

3.10 SATISFACTORY LAWNS

- A. Lawn installations shall meet the following criteria as determined by Landscape Architect:
 - 1. Satisfactory Seeded Lawns: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. (0.92 sq. m) and bare spots not exceeding 5 by 5 inches (125 by 125 mm).
- B. Use specified materials to reestablish lawns that do not comply with requirements and continue maintenance until lawns are satisfactory.

END OF SECTION 32 92 00

SECTION 329300 - PLANTS

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. Trees.
- 2. Shrubs.
- 3. Plants.
- 4. Mulch.
- 5. Metal Edging.

- B. Related Sections:

- 1. Division 01 Section "Temporary Tree and Plant Protection" for protecting trees remaining on-site that are affected by site operations, including pneumatic excavation in and around tree protection zones.
- 2. Division 31 Section "Site Clearing and Demolition" for tree removal and protection, and tree pruning.
- 3. Division 31 Section "Earthwork" for excavation, filling, and rough grading and for subsurface aggregate drainage and drainage backfill materials.
- 4. Division 32 Section "Soil Preparation" for planting soil mixes.
- 5. Division 32 Section "Turf and Grasses" for lawn planting.
- 6. Division 33 Section "Storm Drainage" for below-grade drainage of landscaped areas, paved areas, and wall perimeters.

1.3 DEFINITIONS

- A. Backfill: The earth used to replace or the act of replacing earth in an excavation.
- B. Balled and Burlapped Stock: Exterior plants dug with firm, natural balls of earth in which they are grown, with ball size not less than diameter and depth recommended by ANSI Z60.1 for type and size of tree or shrub required; wrapped, tied, rigidly supported, and drum laced as recommended by ANSI Z60.1.
- C. Balled and Potted Stock: Exterior plants dug with firm, natural balls of earth in which they are grown and placed, unbroken, in a container. Ball size is not less than diameter and depth recommended by ANSI Z60.1 for type and size of exterior plant required.

- D. Clump: Where three or more young trees were planted in a group and have grown together as a single tree having three or more main stems or trunks.
- E. Container-Grown Stock: Healthy, vigorous, well-rooted exterior plants grown in a container with well-established root system reaching sides of container and maintaining a firm ball when removed from container. Container shall be rigid enough to hold ball shape and protect root mass during shipping and be sized according to ANSI Z60.1 for type and size of exterior plant required.
- F. Final Acceptance: At the end of the Maintenance Period, Landscape Architect shall reinspect all plantings to determine satisfactory plant establishment.
- G. Finish Grade: Elevation of finished surface of planting soil.
- H. Initial Acceptance: Completion of planting, with adequacy determined by Landscape Architect. Maintenance period shall commence for 60 days after initial acceptance, and continue until Final Acceptance.
- I. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- J. Multi-Stem: Where three or more main stems arise from the ground from a single root crown or at a point right above the root crown.
- K. Planting Soil: Native or imported topsoil, manufactured topsoil, or surface soil modified to become topsoil; mixed with soil amendments.
- L. Subgrade: Surface or elevation of subsoil remaining after completing excavation, or top surface of a fill or backfill, before placing planting soil.
- M. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For qualified landscape Installer.
- C. Product Certificates: For each type of manufactured product, from manufacturer, and complying with the following:
 - 1. Manufacturer's certified analysis for standard products.
 - 2. Analysis of other materials by a recognized laboratory made according to methods established by the Association of Official Analytical Chemists, where applicable.
- D. Planting Schedule: Indicating anticipated planting dates for exterior plants.
- E. Maintenance Instructions: Recommended procedures to be established by Owner for maintenance of exterior plants during a calendar year. Submit before expiration of required maintenance periods.

- F. Warranty: Sample of special warranty.

1.5 QUALITY ASSURANCE

- A. Installer Qualifications: A qualified landscape installer whose work has resulted in successful establishment of exterior plants.
 - 1. Installer's Field Supervision: Require Installer to maintain an experienced full-time supervisor on Project site when planting is in progress.
- B. Provide quality, size, genus, species, and variety of exterior plants indicated, complying with applicable requirements in ANSI Z60.1, "American Standard for Nursery Stock."
 - 1. Selection of exterior plants purchased under allowances will be made by Landscape Architect, who will tag plants at their place of growth before they are prepared for transplanting.
- C. Tree and Shrub Measurements: Measure according to ANSI Z60.1 with branches and trunks or canes in their normal position. Do not prune to obtain required sizes. Take caliper measurements 6 inches (150 mm) above the ground for trees up to 4-inch (100-mm) caliper size, and 12 inches (300 mm) above the ground for larger sizes. Measure main body of tree or shrub for height and spread; do not measure branches or roots tip-to-tip.
- D. Observation: Landscape Architect may observe trees and shrubs either at place of growth or at site before planting for compliance with requirements for genus, species, variety, size, and quality. Landscape Architect retains right to observe trees and shrubs further for size and condition of balls and root systems, insects, injuries, and latent defects and to reject unsatisfactory or defective material at any time during progress of work. Remove rejected trees or shrubs immediately from Project site.
- E. Preinstallation Conference: Conduct conference at Project site.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Deliver exterior plants freshly dug.
- B. Do not prune trees and shrubs before delivery except as approved by Landscape Architect. Protect bark, branches, and root systems from sun scald, drying, sweating, whipping, and other handling and tying damage. Do not bend or bind-tie trees or shrubs in such a manner as to destroy their natural shape. Provide protective covering of exterior plants during delivery. Do not drop exterior plants during delivery and handling.
- C. Handle planting stock by root ball.
- D. Deliver exterior plants after preparations for planting have been completed and install immediately. If planting is delayed more than six hours after delivery, set exterior plants and trees in shade, protect from weather and mechanical damage, and keep roots moist.
 - 1. Set balled stock on ground and cover ball with soil, mulch, sawdust, or other acceptable material.

2. Do not remove container-grown stock from containers before time of planting.
3. Water root systems of exterior plants stored on-site with a fine-mist spray. Water as often as necessary to maintain root systems in a moist condition.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with maintenance periods to provide required maintenance from date of Substantial Completion.
 1. Spring Planting: April 1 to June 30.
 2. Fall Planting: September 1 to November 30.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed according to manufacturer's written instructions and warranty requirements.
- C. Coordination with Lawns: Plant trees and shrubs after finish grades are established and before planting lawns unless otherwise acceptable to Landscape Architect.
 1. When planting trees and shrubs after lawns, protect lawn areas and promptly repair damage caused by planting operations.

1.8 WARRANTY

- A. Special Warranty: Installer's standard form in which Installer agrees to repair or replace plantings and accessories that fail in materials, workmanship, or growth within specified warranty period.
 1. Failures include, but are not limited to, the following:
 - a. Death and unsatisfactory growth, except for defects resulting from lack of adequate maintenance, neglect, abuse by Owner, or incidents that are beyond Contractor's control.
 - b. Structural failures including plantings falling or blowing over.
 - c. Faulty operation of tree stabilization, edgings, and tree grates.
 - d. Deterioration of metals, metal finishes, and other materials beyond normal weathering.
 2. Warranty Periods from Date of Initial Acceptance:
 - a. Trees and Shrubs: One year.
 - b. Ground Cover and Plants: One year.
 3. Include the following remedial actions as a minimum:
 - a. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.
 - b. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each exterior plant will be required except for losses or replacements due to failure to comply with requirements.

- d. Provide extended warranty for replaced plant materials; warranty period equal to original warranty period.

1.9 MAINTENANCE SERVICE

- A. Initial Maintenance Service for All Plants: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until plantings are acceptably healthy and well established, but for not less than maintenance period below.

1. Maintenance Period: 60 days from date of Initial Acceptance.

PART 2 - PRODUCTS

2.1 TREE AND SHRUB MATERIAL

- A. General: Furnish nursery-grown trees and shrubs complying with ANSI Z60.1, with healthy root systems developed by transplanting or root pruning. Provide well-shaped, fully branched, healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun scald, injuries, abrasions, and disfigurement.
- B. Provide trees and shrubs of sizes, grades, and ball or container sizes complying with ANSI Z60.1 for types and form of trees and shrubs required. Trees and shrubs of a larger size may be used if acceptable to Landscape Architect, with a proportionate increase in size of roots or balls.
- C. Root-Ball Depth: Furnish trees and shrubs with root balls measured from top of root ball, which shall begin at root flare according to ANSI Z60.1. Root flare shall be visible before planting.
- D. Label each tree and shrub with securely attached, waterproof tag bearing legible designation of botanical and common name.
- E. Label at least one tree and one shrub of each variety and caliper with a securely attached, waterproof tag bearing legible designation of botanical and common name.
- F. If formal arrangements or consecutive order of trees or shrubs is shown, select stock for uniform height and spread, and number label to assure symmetry in planting.

2.2 SHADE AND FLOWERING TREES

- A. Shade Trees: Single-stem trees with straight trunk, well-balanced crown, and intact leader, of height and caliper indicated, complying with ANSI Z60.1 for type of trees required.
 1. Provide balled and burlapped trees.
 2. Branching Height: One-third to one-half of tree height.
- B. Small Upright Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:

1. Stem Form: As specified.
 2. Provide balled and burlapped and container-grown trees.
- C. Small Spreading Trees: Branched or pruned naturally according to species and type, with relationship of caliper, height, and branching according to ANSI Z60.1; stem form as follows:
1. Stem Form: As specified.
 2. Root: As specified.

2.3 DECIDUOUS SHRUBS

- A. Form and Size: Shrubs with not less than the minimum number of canes required by and measured according to ANSI Z60.1 for type, shape, and height of shrub.
1. Shrub sizes indicated are sizes after pruning.

2.4 CONIFEROUS EVERGREENS

- A. Form and Size: Normal-quality, well-balanced, coniferous evergreens, of type, height, spread, and shape required, complying with ANSI Z60.1.
1. Do not shear.

2.5 PLANTS

- A. Provide healthy, disease-free plants of species and variety shown or listed, with well-established root systems reaching to sides of the container to maintain a firm ball, but not with excessive root growth encircling the container. Provide only plants that are acclimated to outdoor conditions before delivery and that are in bud but not yet in bloom.
- B. Perennials: Provide healthy, field-grown plants from a commercial nursery, of species and variety shown or listed, complying with requirements in ANSI Z60.1.

2.6 MULCHES

- A. Organic Mulch: Free from deleterious materials and suitable as a top dressing of trees and shrubs, consisting of one of the following:
1. Type: Double ground or shredded bark.
- B. Gravel Mulch:
1. Type: Rounded riverbed gravel or smooth-faced stone.
 2. Size Range: 1-1/2 inches maximum to 3/4" minimum.
 3. Color: Natural gravel gray color range.
- C. Steel Edging: Standard commercial-steel edging, rolled edge, fabricated in sections of standard lengths, with loops stamped from or welded to face of sections to receive stakes.

1. Basis-of-Design Product: Subject to compliance with requirements provide one of the following or comparable product by one of the following:
 - a. Border Concepts, Inc.
 - b. Russel, J.D Company
 - c. Sure-Loc Edging Company
2. Edging Size: 1/8" wide by 5" tall.
3. Radius: Radius pieces must be shop fabricated, not bent in field
4. Stakes: Tapered steel, min. 15" long
5. Accessories: Standard tapered ends, corners, and splicers.
6. Finish: Standard paint
7. Color: Black

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to receive exterior plants for compliance with requirements and conditions affecting installation and performance.
 1. Inspect planting bed subgrade to verify that subgrade has been fractured, and planting soil mix placed and incorporated fully.
 2. Confirm that planting beds are not waterlogged or holding water. Notify Owner's Representative of any saturated conditions.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, and lawns and existing exterior plants from damage caused by planting operations.
- B. Provide erosion-control measures to prevent erosion or displacement of soils and discharge of soil-bearing water runoff or airborne dust to adjacent properties and walkways.
- C. Lay out individual tree and shrub locations and areas for multiple plantings. Stake locations, outline areas, adjust locations when requested, and obtain Landscape Architect's acceptance of layout before planting. Make minor adjustments as required.
- D. Lay out exterior plants at locations directed by Landscape Architect. Stake locations of individual trees and shrubs and outline areas for multiple plantings.
- E. Wrap trees and shrubs with burlap fabric over trunks, branches, stems, twigs, and foliage to protect from wind and other damage during digging, handling, and transportation.

3.3 EXCAVATION FOR TREES AND SHRUBS

- A. Planting beds should be backfilled with planting soil mix. Planting soil mix shall be loose and friable.

- B. Pits and Trenches: Excavate circular pits with sides sloped inward. Trim base leaving center area raised slightly to support root ball and assist in drainage. Do not further disturb base. Scarify sides of plant pit smeared or smoothed during excavation.
 - 1. Excavate approximately three times as wide as ball diameter for all stock.
 - 2. If drain tile is shown or required under planted areas, excavate to top of porous backfill over tile.
- C. Subsoil removed from excavations may not be used as backfill unless amended per Section 329113 Soil Preparation.
- D. Obstructions: Notify Landscape Architect if unexpected rock or obstructions detrimental to trees or shrubs are encountered in excavations.
 - 1. Hardpan Layer: Drill 6-inch- (150-mm-) diameter holes, 24 inches (600 mm) apart, into free-draining strata or to a depth of 10 feet (3 m), whichever is less, and backfill with free-draining material.
- E. Drainage: Notify Landscape Architect if subsoil conditions evidence unexpected water seepage or retention in tree or shrub pits.
- F. Fill excavations with water and allow to percolate away before positioning trees and shrubs.

3.4 TREE AND SHRUB PLANTING

- A. Before planting, verify that root flare is visible at top of root ball according to ANSI Z60.1.
- B. Set balled and burlapped stock plumb and in center of pit or trench with top of root ball 2 inches (50 mm) above adjacent finish grades.
 - 1. Remove burlap and wire baskets from tops of root balls and partially from sides, but do not remove from under root balls. Remove pallets, if any, before setting. Do not use planting stock if root ball is cracked or broken before or during planting operation.
 - 2. Place planting soil mix around root ball in layers, tamping to settle mix and eliminate voids and air pockets. When pit is approximately one-half backfilled, water thoroughly before placing remainder of backfill. Repeat watering until no more water is absorbed. Water again after placing and tamping final layer of planting soil mix.
- C. Organic Mulching: Apply [2-inch (50-mm)] [3-inch (75-mm)] average thickness of organic mulch extending 12 inches (300 mm) beyond edge of planting pit or trench. Do not place mulch within [3 inches (75 mm)] <Insert measurement> of trunks or stems.

3.5 TREE AND SHRUB PRUNING

- A. Remove only dead, dying, or broken branches. Do not prune for shape.
- B. Prune, thin, and shape trees and shrubs according to standard horticultural practice. Prune trees to retain required height and spread. Unless otherwise indicated by Landscape Architect, do not cut tree leaders; remove only injured or dead branches from flowering trees. Prune shrubs to retain natural character.

3.6 GROUND COVER AND PLANT PLANTING

- A. Set out and space ground cover and plants as indicated. Review layout with Landscape Architect.
- B. Dig holes large enough to allow spreading of roots and backfill with planting soil.
- C. Work soil around roots to eliminate air pockets and leave a slight saucer indentation around plants to hold water.
- D. Water thoroughly after planting, taking care not to cover plant crowns with wet soil.
- E. Protect plants from hot sun and wind; remove protection if plants show evidence of recovery from transplanting shock.

3.7 PLANTING BED MULCHING

- A. Mulch backfilled surfaces of planting beds and other areas indicated. Provide mulch ring around trees in lawn areas, including all existing trees.
 - 1. Organic Mulch: Apply 4-inch average thickness of organic mulch, and finish level with adjacent finish grades. Do not place mulch against plant stems.

3.8 PLANT MAINTENANCE

- A. Tree and Shrub Maintenance: Maintain plantings by pruning, cultivating, watering, weeding, fertilizing, restoring planting saucers, adjusting, and resetting to proper grades or vertical position, as required to establish healthy, viable plantings. Spray or treat as required to keep trees and shrubs free of insects and disease. Restore or replace damaged tree wrappings.
- B. Ground Cover and Plant Maintenance: Maintain and establish plantings by watering, weeding, fertilizing, mulching, and other operations as required to establish healthy, viable plantings.

3.9 CLEANUP AND PROTECTION

- A. During planting, keep adjacent paving and construction clean and work area in an orderly condition.
- B. Protect exterior plants from damage due to landscape operations, operations by other contractors and trades, and others. Maintain protection during installation and maintenance periods. Treat, repair, or replace damaged plantings.

3.10 DISPOSAL

- A. Disposal: Remove surplus soil and waste material, including excess subsoil, unsuitable soil, trash, and debris, and legally dispose of them off Owner's property.
- B. Owner shall retain right of first refusal on any excess amended planting mixes.

3.11 INSPECTION AND ACCEPTANCE

- A. Contractor shall notify Landscape Architect to make inspection of all plantings to determine acceptability. Contractor shall provide notification at least 10 working days before requested inspection date. Landscape Architect shall provide letter in writing stating acceptability of plantings.
 - 1. Where inspected plants not comply with requirements, replace rejected work and continue specified maintenance until re-inspected by Landscape Architect and found to be acceptable. Remove rejected material and dispose of legally off Owner's property.
 - 2. Plantings may be inspected for acceptance in parts agreeable to Landscape Architect, provided work offered for inspection is complete, including maintenance.
- B. Upon initial acceptance, 60-day maintenance period for all plants shall commence. At end of 60-day period, all plants must be in healthy, vigorous, and otherwise satisfactory condition, as determined by Owner's Representative and/or Landscape Architect.
- C. Final acceptance shall occur at the end of the 60-day maintenance period.
- D. Warranty inspection of the entire project will be performed by Landscape Architect at the end of the 1-year warranty period.
 - 1. If any plantings are not satisfactory, include the following remedial actions as a minimum, at no additional cost to the Owner:
 - a. Remove dead exterior plants immediately. Replace immediately unless required to plant in the succeeding planting season.
 - b. Replace exterior plants that are more than 25 percent dead or in an unhealthy condition at end of warranty period.
 - c. A limit of one replacement of each exterior plant will be required except for losses or replacements due to failure to comply with requirements.
 - d. Provide extended warranty for replaced plant materials; warranty period equal to original warranty period.

END OF SECTION 32 93 00

SECTION 331000 – WATER DISTRIBUTION

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Pipe, fittings and accessories for below grade domestic water mains.
- B. Pipe bedding.
- C. Below grade valves.

1.2 RELATED SECTIONS

- A. Division 31 Section “Site Earthwork”.

1.3 REFERENCES

- A. ANSI/AWWA C104 - Cement-mortar Lining for Ductile-iron Pipe and Fittings for Water.
- B. ANSI/AWWA C111 - Rubber-gasket Joints for Ductile-iron and Gray-iron Pressure Pipe and Fittings.
- C. ANSI/AWWA C151 - Ductile-iron Pipe, Centrifugally Cast in Metal Molds or Sand-lined Molds, for Water and Other Liquids.
- D. ANSI/AWWA C153 - Ductile-iron Compact Fittings.
- E. ANSI/AWWA C509 - Resilient Seated Gate Valves 3 inch through 12 inch NRS, for Water and Sewage Systems.
- F. ANSI/AWWA C515 – Reduced-Wall, Resilient Seated Gate Valves 3 inch through 48 inch NRS, for Water and Sewage Systems.
- G. ANSI/AWWA C600 - Installation of Ductile-iron Water Mains and Appurtenances.
- H. ANSI/AWWA C800 - Standard for Underground Service Line Valves and Fittings.
- I. ANSI/AWWA C900 – Standard for Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings, 4 In. Through 12 In., for Water Distribution.
- J. ASTM B88 - Seamless Copper Water Tube.
- K. NSF/ANSI 61 - Annex G and Annex F for lead-free requirements

1.4 PROJECT RECORD DOCUMENTS

- A. Submit to City of Ithaca, Owner and Engineer prior to final payment.
- B. Accurately record actual locations of pipe runs, fittings, valves, service connection taps and curb boxes, and invert elevations.

1.5 QUALITY ASSURANCE

- A. Pipe and Fittings: Marked with manufacturer’s name, nominal diameter of openings, pressure rating, class or thickness, linings, material, date and country of manufacture. Submit manufacturer’s certificate.
- B. Valves: Marked on the bonnet or valve body with manufacturer’s name, year the valve casting was made, pressure rating.
- C. Hydrants: Marked on hydrant with manufacturer's name, year the hydrant casting was made, depth of bury.

1.6 REGULATORY REQUIREMENTS

- A. Lead-free Requirements: Comply with the lead-free requirements as defined by the 2014 provisions of the Safe Drinking Water Act per NSF 372.

1.7 SUBMITTALS

- A. Product Data: Provide data on piping, fittings, pipe restraints, couplings, polyethylene wrap, valves and valve boxes.

PART 2 - PRODUCTS

2.1 DUCTILE IRON PIPE FOR WATER SERVICE

- A. Pipe thickness shall not be less than Class 52. Pipe shall be centrifugally cast for water conforming to AWWA C151. Joints for ductile iron shall be push-on type in accordance with AWWA C111. Rubber gaskets furnished shall be in accordance with AWWA C111.
- B. The asphaltic outside coating shall be in accordance with AWWA C151. The cement-mortar lining and inside coating shall be in accordance with AWWA C104 and ANSI/NSF 61. All coatings, sealants and linings shall be listed by nsf international and conform to the requirements of ANSI/NSF 61.
- C. The exterior of ductile iron pipe shall be coated with a layer of arc-sprayed zinc per ISO 8179. The mass of the zinc applied shall be 200 g/m² of pipe surface area. A finishing layer topcoat shall be applied to the zinc. The mean dry film thickness of the finishing layer shall not be less than 3 mils with a local minimum not less than 2 mils. The zinc coating system shall conform to ISO 8179-1.

2.2 DUCTILE-IRON MECHANICAL JOINT COMPACT FITTINGS FOR WATER SERVICE

- A. Fittings shall be ductile iron Class 350 and shall conform to all the requirements of AWWA C153. Fittings shall have protective asphaltic seal- coat and cement-mortar lining in accordance with AWWA C104.
- B. Accessories (glands, bolts and rubber gaskets) are to conform to AWWA C111.

2.3 DUCTILE IRON PIPE ACCESSORIES

- A. Retainer glands
 - 1. Shall be Uni-Flange Series 1400 as manufactured by Ford or an approved equal.
 - 2. Retainer glands shall be wedge action type with gland body of high strength ductile iron per ASTM A536, Grade 65-45-12. Gland shall be compatible with all mechanical joints conforming to AWWA C111.
 - 3. Ductile iron wedge actuating screw heads shall be of break-away type when design torque is attained. Wedges shall be ductile iron, heat treated and hardened to 370 BHN minimum.
- B. Mechanical Joint Bolt & Gasket Packs
 - 1. Shall be part number SS-140-070-135 (4"), SS-160-070-135 (6"), or SS-180-070-140 (8") as manufactured by Napac, Inc., Worcester, MA, or equal. "T" bolts and nuts shall be Corten. Parts shall be suitable for AWWA C110 & C153 mechanical joints.
- C. Bolt-thru Mechanical Joint Restraints
 - 1. Shall be the Infact Corporation Foster Adaptor, or equal. The device shall be used with standard mechanical joint fittings (AWWA C110 or C153) and valves. The device shall come complete with all accessories, including standard styrene butadiene rubber (SBR) MJ gaskets and weathering steel (Corten) bolts. Nuts for 3 through 12- inch sizes shall be SAE Grade 5 steel with black oxide coating. Nuts for 14-inch and larger adaptors shall be heavy

hex Corten steel. Sizes 3-12-inch shall be supplied with an NSF 61 asphaltic seal coating in accordance with AWWA C104. Sizes 14-36-inch shall be supplied with NSF 61, 7-mil. fusion bonded epoxy conforming to AWWA C116.

D. Tapping Sleeves

1. Tapping sleeves shall be the FAST style sleeves as manufactured by Ford Meter Box Company or approved equal. Sleeves shall be constructed of Type 304 stainless steel with ASTM A36 carbon steel flange. Flange shall conform to AWWA C207 Class D ANSI 150# drilling. Studs, nuts, and washers shall be Type 304 stainless steel. Outlet gasket shall be gridded virgin Buna-N compounded for water service. Full gasket shall be gridded virgin SBR compounded for water service.

E. Wide-Range Repair Coupling

1. Coupling shall be the HYMAX2 coupling as manufactured by Krausz. End rings shall be constructed of ASTM A283/A283M Grade C steel. Center ring shall be constructed of ASTM A53 Grade A steel. EPDM gaskets compounded for water service meeting NSF 61. Bridge, spacers, nuts, and bolts shall be constructed of AISI 304 stainless steel. Coupling shall be coated with fusion bonded epoxy with minimum 14 mil thickness.

F. 360-degree Repair Clamp

1. Shall be the Ford F2-style double section repair clamp as manufactured by Ford Meter Box Company or approved equal. Band shall be constructed of Type 304 stainless steel with gridded virgin Styrene Butadiene Rubber (SBR) compounded for water service per ASTM D2000. Low alloy bolts and nuts per ASTM A242 and AWWA C111. Lugs constructed of ductile iron ASTM A536.

G. Valves

1. Gate Valves

- a. Gate valves shall be the Kenseal II R/W valve with SMJ ends. Valves shall open left.
 - 1). #8571 regular valves
 - 2). #8950 tapping valves
 - 3). #8576 cut-in valves

2. Valves shall conform to the latest revision of AWWA C509, be UL listed and FM approved for service to 250 PSI, cold water, non-shock water works service and 200 PSI fire protection service. Flanges drilled to ANSI B-16.1 (125#). All internal parts shall be accessible without removing the body from the line. The wedge shall be of cast iron completely encapsulated with resilient material. The resilient sealing material shall be permanently bonded to the cast iron wedge with a rubber tearing bond to meet ASTM D 429. NRS stems shall be cast bronze with internal collars in compliance with AWWA. OS&Y stems shall be bronze. There shall be two "O" Ring seals above the thrust collar and one "O" Ring below the thrust collar. The two "O" Rings above the thrust collar shall be field replaceable without removing the valve from service. The third "O" Ring below facilitates such field replacement. There shall be low friction thrust bearings above and below the stem collar. The stem nut shall be independent of the wedge and of solid bronze. The waterway in the seat area shall be smooth, unobstructed and free of cavities. Stuffing box shall be attached to the bonnet and bonnet to the body with bolts and nuts. Blind bolts threaded directly into the body or bonnet will not be acceptable. The body and bonnet shall be coated interior and exterior with fusion bonded thermosetting plastic. Each valve shall be hydrostatically tested at 500 PSI.

H. Valve Boxes

1. Street Valve Boxes (5 1/4")

- a. Shall be the 3-piece screw-type valve box as manufactured by Bingham & Taylor, Figure 4906, or approved equal.
 - 1). #6 (11") Round base
 - 2). 5 1/4" Drop in Lid labeled "WATER"
 - 3). #55 (15") Short Top Section
 - 4). #56 (26") Long Top Section
 - 5). #58 (18") Short Middle Section
 - 6). #59 (24") Long Middle Section

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that water main size, location and elevation are as shown on the drawings.
- B. Thoroughly clean inside of pipe and fittings before installation.
- C. Open and close gate valves to determine proper operation before installation. Tighten bolts and lubricate as per manufacturer's instructions. Keep valves fully open or shut.
- D. Verify required bury depth for valve boxes.
- E. Verify restraint of existing main at connections to municipal system.

3.2 SCHEDULE

- A. Schedule work involving disruption of water service between the hours of 11:00 PM and 7:00 AM. Do not interrupt existing service without authorization from Owner and City of Ithaca.

3.3 BEDDING

- A. Excavate pipe trench in accordance with Division 31 Section "Site Earthwork" for work of this section. Hand trim excavation for accurate placement of pipe to elevations indicated.
- B. Place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches will be under the bottom of the pipe and the bottom quadrant of the pipe will be below the level surface of the bedding material each side of the pipe barrel.
- C. Shape the bed to receive the pipe. Work bedding material under the pipe to provide continuous support.

3.4 PIPE AND FITTINGS

- A. Maintain minimum 10 feet horizontal separation, unless shown otherwise, of water main from sanitary sewer mains and storm piping. Maintain minimum 18-inch vertical separation of water main and sanitary sewer mains and storm piping at crossings.
- B. Install pipe to indicated elevation to within tolerance of 3 inches.
- C. Install ductile iron pipe and fittings in accordance with ANSI/AWWA C600. Install PVC pipe in accordance with ANSI/AWWA C605. Lay piping with bells facing the direction in which the work is progressing.
- D. Install polyethylene encasement on ductile iron pipe, fittings and valves at locations shown on the Drawings and in accordance with AWWA C105, Method A or Method B.
- E. Lay pipe flat or slope up to building. Do not create high points in the main.
- F. Route pipe in direct route between fittings.
- G. Install sampling taps as required to permit disinfection of water system.

- H. Form and place concrete for thrust blocks against solid rock or undisturbed earth at each bend or change of direction of pipe main. Leave all mechanical joint nuts and bolts accessible after form work has been removed.
- I. Close all open ends or fittings at the end of each construction day with watertight expandable plugs. Do not use plywood, burlap, plastic or any other non-watertight covers.
- J. Backfill trench in accordance with Division 31 Section "Site Earthwork".

3.5 PROTECTIVE WARNING TAPE AND TRACER WIRE

- A. Nonconductive Water Pipe:
 - 1. Tape tracer wire to the top center of all PVC water pipe.
 - 2. Terminate tracer wires in valve boxes just below lid.
 - 3. Install plastic warning tape in addition to tracer wire.
- B. Conductive Water Pipe: Install continuous warning tape at 18 inches below final grade.

3.6 VALVES

- A. Set all gate valves vertically on a minimum 6 x 12 x 12-inch solid concrete block.
- B. Center and plumb valve box over valve.
- C. Adjust all valve boxes to be flush with finish grades in landscaped areas and ½ inch below finish grade in pavements.

3.7 HYDROSTATIC TESTING AND DISINFECTION OF WATER SYSTEMS

- A. Flush, hydrostatic test and disinfect all water pipe in accordance with City of Ithaca requirements for domestic and fire water services.

END OF SECTION 331000

SECTION 333000 – SANITARY SEWERAGE

PART 1 - GENERAL

1.01 SECTION INCLUDES

- A. Pipe, fittings, and accessories for sanitary sewer lateral.
- B. Cleanout access.

1.02 RELATED SECTIONS

- A. Division 31 Section “Site Earthwork”; Excavation and backfill for below grade pipes.

1.03 REFERENCES

- A. ASTM F1417-92(1998) Standard Test Method for Installation Acceptance of Plastic Gravity Sewer Lines Using Low-Pressure Air.
- B. ANSI/ASTM D3034 - Type PSM Poly (Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- C. ASTM D2241 - Standard specification for poly vinyl chloride (PVC) plastic pipe (SDR-PR).

1.04 SUBMITTALS

- A. Product data for sewer pipe.
- B. Record Drawings: Showing structures, pipe sizes, locations, and elevations. Include details of underground structures and connections.
- C. Test Reports: Indicate results comparative to specified requirements.

1.05 DELIVERY, STORAGE AND HANDLING

- A. Do not store plastic pipe and fittings in direct sunlight.
- B. Protect pipe, pipe fittings, and seals from dirt and damage.

1.06 PROJECT RECORD DOCUMENTS

- A. Accurately record actual location of pipe runs, fittings, manholes, lateral connections to the main, and invert elevations.
- B. Submit to City of Ithaca, Owner and Engineer prior to final payment.

1.07 PROJECT CONDITIONS

- A. Site Information: Perform site survey, research City of Ithaca utility records, and verify existing utility locations.
- B. Locate existing sewer laterals to be protected.
- C. Existing Utilities: Do not interrupt public utilities unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Owner not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Owner’s written permission.
 - 3. Coordinate work with the location, alignment and elevation of water mains and storm sewers.
 - 4. Verify pressure testing procedures with City of Ithaca.

1.08 QUALITY ASSURANCE

- A. Pipe and Fittings: All plastic sewer pipe and fittings marked with manufacturer's name, nominal diameter of opening, material designation "PVC", the legend "Type PSM SDR 35", identity of standard.

PART 2 - PRODUCTS

2.01 PIPE AND FITTINGS

- A. Gravity Lines:
 - 1. SDR 35 PVC Plastic Pipe and Fittings
 - a. Pipe shall meet the requirements of the latest ASTM Standard F679. The pipe shall conform to the requirements of CSA B-182.2. Integral gasketed bell ends shall be provided on the pipe, the pipe joint must meet the requirements of ASTM D3212. The normal pipe length will be 14'±1" laying length.
 - b. SDR-35 PVC Fittings: shall conform to ASTM D3034, gaskets to conform to ASTM F477.

2.02 BEDDING MATERIALS

- A. Pipe and Fittings: All pipe and fittings bedded and encased in bedding stone, as specified in Division 31 Section "Site Earthwork".

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify main size, location and elevations of connection to existing system are as shown on Drawings.
- B. Verify that intended locations and elevations of pipe runs shown on Drawings, will not conflict with storm sewerage and water mains.
- C. Verify minimum separation requirements at crossings with other utilities.

3.02 BEDDING

- A. Excavate in accordance with Division 31 Section "Site Earthwork" for work of this Section. Hand trim excavation for accurate placement of pipe to elevations indicated.
- B. Place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches will be under the bottom of the pipe.
- C. Shape the bed to receive the pipe, Work bedding material under the pipe to provide continuous support.

3.03 PIPE AND FITTINGS

- A. Maintain minimum 10 feet horizontal separation of sewer main from water mains. Maintain minimum 18 inch vertical separation of sewer main and water main at crossings.
- B. Install plastic sewer pipe, fittings, and accessories in accordance with ASTM D2321 and manufacturer's instructions.
- C. Install pipe in straight line between manholes and fittings to grades indicated on drawings with unbroken continuity of invert. Horizontal dimensions indicated for piping are to centerline of manholes or fittings. Place bell ends of piping facing upstream.

- D. Use 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. Lift or roll pipe into position, do not drop or drag pipe over prepared bedding material.
- F. Install gaskets, seals, sleeves, and couplings according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements.
- G. Shore pipe to required position and retain in place until after placing and compacting of adjacent backfill. Ensure pipe remains in correct position and to required slope.
- H. Close all open pipe ends and fittings at the end of each construction day with watertight expandable plugs. Do not use plywood, burlap, plastic and other non-watertight covers.
- I. Establish elevations of buried piping to ensure not less than 4.5 feet of cover, unless shown otherwise.
- J. Backfill trench in accordance with Division 31 Section "Site Earthwork".

3.04 TAP CONNECTIONS

- A. Make connections to existing sewer piping so finished Work complies as nearly as practical with requirements specified for new Work.
 - 1. Comply with requirements of the City of Ithaca.
- B. Use commercially manufactured wye fittings for piping branch connections. Remove section of existing pipe; install wye fitting into existing piping; and encase entire wye fitting, plus 6-inch overlap, with not less than 6 inches of concrete with 28-day compressive strength of 3000 psi.
- C. Protect existing piping and structures to prevent concrete or debris from entering while making tap connections. Remove debris or other extraneous material that may accumulate.

3.05 FIELD QUALITY CONTROL

- A. Clear interior of piping and structures of dirt and superfluous material as work progresses.
- B. Pressure Test:
 - 1. Test gravity sewers by use of air equipment. Provide all labor, materials and equipment for the test.
 - 2. For the section of main being tested, there may be a permissible drop of 0.5 psi gage from 3.5 to 3.0 psi gage in the minimum times listed in the following table:

SPECIFICATION TIME REQUIRED FOR A 0.5 PSIG PRESSURE DROP
FOR SIZE AND LENGTH OF PIPE INDICATED

| Pipe Dia. (in) | Min. Time (min. sec.) | Length for Min Time (ft.) | Time for Longer Length (sec.) | Specification Time for Length (L) Shown (min:sec) | | | |
|----------------------|--------------------------|---------------------------------|----------------------------------------|------------------------------------------------------|--------|--------|--------|
| | | | | 100 ft | 200 ft | 300 ft | 400 ft |
| 4 | 1:53 | 597 | .190L | 1:53 | 1:53 | 1:53 | 1:53 |
| 6 | 2:50 | 398 | .427L | 2:50 | 2:50 | 2:50 | 2:51 |
| 8 | 3:47 | 298 | .760L | 3:47 | 3:47 | 3:48 | 5:04 |
| 10 | 4:43 | 239 | 1.187L | 4:43 | 4:43 | 5:56 | 7:54 |
| 12 | 5:40 | 199 | 1.709L | 5:40 | 5:42 | 8:33 | 11:24 |

- C. If testing and inspection indicate defects, correct such defects and retest.

END OF SECTION 333000

SECTION 334000 – STORM SEWERAGE

PART 1 - GENERAL

1.1 SECTION INCLUDES

- A. Storm sewer piping, fittings, and accessories.
- B. Underdrain systems
- C. Pre-cast concrete drainage structures, frames, grates and covers.

1.2 RELATED SECTIONS

- A. Division 31 Section “Site Earthwork”.

1.3 REFERENCES

- A. ASTM A536 – Ductile Iron Castings
- B. ANSI/ASTM D3034 - Type PSM Poly Vinyl Chloride (PVC), SDR 35, Solid and Perforated Sewer Pipe.
- C. New York State Department of Transportation, Standard Specifications, Construction and Materials, latest edition.

1.4 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of pipe runs, fittings, connections, drainage inlets, and invert elevations.
- B. Identify and describe unexpected variations to subsoil conditions or discovery of uncharted utilities.

1.5 COORDINATION

- A. Coordinate work with location of building drains, site drain inlets and alignment of curbing.
- B. Coordinate work with location and alignment of existing drainage structures.

1.6 SUBMITTALS

- A. Product data for storm sewer pipe and fittings.
- B. Materials Source: Submit name and address of imported aggregate materials suppliers. Provide materials from same source throughout the Work. Change of source requires Engineer approval.
- C. Test Reports: Submit the following reports directly to Owner from the testing services, with copy to Engineer.
 - 1. Analysis of aggregate materials performed in accordance with ASTM C136/C136M-14. Testing shall be performed within twelve months of the submittal date.
- D. Shop Drawings: Include plans, elevations, details and attachments for precast concrete structures including flow inverts, frames, covers and grates.
- E. Record Drawings: Showing structures and other structures, pipe sizes, locations, and elevations. Include details of underground structures and connections.

1.7 ENVIRONMENTAL REQUIREMENTS

- A. Maintain materials and surrounding air temperature to minimum 50 degrees F prior to, during, and 48 hours after completion of masonry work.

PART 2- PRODUCTS

2.1 STORM SEWER PIPE AND ACCESSORIES

- A. Corrugated Polyethylene Plastic Pipe:
 - 1. ASTM D3350 with strength requirements of AASHTO M252 for sizes 4 to 10 inch diameter and AASHTO M294 for sizes 12 to 36 inch diameter; smooth interior. Sizes and lengths as shown on Drawings.
 - 2. Coupling bands or external snap couplers same material as pipe.
- B. Plastic Pipe and Fittings: ANSI/ASTM D3034, Type PSM, Poly Vinyl Chloride (PVC) material, SDR 35; nominal diameter as shown on the drawings; and bell and spigot style rubber ring sealed gasket joint.
- C. Underdrain Pipe and Fittings:
 - 1. ANSI/ASTM D3034, Type PSM, Perforated Poly Vinyl Chloride (PVC) material, SDR 35; nominal diameter as shown on the drawings; and bell and spigot style rubber ring sealed gasket joint.
- D. Ductile Iron Pipe:
 - 1. Push-on and mechanical joint pipe, Class 50, in accordance with ANSI/AWWA C151; pipe and fittings with cement lining in accordance with ANSI/AWWA C104.
 - 2. Fittings: Ductile iron, compact mechanical joint, working pressure of 350 psi in accordance with ANSI/AWWA C153. Rubber gaskets for joints in accordance with ANSI/AWWA C111.

2.2 DRAINAGE STRUCTURES

- A. Reinforced pre-cast concrete drainage inlets in accordance with ASTM C478. AASHTO HS-20-44 design loading. Shape and inside dimensions in accordance with requirements shown on Drawings. Base and riser sections to have a minimum 6 inch thickness and lengths as necessary to meet invert and rim elevations.
- B. Reinforced pre-cast concrete manholes in accordance with ASTM C478. Utilize rubber -O-rings or Butyl Sealant for jointing between sections. Copolymer polypropylene encapsulated steel manhole steps, in accordance with ASTM C478, spaced at 12 inches on center and formed integral with manhole section. Align steps with eccentric riser section, clear inside dimension 48 inches.
- C. Heavy Duty Frame and Grate: ASTM A 48, Grade 35B, gray iron. Uniform quality, close grained, free from blow holes, shrinkage, cracks and other defects. Plugging of defective castings not permitted. Grates to seat in any position without rocking. Grates and covers as specified on Drawings.
- D. Grade Rings: Pre-cast concrete only.

2.3 BEDDING MATERIALS

- A. Storm Sewer Pipe: All storm sewer pipe bedded and encased in bedding stone as specified in Division 31 Section "Site Earthwork".
- B. Underdrain Pipe: All underdrain pipe bedded and encased in bedding stone, as specified in Division 31 Section "Site Earthwork".

2.4 COUPLINGS AND SLEEVES

- A. Coupling: Rubber or elastomeric sleeve and stainless steel band assembly fabricated to match outside diameters of pipes to be joined.

- B. Sleeves: ASTM C425, rubber for vitrified clay pipe; ASTM C443, rubber for concrete pipe; ASTM C564, rubber for cast-iron soil pipe; and ASTM F477, elastomeric seal for plastic pipe. Sleeves for dissimilar or other pipe materials shall be compatible with pipe materials to be joined.
- C. Bands and Clamp Housing: 301 stainless steel, one at each pipe insert.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify that inside dimensions of drainage inlets, pipe slopes and invert elevations are as shown on Drawings.
- B. Verify that existing underdrain systems are correctly reconnected to the storm sewer system.

3.2 EXCAVATION

- A. Excavate for trenches and structures in accordance with Division 31 Section "Site Earthwork".

3.3 BEDDING

- A. For storm sewer pipe, place bedding material at trench bottom across entire width of trench in such thickness that a minimum of 6 inches will be under the bottom of the pipe.
- B. For underdrain pipe, place a minimum of 6 inches of bedding material beneath the invert. Place balance of aggregate encasement to depth and width shown on the Drawings.

3.4 PIPE AND FITTINGS

- A. Install plastic solid and perforated pipe, in accordance with ASTM D2321 and manufacturer's instructions.
- B. Lift or roll pipe in position. Do not drop or drag pipe over prepared bedding. Lay pipe at down-stream end and progress upstream. Begin work at existing catch basin.
- C. Shore pipe to required position; retain in place until after compaction of adjacent fills. Ensure pipe remains in correct position and to required slope.
- D. Lay pipe to invert elevations shown on Drawings.
- E. Refer to Division 31 Section "Site Earthwork" for backfill requirements. Do not displace or damage pipe when compacting.

3.5 DRAINAGE STRUCTURES

- A. Place pre-cast concrete structures on leveled bedding stone and at required elevation to maintain pipe invert elevations shown on Drawings.
- B. Install pipe flush with the inside face of structure wall. Seal voids between pipe and knockout with cement grout inside and outside of structure.
- C. Do not begin backfilling until cement grout seal is completely set.
- D. Maintain drainage by installing frame and grate flush with temporary finished grade and bring to final elevation at time of paving with pre-cast concrete grade ring and grout frame permanently in place.
- E. Mount frame level in grout to required elevations and secured to top of structure. Align inlet frames to match the line of curbing. Set grate in frame and correct deficiency in casting such that grate will seat in position without rocking.

- F. Install poured concrete invert in drainage inlets and manholes to dimensions shown on Drawings. Use a stiff mix and finish smooth to prohibit standing water.
- G. Verify installation of manhole steps to avoid conflict with inlet and outlet pipes.

3.6 ERECTION TOLERANCES

- A. Maximum Variation from Intended Elevation of Culvert Invert: 1/2 inch.
- B. Maximum Offset of Pipe from True Alignment: 3 inches.
- C. Maximum Variation in Profile of Structure from Intended Position: 1/8 percent.

3.7 FIELD QUALITY CONTROL

- A. Inspect interior of pipe to determine whether line displacement or other damage has occurred. Make inspection after pipe has been installed and backfill is in place, and again at completion of work.
- B. If inspection indicates poor alignment, displaced or collapsed pipe, or other defect, correct such defect and re-inspect.

END OF SECTION 334000

SECTION 334100 - SUBDRAINAGE

PART 1 GENERAL

1.01 SECTION INCLUDES

- A. Building Perimeter, Retaining Wall, and Under-Slab Drainage Systems.

1.02 RELATED REQUIREMENTS

- A. Section 310519 - Geosynthetics for Earthwork.
- B. Section 312316 - Excavation: Excavating for subdrainage system piping and surrounding filter aggregate.
- C. Section 312323 - Fill: Backfilling over filter aggregate, up to subgrade elevation.

1.03 REFERENCE STANDARDS

- A. ASTM D1603 - Standard Test Method for Carbon Black Content in Olefin Plastics.
- B. ASTM D1621 - Standard Test Method for Compressive Properties of Rigid Cellular Plastics.
- C. ASTM D2729 - Standard Specification for Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings.
- D. ASTM D4355/D4355M - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture, and Heat in a Xenon Arc-Type Apparatus.

1.04 SUBMITTALS

- A. See Section 013000 - Administrative Requirements, for submittal procedures.
- B. Product Data: Provide data on pipe drainage products, pipe accessories, and _____.
- C. Shop Drawings: Indicate dimensions, layout of piping, high and low points of pipe inverts, gradient of slope between corners and intersections, and _____.
- D. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- E. Project Record Documents: Record location of pipe runs, connections, cleanouts and principal invert elevations.

PART 2 PRODUCTS

2.01 REGULATORY REQUIREMENTS

- A. Comply with applicable code for materials and installation of the work of this section.

2.02 PIPE MATERIALS

- A. Polyvinyl Chloride Pipe: ASTM D2729; plain end, 4 inch inside diameter; with required fittings.
 - 1. Perforated PVC Sewer Pipe and Fittings: ASTM D 2729, bell-and-spigot ends, for loose joints.
- B. Corrugated Plastic Tubing: Flexible type; 4 inch diameter, with required fittings.
 - 1. NPS 6 and Smaller: ASTM F 405 or AASHTO M 252, Type CP; corrugated, for coupled joints.
 - 2. NPS 8 and Larger: ASTM F 667; AASHTO M 252, Type CP; or AASHTO M 294, Type CP; corrugated; for coupled joints.
 - 3. Couplings: Manufacturer's standard, band type.
- C. Use perforated pipe at subdrainage system; unperforated through sleeved walls.

2.03 AGGREGATE AND BEDDING

- A. Filter Aggregate and Bedding Material: Granular fill as specified in Section 312323.
- B. Filter Sand and Bedding Material: Sand as specified in Section 312323.
- C. Geosynthetic Drainage: Plastic rings overlaid on grids, interlocking, nonwoven geotextile bottom.
 - 1. Ring Thickness: 1 inch, minimum.
 - 2. Grid Opening: 3 inches (76.2 mm), maximum.
 - 3. Recycled Content: 100 percent.
 - 4. Material: High density polyethylene, minimum 1-1/2 percent carbon black, when tested in accordance with ASTM D1603.
 - 5. Ultraviolet Stability: 65 percent, minimum, when tested in accordance with ASTM D4355/D4355M.
 - 6. Compressive Strength: 100 psi (690 kPa), minimum, when tested in accordance with ASTM D1621.

2.04 ACCESSORIES

- A. Pipe Couplings: Solid plastic.
- B. Special Pipe Couplings
 - 1. Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition coupling, for joining underground non-pressure piping. Include ends of same sizes as piping to be joined and corrosion-resistant metal tension band and tightening mechanism on each end.
 - a. For Cast-Iron Soil Pipes: ASTM C 564, rubber.
 - b. For Plastic Pipes: ASTM F 477, elastomeric seal or ASTM D 5926, PVC.
 - c. For Dissimilar Pipes: ASTM D 5926, PVC or other material compatible with pipe materials being joined.
- C. Geotextile Fabric: As specified in Section 310519.
- D. Sleeve: PVC type for foundation wall.
- E. Cleanouts
 - 1. Cast-Iron Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing; and secured, scoriated, Medium-Duty Loading class, cast-iron cover. Include cast-iron

- ferrule and countersunk, brass cleanout plug.
- 2. Copper-Alloy Cleanouts: ASME A112.36.2M; with round-flanged, cast-iron housing with clamping device; and scoriated, Medium-Duty Loading class, copper-alloy cover. Include countersunk, brass cleanout plug.

PART 3 EXECUTION

3.01 EXAMINATION

- A. Verify that trench cut is ready to receive work and excavations, dimensions, and elevations are as indicated on layout drawings.

3.02 PREPARATION

- A. Hand trim excavations to required elevations. Correct over-excavation with _____.
- B. Remove large stones or other hard matter that could damage drainage piping or impede consistent backfilling or compaction.

3.03 INSTALLATION

- A. Install and join pipe and pipe fittings in accordance with pipe manufacturer's instructions.
- B. Place drainage pipe on clean cut subsoil.
- C. Place pipe with perforations facing down. Mechanically join pipe ends.
- D. Install pipe couplings.
- E. Install filter aggregate at sides, over joint covers and top of pipe. Provide top cover compacted thickness of 12 inches.
- F. Place aggregate in maximum 4 inch lifts, consolidating each lift.
- G. Refer to Section 312323 for compaction requirements. Do not displace or damage pipe when compacting.
- H. Place impervious fill over drainage pipe aggregate cover and compact.
- I. Coordinate the Work with connection to municipal sewer utility service, and trenching.

3.04 FIELD QUALITY CONTROL

- A. Section 014000 - Quality Requirements: Field inspection and testing.

3.05 PROTECTION

- A. Protect pipe and aggregate cover from damage or displacement until backfilling operation begins.

END OF SECTION 334100