



DRAW Project Number: 22-S49-01B

NEW DISTRICT MAINTENANCE & BUS DEPOT FACILITY

3600 Old Oakdale Road, South Fayette Township, Allegheny County, Pennsylvania

OWNER: South Fayette Township School District
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McDonald, PA 15057

ARCHITECT:



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ENGINEERS:



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SECTION 21 0500 - COMMON WORK RESULTS FOR FIRE SUPPRESSION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Mechanical sleeve seals.
 - 3. Sleeves.
 - 4. Escutcheons.
 - 5. Grout.
 - 6. Fire suppression equipment and piping demolition.
 - 7. Equipment installation requirements common to equipment sections.
 - 8. Painting and finishing.
 - 9. Concrete bases.
 - 10. Supports and anchorages.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product data for the following:
 - 1. Mechanical sleeve seals.
 - 2. Escutcheons.
- B. Welding certificates.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.

1.07 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire suppression installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for fire suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- D. This Plumbing Contractor must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.

- E. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD Format prepared by the Mechanical Contractor. The Mechanical Contractor shall start their drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
- F. After the Mechanical Contractor has finished, it shall forward one print along with an electronic file to the Plumbing trade, which in turn will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Fire Protection trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades.
- G. Interference plans and elevations shall show in detail the location of the following items which require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the paragraph entitled "Space Priority".
- H. In addition, show mechanical and electrical work in equipment rooms.
- I. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.
- J. Reproducible copies along with electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
- K. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 21 piping Sections for pipe, tube, and fitting materials and joining methods.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.

2.03 JOINING MATERIALS

- A. Refer to individual Division 21 piping Sections for special joining materials not listed below.
- B. Pipe Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 - 1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.

- a. Full-Face Type: For flat-face, Class 125, cast iron and cast bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250 cast iron and steel flanges.
- 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.04 MECHANICAL SLEEVE SEALS

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

2.05 SLEEVES

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

2.06 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep Pattern Type: Deep-drawn, box shaped brass with polished chrome plated finish.
- C. One-Piece, Cast Brass Type: With set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- D. Split-Casting, Cast Brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- E. One-Piece, Stamped steel Type: With set screw or spring clips and chrome plated finish.
- F. Split-Plate, Stamped steel Type: With concealed hinge, set screw or spring clips, and chrome plated finish.
- G. One-Piece, Floor plate Type: Cast iron floor plate.
- H. Split-Casting, Floor plate Type: Cast brass with concealed hinge and set screw.

2.07 GROUT

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

PART 3 - EXECUTION

3.01 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 21 sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping to permit valve servicing.

- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome plated Piping: One-piece, cast-brass type with polished chrome plated finish.
 - c. Insulated Piping: One-piece, stamped steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast-brass type with polished chrome plated finish.
 - e. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped steel type.
 - f. Bare Piping at Ceiling Penetrations in Finished Spaces: **One-piece or split-casting**, cast-brass type with polished chrome plated finish.
 - g. Bare Piping at Ceiling Penetrations in Finished Spaces: **One-piece, stamped steel type or split-plate, stamped steel type with concealed hinge** and set screw.
 - h. Bare Piping in Unfinished Service Spaces: One-piece, cast-brass type with polished chrome plated finish.
 - i. Bare Piping in Unfinished Service Spaces: One-piece, stamped steel type with concealed hinge and **set screw or spring clips**.
 - j. Bare Piping in Equipment Rooms: One-piece, cast-brass type.
 - k. Bare Piping in Equipment Rooms: One-piece, stamped steel type with **set screw or spring clips**.
 - l. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor plate type.
- M. Sleeves are not required for core-drilled holes.
- N. Permanent sleeves are not required for holes formed by removable PE sleeves.
- O. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- P. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast iron soil pipe to extend sleeve to 2 inches above finished floor level. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.

- 1) Seal space outside of sleeve fittings with grout.
4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- Q. Aboveground, Exterior Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 2. Install cast iron "wall pipes" for sleeves 6 inches and larger in diameter.
 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- R. Underground, Exterior Wall Pipe Penetrations: Install cast iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- S. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- T. Verify final equipment locations for roughing-in.
- U. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.02 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 21 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. 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, 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.

3.03 PAINTING

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

3.04 CONCRETE BASES

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

3.05 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

3.06 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

3.07 GROUTING

- A. Mix and install grout for fire suppression equipment base bearing surfaces, pump and other equipment base plates, and anchors.

- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

END OF SECTION 21 0500

SECTION 21 1000 - WATER BASED FIRE SUPPRESSION SYSTEM (WET SPRINKLER ONLY)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following fire suppression piping inside the building:
 - 1. Wet pipe sprinkler systems.
- B. Related Sections include the following:
 - 1. Division 10 Section "Fire Extinguisher Cabinets" and "Fire Extinguishers" for cabinets and fire extinguishers.
 - 2. Division 26 Section 26 1900 "Addressable Fire Alarm System" for alarm devices not specified in this Section.

1.03 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. High pressure Piping System: Fire suppression piping system designed to operate at working pressure higher than standard 175 psig.
- C. PE: Polyethylene plastic.
- D. Underground Service Entrance Piping: Underground service piping below the building.

1.04 SYSTEM DESCRIPTIONS

- A. Sprinkler System: Fire suppression system with sprinkler system.
- B. Wet pipe Sprinkler System: Automatic sprinklers are attached to piping containing water and that is connected to water supply. Water discharges immediately from sprinklers when they are opened. Sprinklers open when heat melts fusible link or destroys frangible device.
- C. Dry pipe Sprinkler System: Automatic sprinklers are attached to piping containing compressed air. Opening of sprinklers releases compressed air and permits water pressure to open dry pipe valve. Water then flows into piping and discharges from opened sprinklers.

1.05 PERFORMANCE REQUIREMENTS

- A. Standard Piping System Component Working Pressure: Listed for at least 175 psig.

- B. Fire suppression sprinkler system design shall be approved by authorities having jurisdiction.
1. Water design velocity in the fire protection system shall be limited to a maximum of 20 feet per second. Pressure drops shall be limited to 0.25 PSI per foot of pipe.
 2. The hydraulic calculation room design method discussed in NFPA 13 shall not be used.
 3. Special design methods discussed in NFPA 13 shall not be used.
 4. The small room method discussed in NFPA 13 shall not be used.
 5. Margin of Safety for Water Pressure: 10 percent of the system demand pressure or 10 psi including losses through water-service piping, valves, and backflow preventers.
 6. Sprinkler Occupancy Hazard Classifications:
 - a. Building Service Areas: Ordinary Hazard, Group 1.
 - b. Electrical Equipment Rooms: Ordinary Hazard, Group 1.
 - c. General Storage Areas: Ordinary Hazard, Group 1.
 - d. Mechanical Equipment Rooms: Ordinary Hazard, Group 1.
 - e. Office and Public Areas: Light Hazard.
 7. Minimum Density for Automatic Sprinkler Piping Design:
 - a. Light hazard Occupancy: 0.10 gpm over 1500 square foot area.
 - b. Ordinary hazard, Group 1 Occupancy: 0.15 gpm over 1500 square foot area.
 - c. Ordinary hazard, Group 2 Occupancy: 0.20 gpm over 1500 square foot area.
 - d. Extra-Hazard, Group 1 Occupancy: 0.30 gpm over 2500 square foot area.
 - e. Extra-Hazard, Group 2 Occupancy: 0.40 gpm over 2500 square foot area.
 8. Maximum Protection Area per Sprinkler: Per UL listing.
 9. Maximum Protection Area per Sprinkler:
 - a. Office Spaces: 225 sq. ft.
 - b. Storage Areas: 130 square feet
 - c. Mechanical Equipment Rooms: 130 square feet
 - d. Electrical Equipment Rooms: 130 square feet
 - e. Other Areas: According to NFPA 13 recommendations, unless otherwise indicated.
 10. Total Combined Hose Stream Demand Requirement - according to NFPA 13, unless otherwise indicated:
 - a. Light hazard Occupancies: 100 gpm for 30 minutes.
 - b. Ordinary hazard Occupancies: 250 gpm for 60 to 90 minutes.
 - c. Extra Hazard Occupancies: 500 gpm for 90 to 120 minutes.
- C. Seismic Performance: Fire suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13 and ASCE 7, "Minimum Design Loads for Buildings and Other Structures": Section 9, "Earthquake Loads."

1.06 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable fire protection systems complete in every respect.
- B. Any apparatus, appliance, material or work not shown as standard industry practice on drawings, but mentioned in the specifications, or vice versa, shall be provided by the Fire Protection Contractor without additional expense to the Owner.
- C. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.

- D. Due to the small scale of the drawings, all required offsets and fittings may not be shown but shall be provided at no change in Contract price.
- E. As many of the small lines required for the complete installation are shown on the drawings as is practicable, but some may have been omitted. The Contractor shall do all such piping that may be required or directed to effect proper connections to all apparatus, equipment, and sprinkler heads in accordance with the manufacturer's detailed drawings and instructions.
- F. The equipment schedules shown on the drawings list the manufacturer used as the basis of design in the preparation of the Bid Drawings. The equipment specifications list that manufacturer as well as other manufacturers the Engineer, Architect and/or Owner find acceptable from a performance and product quality standpoint. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they have a positive or negative monetary impact on the design shown on the Bid Drawings. In addition, listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether the dimensions of these products will have a negative impact on the space allotted for this equipment. If the Contractor or his Subcontractors decide to use a product or manufacturer that is listed as acceptable in the specifications but is different from the product or manufacturer scheduled on the drawings, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the HVAC system(s) and/or the plumbing system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, etc., between the scheduled item and the equipment item used.
 - 1. Use of a product or manufacturer not scheduled on the Bid Drawings constitutes a representation that:
 - a. The Fire Protection Trade has investigated the proposed product and determined that the product can be installed within the space allotted.
 - b. The Fire Protection Trade will coordinate the installation of product used into the work
 - c. The Fire Protection Trade will be responsible for making all changes as may be required to make the work complete in all respects; waives all claims for additional costs under his responsibility, which may subsequently become apparent.

1.07 SUBMITTALS

- A. Product data for the following:
 - 1. Piping materials, including dielectric fittings, flexible connections, and sprinkler specialty fittings.
 - 2. Pipe hangers and supports, including seismic restraints.
 - 3. Valves, including listed fire protection valves, unlisted general-duty valves, and specialty valves and trim.
 - 4. Sprinklers, escutcheons, and guards. Include sprinkler flow characteristics, mounting, finish, and other pertinent data.
 - 5. Fire hydrants.
 - 6. Fire department connections, including type; number, size, and arrangement of inlets; caps and chains; size and direction of outlet; escutcheon and marking; and finish.
 - 7. Alarm devices, including electrical data.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Fire hydrant flow test report, must have been performed within the last 12 months. Include the following information:
 - 1. Date:
 - 2. Time:
 - 3. Performed by:

4. Location of Residual Fire Hydrant R: Location and elevation.
 5. Location of Flow Fire Hydrant F: Location and elevation.
 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):
- D. Approved Sprinkler Piping Drawings: Working plans, prepared according to NFPA 13, that have been approved by authorities having jurisdiction, including hydraulic calculations, if applicable.
- E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
- F. Welding certificates.
- G. Field quality control test reports.
- H. Operation and Maintenance Data: For sprinkler specialties to include in emergency, operation, and maintenance manuals.

1.08 QUALITY ASSURANCE

- A. Installer Qualifications
1. Installer's responsibilities include designing, fabricating, and installing fire suppression systems and providing professional engineering services needed to assume engineering responsibility. Base calculations on results of fire hydrant flow test.
 - a. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified professional engineer. Drawings and calculations shall be sealed by the Professional Engineer.
- B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- C. NFPA Standards - fire suppression system equipment, specialties, accessories, installation, and testing shall comply with the following:
1. NFPA 13, "Installation of Sprinkler Systems."
 2. NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances."

1.09 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire protection installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

- D. Coordinate requirements for access panels and doors for fire protection items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- E. This Fire Protection Contractor must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.
- F. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD Format prepared by the Mechanical Contractor. The Mechanical Contractor shall start their drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
- G. After the Mechanical Contractor has finished, it shall forward one print along with an electronic file to the Plumbing trade that in turn will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Fire Protection trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades
- H. Interference plans and elevations shall show in detail the location of the following items which require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the following paragraph entitled "Space Priority".
 - 1. In addition, show mechanical and electrical work in equipment rooms.
 - 2. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.
- I. Reproducible copies along with electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
- J. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

1.10 SPACE PRIORITY

- A. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
 - 1. Gravity flow piping systems.
 - 2. Vent piping systems.
 - 3. Ceiling recessed lighting fixtures.
 - 4. Concealed air terminal units, fans.
 - 5. Air duct systems.
 - 6. Sprinkler systems piping.
 - 7. Forced flow piping systems.
 - 8. Electrical conduit, wiring, control wiring.
- B. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
- C. Change in order of priority is permissible by mutual agreement of all affected trades.

- D. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
- E. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the Work, materials and equipment of another trade.
- F. This Contractor shall verify roughing-in dimensions for all fixtures and equipment prior to his roughing-in for such fixtures and equipment.

1.11 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sprinkler Cabinets: Finished, wall mounting, steel cabinet with hinged cover, with space for minimum of six spare sprinklers plus sprinkler wrench. Include number of sprinklers required by NFPA 13 and sprinkler wrench. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.

2.02 DUCTILE IRON PIPE AND FITTINGS

- A. Mechanical joint, ductile iron Pipe: AWWA C151, with mechanical joint bell end and plain end.
 - 1. Mechanical joint, ductile iron Fittings: AWWA C110, ductile or gray iron standard pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile or gray iron gland, rubber gasket, and steel bolts and nuts.
- B. Push-on-Joint, Ductile iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
 - 1. Push-on-Joint, Ductile iron Fittings: AWWA C110, ductile- or gray iron standard pattern.
 - 2. Gaskets: AWWA C111, rubber.
- C. Grooved end, Ductile iron Pipe: AWWA C151, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.
 - 1. Grooved-Joint Piping Systems:
 - a. Available Manufacturer:
 - 1) Victaulic Company of America.
 - b. Grooved end Fittings: ASTM A 536, ductile iron casting with OD matching ductile iron pipe OD and cement lining.
 - c. Grooved end-Pipe Couplings: AWWA C606, gasketed fitting matching ductile iron pipe OD. Include ductile iron housing with keys matching ductile iron pipe and fitting grooves, pre-lubricated rubber gasket with center leg, and steel bolts and nuts.

- d. Grooved end-Pipe Transition Coupling: UL 213 and AWWA C606, gasketed fitting with end matching ductile iron pipe OD and end matching steel pipe OD. Include ductile iron housing with key matching ductile iron pipe groove and key matching steel pipe groove, pre-lubricated rubber gasket listed for use with housing, and steel bolts and nuts.
- e. Grooved end Transition Flange: UL 213, gasketed fitting with key for ductile iron pipe dimensions. Include flange-type, ductile iron housing with rubber gasket listed for use with housing and steel bolts and nuts.

2.03 STEEL PIPE AND FITTINGS

- A. Threaded-End, Standard-Weight Steel Pipe: ASTM A 53/A 53M, with factory or field formed threaded ends.
 - 1. Cast iron Threaded Flanges: ASME B16.1.
 - 2. Malleable Iron Threaded Fittings: ASME B16.3.
 - 3. Gray Iron Threaded Fittings: ASME B16.4.
 - 4. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe. Include ends matching joining method.
 - 5. Steel Threaded Couplings: ASTM A 865.
- B. Plain End, Standard Weight Steel Pipe: ASTM A 53/A 53M
 - 1. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
 - 2. Steel Flanges and Flanged Fittings: ASME B16.5.
- C. Grooved end, Standard-Weight Steel Pipe: ASTM A 53/A 53M, with factory or field formed, roll-grooved ends.
 - 1. Grooved Joint Piping Systems:
 - a. Available Manufacturers:
 - 1) Anvil International, Inc.
 - 2) Central Sprinkler Corporation
 - 3) Star Pipe Products; Star Fittings Division
 - 4) Victaulic Company of America.
 - 5) Ward Manufacturing.
 - b. Grooved end Fittings: UL-listed, ASTM A 536, ductile iron casting with OD matching steel pipe OD.
 - c. Grooved end-Pipe Couplings: UL 213 and AWWA C606, rigid pattern, unless otherwise indicated gasketed fitting matching steel pipe OD. Include ductile iron housing with keys matching steel pipe and fitting grooves, pre-lubricated rubber gasket listed for use with housing, and steel bolts and nuts.

2.04 DIELECTRIC FITTINGS

- A. Assembly shall be copper alloy, ferrous, and insulating materials with ends matching piping system.
- B. Dielectric Unions: Factory fabricated assembly, designed for 250-psig minimum working pressure at 180°F. Include insulating material that isolates dissimilar materials and ends with inside threads according to ASME B1.20.1.
 - 1. Available Manufacturers:
 - a. Central Plastics Company.
 - b. Epco Sales, Inc.
 - c. Watts Industries, Inc.; Water Products Division
 - d. Zurn Industries, Inc.; Wilkins Division

- C. Dielectric Flanges: Factory fabricated companion flange assembly, for 175-psig minimum working pressure rating as required for piping system.
 - 1. Available Manufacturers:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Division
- D. Dielectric Flange Insulation Kits: Components for field assembly shall include CR or phenolic gasket, PE or phenolic bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Available Manufacturers:
 - a. Advance Products and Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company
 - d. Pipeline Seal and Insulator, Inc.
- E. Dielectric Couplings: Galvanized steel with inert and noncorrosive thermoplastic lining and threaded ends and 300-psig working pressure rating at 225°F.
 - 1. Available Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation
- F. Dielectric Nipples: Electroplated steel with inert and noncorrosive thermoplastic lining, with combination of plain, threaded, or grooved ends and 300-psig working-pressure rating at 225°F.
 - 1. Available Manufacturers:
 - a. Perfection Corporation
 - b. Precision Plumbing Products, Inc.
 - c. Victaulic Company of America

2.05 CORROSION PROTECTIVE ENCASEMENT FOR PIPING

- A. Encasement for Underground Metal Piping: ASTM A 674 or AWWA C105, PE film, 0.008-inch minimum thickness, tube or sheet.

2.06 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working pressure rating, and made of materials compatible with piping. Sprinkler specialty fittings shall have 250-psig minimum working-pressure rating if fittings are components of high-pressure piping system.
- B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
 - 1. Available Manufacturers:
 - a. Central Sprinkler Corporation
 - b. Fire-End and Croker Corporation
 - c. Viking Corporation
 - d. Victaulic Company of America

- C. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
 - 1. Available Manufacturers:
 - a. Elkhart Brass Mfg. Company, Inc.
 - b. Fire-End and Croker Corporation
 - c. Potter-Roemer; Fire protection Division
- D. Sprinkler Inspector's Test Fitting: Cast- or ductile iron housing with threaded inlet and drain outlet and sight glass.
 - 1. Available Manufacturers:
 - a. AGF Manufacturing Company
 - b. Central Sprinkler Corporation
 - c. G/J Innovations, Inc.
 - d. Triple R Specialty of Ajax, Inc.
- E. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
 - 1. Available Manufacturers:
 - a. CECA, LLC
 - b. Merit

2.07 LISTED FIRE PROTECTION VALVES

- A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.
- B. Gate Valves with Wall Indicator Posts:
 - 1. Gate Valves: UL 262, cast iron body, bronze mounted, with solid disc, non-rising stem, operating nut, and flanged ends.
 - 2. Indicator Posts: UL 789, horizontal-wall type, cast iron body, with operating wrench, extension rod, locking device, and cast-iron barrel.
 - 3. Available Manufacturers:
 - a. Grinnell Fire Protection
 - b. McWane, Inc.; Kennedy Valve Division
 - c. NIBCO
 - d. Stockham
- C. Ball Valves: Comply with UL 1091, except with ball instead of disc.
 - 1. NPS 1-1/2 (DN 40) and Smaller: Bronze body with threaded ends.
 - 2. NPS 2 and NPS 2-1/2 (DN 50 and DN 65): Bronze body with threaded ends or ductile iron body with grooved ends.
 - 3. NPS 3 (DN 80): Ductile iron body with grooved ends.
 - 4. Available Manufacturers:
 - a. NIBCO
 - b. Victaulic Company of America

D. Butterfly Valves: UL 1091.

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.
 - a. Available Manufacturers:
 - 1) Global Safety Products, Inc.
 - 2) Milwaukee Valve Company
2. NPS 2-1/2 (DN 65) and Larger: Bronze, cast iron, or ductile iron body; wafer type or with flanged or grooved ends.
 - a. Available Manufacturers:
 - 1) Central Sprinkler Corporation
 - 2) McWane, Inc.; Kennedy Valve Division
 - 3) Mueller Company
 - 4) NIBCO
 - 5) Victaulic Company of America

E. Check Valves NPS 2 (DN 50) and Larger: UL 312, swing type, cast iron body with flanged or grooved ends.

1. Available Manufacturers:
 - a. Crane Company; Crane Valve Group; Crane Valves
 - b. Grinnell Fire Protection
 - c. McWane, Inc.; Kennedy Valve Division
 - d. Mueller Company
 - e. NIBCO
 - f. Victaulic Company of America
 - g. Watts Industries, Inc.; Water Products Division

F. Gate Valves: UL 262, OS&Y type:

1. NPS 2 (DN 50) and Smaller: Bronze body with threaded ends.
 - a. Available Manufacturers:
 - 1) Crane Company; Crane Valve Group; Crane Valves
 - 2) Hammond Valve
 - 3) NIBCO
 - 4) United Brass Works, Inc.
2. NPS 2-1/2 (DN 65) and Larger: Cast iron body with flanged ends.
 - a. Available Manufacturers:
 - 1) Crane Company; Crane Valve Group; Crane Valves
 - 2) Hammond Valve
 - 3) Milwaukee Valve Company
 - 4) Mueller Company
 - 5) NIBCO

G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.

1. Indicator: Electrical, 115-V ac, prewired, supervisory switch.
2. NPS 2 (DN 50) and Smaller: Ball or butterfly valve with bronze body and threaded ends.
 - a. Available Manufacturers:
 - 1) Milwaukee Valve Company
 - 2) NIBCO

- 3) Victaulic Company of America
3. NPS 2-1/2 (DN 65) and Larger: Butterfly valve with cast- or ductile iron body; wafer type or with flanged or grooved ends.
 - a. Available Manufacturers:
 - 1) Grinnell Fire Protection
 - 2) McWane, Inc.; Kennedy Valve Division
 - 3) Milwaukee Valve Company
 - 4) NIBCO
 - 5) Victaulic Company of America

2.08 UNLISTED GENERAL-DUTY VALVES

- A. Ball Valves NPS 2 (DN 50) and Smaller: MSS SP-110, 2-piece copper-alloy body with chrome plated brass ball, 600-psig minimum CWP rating, blowout-proof stem, and threaded ends.
- B. Check Valves NPS 2 (DN 50) and Smaller: MSS SP-80, Type 4, Class 125 minimum, swing type with bronze body, nonmetallic disc, and threaded ends.
- C. Gate Valves NPS 2 (DN 50) and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
- D. Globe Valves NPS 2 (DN 50) and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.09 SPECIALTY VALVES

- A. Sprinkler System Control Valves: UL listed or FMG approved, cast- or ductile iron body with flanged or grooved ends, and 175-psig minimum pressure rating. Control valves shall have 250-psig minimum pressure rating if valves are components of high-pressure piping system.
 1. Available Manufacturers:
 - a. Globe Fire Sprinkler Corporation
 - b. Grinnell Fire Protection
 - c. Star Sprinkler Inc.
 - d. Victaulic Company of America
 - e. Viking Corporation
 2. Alarm Check Valves: UL 193, designed for horizontal or vertical installation, with bronze grooved seat with O-ring seals, single-hinge pin, and latch design. Include trim sets for bypass, drain, electrical sprinkler alarm switch, pressure gauges, retarding chamber, and fill-line attachment with strainer.
 - a. Drip Cup Assembly: Pipe drain without valves and separate from main drain piping.
 - b. Drip Cup Assembly: Pipe drain with check valve to main drain piping.
 3. Dry pipe Valves: UL 260, differential type; with bronze seat with O-ring seals, single-hinge pin, and latch design. Include UL 1486, quick-opening devices, trim sets for air supply, drain, priming level, alarm connections, ball drip valves, pressure gauges, priming chamber attachment, and fill-line attachment.
 - a. Air pressure Maintenance Device: UL 260, automatic device to maintain correct air pressure in piping. Include shutoff valves to permit servicing without shutting down sprinkler piping, bypass valve for quick filling, pressure regulator or switch to maintain pressure, strainer, pressure ratings with 14- to 60-psig adjustable range, and 175-psig maximum inlet pressure.

- 1) Available Manufacturers:
 - a) Central Sprinkler Corporation
 - b) Globe Fire Sprinkler Corporation.
 - c) Grinnell Fire Protection.
 - d) Reliable Automatic Sprinkler Co., Inc.
 - e) Star Sprinkler Inc.
 - f) Viking Corporation
- b. Air Compressor: UL 753, fractional horsepower 1/3 hp (to be verified by contractor), 120-V ac, 60 Hz, single phase.
 - 1) Available Manufacturers:
 - a) Gast Manufacturing, Inc.
 - b) Grinnell Fire Protection.
 - c) Reliable Automatic Sprinkler Co., Inc.
 - d) Viking Corporation
 - 2) Standard: UL's "Fire Protection Equipment Directory" or FM Global's "Approval Guide."
 - 3) Sized for application and capable of achieving system supervisory pressure within 30 minutes in accordance with requirements of NFPA 13. Provide ASME air receiver tank as required to meet requirements on larger systems.
 - 4) Include filters, relief valves, coolers, automatic drains, and gauges.

2.10 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Sprinklers shall have 250-psig minimum pressure rating if sprinklers are components of high-pressure piping system.
- B. Available Manufacturers:
 1. Central Sprinkler Corporation
 2. Grinnell Fire Protection
 3. Reliable Automatic Sprinkler Company, Inc.
 4. Star Sprinkler Inc.
 5. Victaulic Company of America
 6. Viking Corporation
- C. Automatic Sprinklers - with heat-responsive element complying with the following:
 1. UL 199, for nonresidential applications.
- D. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
 1. Open Sprinklers: UL 199, without heat-responsive element.
 - a. Orifice: 1/2 inch with discharge coefficient K between 5.3 and 5.8.
 - b. Orifice: 17/32 inch with discharge coefficient K between 7.4 and 8.2.
- E. Sprinkler types, features, and options as follows:
 1. Concealed ceiling sprinklers, including cover plate.
 2. Pendent sprinklers.
 3. Pendent, dry type sprinklers.
 4. Sidewall sprinklers.

5. Sidewall, dry barrel type sprinklers.
 6. Upright sprinklers.
- F. Sprinkler Finishes: Chrome plated, bronze, and painted.
- G. Special Coatings: Wax, lead, and corrosion-resistant paint.
- H. Sprinkler Escutcheons: Materials, types, and finishes for the following sprinkler mounting applications. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
1. Ceiling Mounting: Chrome plated steel, one piece, flat
 2. Sidewall Mounting: Chrome plated steel, one piece, flat.
- I. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler. Based on Viking Model D-1 or equal. Shall be installed in all multi-purpose rooms with no ceilings.

2.11 FIRE DEPARTMENT CONNECTIONS

- A. Available Manufacturers
1. Central Sprinkler Corporation
 2. Elkhart Brass Mfg. Company, Inc.
 3. Guardian Fire Equipment Incorporated.
 4. Potter-Roemer; Fire protection Division
 5. Reliable Automatic Sprinkler Company, Inc.
 6. United Brass Works, Inc.
- B. Wall-Type, Fire Department Connection: UL 405, 175-psig minimum pressure rating; with corrosion-resistant-metal body with brass inlets, brass wall escutcheon plate, brass lugged caps with gaskets and brass chains, and brass lugged swivel connections. Include inlets with threads according to NFPA 1963 and matching local fire department sizes and threads, outlet with pipe threads, extension pipe nipples, check devices or clappers for inlets, and escutcheon plate with marking similar to "AUTO SPKR."
1. Type: Flush, with **two** inlets and square or rectangular escutcheon plate.
 2. Type: Exposed, projecting, with two inlets and round escutcheon plate.
 3. Finish: **Polished chrome plated**
 4. Verify hose thread with local fire department.

2.12 ALARM DEVICES

- A. Alarm-device types shall match piping and equipment connections.
- B. Water Motor Operated Alarm: UL 753, mechanical-operation type with Pelton-wheel operator with shaft length, bearings, and sleeve to suit wall construction and 10-inch diameter, cast-aluminum alarm gong with red-enamel factory finish. Include NPS 3/4 (DN 20) inlet and NPS 1 (DN 25) drain connections.
1. Available Manufacturers:
 - a. Firematic Sprinkler Devices, Inc.
 - b. Grinnell Fire Protection.
 - c. Reliable Automatic Sprinkler Company, Inc.
 - d. Star Sprinkler Inc.
 - e. Viking Corporation

- C. Electrically Operated Alarm: UL 464, with 8-inch minimum diameter, vibrating-type, metal alarm bell with red-enamel factory finish and suitable for outdoor use.
 - 1. Available Manufacturers:
 - a. Potter Electric Signal Company.
 - b. System Sensor.

- D. Water-Flow Indicator: UL 346, electrical-supervision, paddle-operated-type, water-flow detector with 250-psig pressure rating and designed for horizontal or vertical installation. Include two single-pole, double-throw circuit switches for isolated alarm and auxiliary contacts, 7 A, 125-V ac and 0.25 A, 24-V dc; complete with factory-set, field-adjustable retard element to prevent false signals and tamperproof cover that sends signal if removed.
 - 1. Available Manufacturers:
 - a. Grinnell Fire Protection.
 - b. ITT McDonnell & Miller.
 - c. Potter Electric Signal Company.
 - d. System Sensor.
 - e. Viking Corporation

- E. Pressure Switch: UL 753, electrical-supervision-type, water-flow switch with retard feature. Include single-pole, double-throw, normally closed contacts and design that operates on rising pressure and signals water flow.
 - 1. Available Manufacturers:
 - a. Grinnell Fire Protection.
 - b. Potter Electric Signal Company.
 - c. System Sensor.
 - d. Viking Corporation

- F. Valve Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled valve is in other than fully open position.
 - 1. Available Manufacturers:
 - a. McWane, Inc.; Kennedy Valve Division
 - b. Potter Electric Signal Company.
 - c. System Sensor.

- G. Indicator-Post Supervisory Switch: UL 753, electrical, single-pole, double-throw switch with normally closed contacts. Include design that signals controlled indicator-post valve is in other than fully open position.
 - 1. Available Manufacturers:
 - a. Potter Electric Signal Company.
 - b. System Sensor.

2.13 SPRINKLER SYSTEM AIR VENT

- A. Available Manufacturers:
 - 1. Potter Signal (Model PAV)

- B. Description: Automatic air release valves for fire protection service UL 2573.
 - 1. Brass construction, 1/2-inch NPT inlet/1/2-inch MNPT outlet to drain.
 - 2. Ball valve supervisory switch.
 - 3. FM approved.

2.14 PRESSURE GAUGES

- A. Available Manufacturers:
 - 1. AGF Manufacturing Company
 - 2. AMETEK, Inc.; U.S. Gauge.
 - 3. Dresser Equipment Group; Instrument Division
 - 4. Marsh Bellofram.
 - 5. WIKA Instrument Corporation.
- B. Description: UL 393, 3-1/2- to 4-1/2-inch diameter, dial pressure gauge with range of 0 to 300 psig.
 - 1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
 - 2. Air System Piping: Include retard feature and caption "AIR" or "AIR/WATER" on dial face.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13, and NFPA 291. Use results for system design calculations required in Part 1 "Quality Assurance" article.
- B. Report test results promptly and in writing.

3.02 EARTHWORK

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.03 PIPING APPLICATIONS, GENERAL

- A. Shop weld pipe joints where welded piping is indicated.
- B. Do not use welded joints for galvanized-steel pipe.
- C. Flanges, flanged fittings, unions, nipples, and transition and special fittings with finish and pressure ratings same as or higher than system's pressure rating may be used in aboveground applications, unless otherwise indicated.
- D. Piping between Fire Department Connections and Check Valves: Galvanized, standard-weight steel pipe with **cast- or malleable-iron threaded fittings; and threaded grooved ends; grooved end fittings; grooved end-pipe couplings; and grooved joints.**
- E. Underground Service-Entrance Piping: Ductile iron, **mechanical**-joint pipe and fittings and restrained joints. Include corrosion-protective encasement.
- F. Underground Service-Entrance Piping: Ductile iron, grooved end pipe and fittings; grooved end-pipe couplings; and grooved joints. Include corrosion-protective encasement.

3.04 SPRINKLER SYSTEM PIPING APPLICATIONS

- A. Standard-Pressure, Wet pipe Sprinkler System, 175-psig Maximum Working Pressure:
1. NPS 1-1/2 (DN 40) and Smaller: Threaded-end, black, Schedule 40 standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
 2. NPS 2 (DN 50): Threaded-end, black, Schedule 40 standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
 3. NPS 2 (DN 50): Grooved end, black, Schedule 40 standard-weight steel pipe; grooved end fittings; grooved end-pipe couplings; and grooved joints.
 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Threaded-end, black, Schedule 40 standard-weight steel pipe; cast- or malleable-iron threaded fittings; and threaded joints.
 5. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Grooved end, black, Schedule 40 standard-weight steel pipe; grooved end fittings; grooved end-pipe couplings; and grooved joints.
 6. NPS 4 to NPS 6 (DN 100 to DN 150): Grooved end, black, Schedule 40 standard-weight steel pipe; grooved end fittings; grooved end-pipe couplings; and grooved joints.
- B. Standard Pressure, Dry pipe and Pre-Action Sprinkler Systems, 175-psig Maximum Working Pressure:
1. NPS 1-1/2 (DN 40) and Smaller: Threaded end, galvanized, Schedule 40 standard weight steel pipe; cast- or malleable iron threaded fittings; and threaded joints.
 2. NPS 2 (DN 50): Threaded end, galvanized, Schedule 40 standard weight steel pipe; cast- or malleable iron threaded fittings; and threaded joints.
 3. NPS 2 (DN 50): Grooved end, galvanized, Schedule 40 standard weight steel pipe; grooved end fittings; grooved end pipe couplings; and grooved joints.
 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Threaded end, galvanized, Schedule 40 standard weight steel pipe; cast- or malleable iron threaded fittings; and threaded joints.
 5. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Grooved end, galvanized, Schedule 40 standard weight steel pipe; grooved end fittings; grooved end pipe couplings; and grooved joints.
 6. NPS 4 to NPS 6 (DN 100 to DN 150): Grooved end, galvanized, Schedule 40 standard weight steel pipe; grooved end fittings; grooved end pipe couplings; and grooved joints.

3.05 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
1. Listed Fire protection Valves: UL listed and FMG approved for applications where required by NFPA 13.
 - a. Shutoff Duty: Use ball, butterfly, or gate valves.
 2. Unlisted General-Duty Valves: For applications where UL-listed and FMG-approved valves are not required by NFPA 13.
 - a. Shutoff Duty: Use ball, butterfly, or gate valves.
 - b. Throttling Duty: Use ball or globe valves.

3.06 JOINT CONSTRUCTION

- A. Refer to Division 21 Section 21 0500 "Common Work Results for Fire Suppression" for basic piping joint construction.

- B. Threaded Joints: Comply with NFPA 13 for pipe thickness and threads. Do not thread pipe smaller than NPS 8 (DN 200) with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gauge and comply with ASME B1.20.1.
- C. Grooved Joints: Assemble joints with listed coupling and gasket, lubricant, and bolts.
 - 1. Ductile iron Pipe: Radius-cut-groove ends of piping. Use grooved end fittings and grooved end-pipe couplings.
 - 2. Steel Pipe: Roll-groove piping as indicated. Use grooved end fittings and rigid, grooved end-pipe couplings, unless otherwise indicated.
 - 3. Copper Tube: Roll-groove tubing. Use grooved end fittings and grooved end-tube couplings.
 - 4. Dry-Pipe Systems: Use fittings and gaskets listed for dry-pipe service.
- D. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.
 - 1. NPS 2 (DN 50) and Smaller: Use dielectric unions, couplings, or nipples.
 - 2. NPS 2-1/2 to NPS 4 (DN 65 to DN 100): Use dielectric flanges.
 - 3. NPS 5 (DN 125) and Larger: Use dielectric flange insulation kits.

3.07 SERVICE-ENTRANCE PIPING

- A. Connect fire suppression piping to water-service piping of size and in location indicated for service entrance to building.
- B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water-service piping.
- C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water service.

3.08 WATER SUPPLY CONNECTION

- A. Connect fire suppression piping to building's interior water distribution piping. Refer to Division 22 Section 22 1116 "Domestic Water Piping" for interior piping.
- B. Install shutoff valve, backflow preventer, pressure gauge, drain, and other accessories indicated at connection to water distribution piping. Refer to Division 22 Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers.
- C. Install shutoff valve, check valve, pressure gauge, and drain at connection to water supply.

3.09 PIPING INSTALLATION

- A. Refer to Division 21 Section 21 0500 "Common Work Results for Fire Suppression" for basic piping installation.
- B. Locations and Arrangements: Drawing plans, schematics, and diagrams indicate general location and arrangement of piping. Install piping as indicated, as far as practical.
 - 1. Deviations from approved working plans for piping require written approval from authorities having jurisdiction. File written approval with Architect before deviating from approved working plans.
- C. Install underground ductile iron service-entrance piping according to NFPA 24 and with restrained joints. Encase piping in corrosion-protective encasement.

- D. Install underground copper service-entrance piping according to NFPA 24. Encase piping in corrosion-protective encasement.
- E. Use approved fittings to make changes in direction, branch takeoffs from mains, and reductions in pipe sizes.
- F. Install unions adjacent to each valve in pipes NPS 2 (DN 50) and smaller. Unions are not required on flanged devices or in piping installations using grooved joints.
- G. Install flanges or flange adapters on valves, apparatus, and equipment having NPS 2-1/2 (DN 65) and larger connections.
- H. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13.
- I. Install sprinkler piping with drains for complete system drainage.
- J. Install sprinkler zone control valves, test assemblies, and drain risers adjacent to standpipes when sprinkler piping is connected to standpipes.
- K. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
- L. Install alarm devices in piping systems.
- M. Hangers and Supports: Comply with NFPA 13 for hanger materials.
 - 1. Install sprinkler system piping according to NFPA 13.
- N. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.
- O. Install pressure gauges on riser or feed main, at each sprinkler test connection. Include pressure gauges with connection not less than NPS 1/4 (DN 8) and with soft metal seated globe valve, arranged for draining pipe between gauge and valve. Install gauges to permit removal, and install where they will not be subject to freezing.
- P. Fill wet pipe sprinkler system piping with water.

3.10 VALVE INSTALLATION

- A. Install listed fire protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to NFPA 13 and authorities having jurisdiction.
- B. Install listed fire protection shutoff valves supervised-open, located to control sources of water supply except from fire department connections. Install permanent identification signs indicating portion of system controlled by each valve.
- C. Install check valve in each water supply connection. Install backflow preventers instead of check valves in potable-water supply sources.
- D. Specialty Valves:
 - 1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.

- E. Specialty Valves:
 - 1. Alarm Check Valves: Install in vertical position for proper direction of flow, including bypass check valve and retarding chamber drain-line connection.

3.11 SPRINKLER APPLICATIONS

- A. Drawings indicate sprinkler types to be used. Where specific types are not indicated, use the following sprinkler types:
 - 1. Rooms without Ceilings: Upright sprinklers.
 - 2. Rooms with Suspended Ceilings: Concealed sprinklers
 - 3. Wall Mounting: Sidewall sprinklers.
 - 4. Spaces Subject to Freezing: Pendent, dry sprinklers, Sidewall, dry sprinklers.
 - 5. Sprinkler Finishes:
 - a. Upright, Pendent, and Sidewall Sprinklers: Chrome plated in finished spaces exposed to view; rough bronze in unfinished spaces not exposed to view; wax coated where exposed to acids, chemicals, or other corrosive fumes.
 - b. Concealed Sprinklers: Rough brass, with factory-painted white cover plate.

3.12 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceilings in center of acoustical ceiling panels and tiles.
- B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry type sprinklers with water supply from heated space.

3.13 FIRE DEPARTMENT CONNECTION INSTALLATION

- A. Install wall-type, fire department connections in vertical wall.
- B. Install ball drip valve at each check valve for fire department connection.

3.14 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Connect water supply piping to fire suppression piping. Include backflow preventer between potable water piping and fire suppression piping. Refer to Division 22 Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers.
- D. Install ball drip valves at each check valve for fire department connection. Drain to floor drain or outside building.
- E. Connect piping to specialty valves, hose valves, specialties, fire department connections, and accessories.
- F. Electrical Connections: Power wiring is specified in Division 26.

- G. Connect alarm devices to fire alarm.
- H. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- I. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."
- J. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.15 LABELING AND IDENTIFICATION

- A. Install labeling and pipe markers on equipment and piping according to requirements in NFPA 13.

3.16 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - a. Hydrostatic tests shall be performed per NFPA 13.
 - b. Pneumatic tests are not allowed except where specifically required by NFPA 13.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Energize circuits to electrical equipment and devices.
 - 4. Start and run excess-pressure pumps.
 - 5. Start and run air compressors.
 - 6. Flush, test, and inspect sprinkler systems according to NFPA 13, "Systems Acceptance" Chapter.
 - 7. Coordinate with fire alarm tests. Operate as required.
 - 8. Coordinate with fire pump tests. Operate as required.
- B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.17 CLEANING AND PROTECTION

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers with paint other than factory finish.
- C. Protect sprinklers from damage until Substantial Completion.

3.18 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain specialty valves. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 21 1000

SECTION 22 0500 - GENERAL PROVISIONS AND COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section and other sections of Division 22.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Piping materials and installation instructions common to most piping systems.
 - 2. Transition fittings.
 - 3. Dielectric fittings.
 - 4. Mechanical sleeve seals.
 - 5. Sleeves.
 - 6. Escutcheons.
 - 7. Grout.
 - 8. Access Panels.
 - 9. Cleaning up/removal of debris.
 - 10. Equipment installation requirements common to equipment sections.
 - 11. Operating and maintenance data and owner instruction.
 - 12. Traps.
 - 13. Flashing.
 - 14. Painting and finishing.
 - 15. Concrete bases.
 - 16. Supports and anchorages.
 - 17. Materials prohibited.
 - 18. Certification.
 - 19. Guarantee of Work.
 - 20. Final plumbing connections.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspace, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in chases.

- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.
- F. The following are industry abbreviations for plastic materials:
 - 1. ABS: Acrylonitrile-butadiene-styrene plastic.
 - 2. CPVC: Chlorinated polyvinyl chloride plastic.
 - 3. PE: Polyethylene plastic.
 - 4. PVC: Polyvinyl chloride plastic.
- G. The following are industry abbreviations for rubber materials:
 - 1. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 2. NBR: Acrylonitrile-butadiene rubber.
- H. The term "as indicated" means as shown on drawings by notes, graphics or schedules, or written into other portions of contract documents. Terms such as "shown", "noted", "scheduled" and "specified" have same meaning as "indicated", and are used to assist the reader in locating particular information.
- I. It is the intention of these Contract Documents to call for finished work, tested and ready for operation.
 - 1. The word "PROVIDE" shall mean "furnish and install, complete and ready for use" all items noted on the drawings and/or indicated in the Specifications.
 - 2. The word "FURNISH" shall mean "supply and deliver to the job site" all items noted on the drawings and/or indicated in the Specifications. The items will be installed by the Owner or another contractor.
 - 3. The word "INSTALL" shall mean "install complete and ready for use" all items furnished by the Owner or another contractor which are noted on the drawings and/or indicated in the Specifications to be installed by the Plumbing Contractor.
 - 4. The word "RELOCATE" shall mean "move from the existing location to the new location installed complete and ready for use" all items noted on the drawings and/or indicated in the Specifications.
- J. References made to Plumbing Contractor throughout Division 22 is intended to refer to the contractor or subcontractor who will furnish and install Plumbing materials and equipment.

1.04 QUALIFICATIONS FOR BIDDERS

- A. The Plumbing Contractor shall be experienced in work similar to that indicated for this Project and shall have a record of successful in-service performance.
- B. Upon request, the Plumbing Contractor shall provide a listing of similar jobs with references.
- C. Before submitting bid, the Plumbing Contractor shall visit the site and examine existing conditions on which his work is in any way dependent. The Plumbing Contractor shall immediately report to the Architect any condition which might prevent him from installing his equipment in the manner intended.

1.05 BID SUBMISSION REQUIREMENTS

- A. The Plumbing Contractor shall submit his bid, including the Base Bid and all Alternate Bids, in accordance with the General Provisions of the Contract, including General, Supplementary and Special Conditions.
- B. Only one manufacturer shall be listed for each equipment item.

1.06 LAWS, CODES, AND REGULATIONS

- A. All work shall be installed in accordance with accepted trade standards or practices. Accepted trade standards or practices shall be documented and shall be based on sound engineering design principles. Accepted trade standards or practices must include a statement indicating that the specific application in question is included within its scope. Accepted trade standards and practices must be documented through an engineering society or trade organization.
- B. Failure to follow laws, codes, public regulations and accepted trade standards or practices will result in rejection of the work. All rejected work shall be removed and replaced at no additional cost to the Owner.
- C. Nothing contained in these Specifications or shown on the Drawings shall be construed to be in conflict with state or local codes, ordinances or regulations governing the installation of the work specified herein. Should any change in the Drawings and/or Specifications be required in order to conform to the applicable codes, ordinances, regulations or laws, the Plumbing Contractor shall notify the engineer immediately upon discovery of the violation.
- D. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in each section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.

1.07 REGULATORY REQUIREMENTS

- A. Conform to applicable Building Codes.
 - 1. Commonwealth of Pennsylvania, Department of Labor and Industry.
 - a. Fire and Panic Regulations.
 - b. Regulations Governing Boilers and Unfired Pressure Vessels.
 - c. Elevator Law.
- B. Fire Protection: Conform to NFPA 13, 14, and 20.
- C. Plumbing: Conform to the 2018 International Plumbing Code and the Allegheny County Health Department Amendments.
- D. Energy conservation shall be provided for plumbing systems as described in the Pennsylvania Building Energy Conservation Act 222.

1.08 PERMITS, FEES, AND NOTICES

- A. The Plumbing Contractor shall give all requisite notices, obtain and pay all deposits and fees necessary for the installation, tests connections to the utility company service lines, street openings, repairs and inspection of all work provided under this Specification. These tests shall be conducted in the presence of the Architect.

1.09 APPLICABLE PUBLICATIONS

- A. The publications listed in each section form a part of that Section to the extent referenced.
- B. The publication date is the publication in effect as of the bid date, except when a specific publication date is specified.

- C. Obtain copies of referenced standards direct from publication source when needed for proper performance of work, or when required for submittal by Contract Documents.

1.10 SCOPE OF WORK

- A. The work to be performed consists of the satisfactory completion of all Plumbing work, as indicated in the Contract Documents.
- B. The work to be performed under these specifications shall include providing all labor, materials and equipment necessary to furnish and install, complete, properly and fully, all Plumbing Work as shown on drawings, herein specified and/or necessary thereto, whether or not specified herein in detail, and/or reasonably implied, and leaving the same in satisfactory operating condition. It is the intent of these specifications that a complete and operating system shall be installed and this Contractor shall carefully examine the site, plans, and specifications, and shall include all items necessary to accomplish this purpose.

1.11 SCHEDULING OF WORK

- A. This project consists of new construction and renovation work. Due to the size, scope and time required to complete this work, it may be necessary to perform the work in phases in order to allow the owner to continue with their business operations with a minimum amount of disruption.
- B. The Contractor shall thoroughly review the plumbing drawings, along with the architectural drawings, for the phasing sequence and shall incorporate into his bid the impact the phasing sequence and the construction schedule has on the Plumbing work in this project.
- C. Initially, upon award of all construction contracts, work shall begin on new construction. Early in this portion of the work, and so as to avoid or minimize disruption to the owner.

1.12 DESCRIPTION OF SYSTEMS

- A. Without intending to limit or restrict the volume of work required by this Specification and the applicable drawings, the work generally consists of:
 - 1. Complete Plumbing systems including sanitary, waste, vent, hot water and cold water piping, specialties and equipment.
 - 2. Installation of new water heaters, air compressor, pumps, piping and piping specialties.
 - 3. Thermal insulation of equipment and piping.
 - 4. Concrete pads for all floor mounted equipment.
 - 5. Cleaning of all equipment, piping, and fixtures.
 - 6. Painting of equipment, piping, supports and hangers.
 - 7. Testing, balancing and adjusting.
 - 8. Cutting and patching for new work in the existing building.
 - 9. Vibration isolation equipment.
 - 10. Structural and Mechanical Engineering services for the design and support of all piping systems for pipe sizes 6" and larger.
 - 11. Operating and maintenance instructions and manuals.
 - 12. Demonstration of successful system operation.

1.13 EQUIPMENT FURNISHED UNDER OTHER CONTRACTS

- A. Unless otherwise specified or shown on the drawings, this Contractor shall make final plumbing connections to all equipment furnished under General and Electrical Contracts. For HVAC equipment, this Contractor shall provide a capped water outlet within two (2) feet of the HVAC equipment, and the HVAC Contractor shall make and be responsible for the final connections. For HVAC gas fired equipment, this Contractor shall make the final gas connections to the equipment.
- B. Unless otherwise specified or shown on drawings, the equipment furnished under the concurrent contracts will be furnished with their operating controls. This Contractor shall provide valves on water and gas, and unless otherwise shown or specified traps on waste outlets, and shall furnish all labor and materials required to connect the equipment and make it operative. Unless otherwise shown or specified valves on lines to equipment shall be ball valves.
- C. Equipment furnished under other contracts will be set in place by the Contractor for that equipment. Controlling devices for this equipment will be furnished with the equipment, but were supplied detached, they shall be installed into the plumbing work piping assemblies by the Plumbing Contractor.
- D. This Contractor shall refer to the shop drawings of equipment furnished under other contracts to obtain the locations of connections and arrangements of piping assemblies to which he is required to connect. All the required pipe, fittings, adapters, couplings and other accessories required to make the equipment operative shall be provided by this Contractor.
- E. Products furnished to the site and paid for by the Owner.

1.14 SPACE PRIORITY

- A. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
 - 1. Gravity flow piping systems.
 - 2. Vent piping systems.
 - 3. Ceiling recessed lighting fixtures.
 - 4. Concealed air terminal units, fans.
 - 5. Air duct systems.
 - 6. Sprinkler systems piping.
 - 7. Forced flow piping systems.
 - 8. Electrical conduit, wiring, control wiring.
- B. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
- C. Change in order of priority is permissible by mutual agreement of all affected trades.
- D. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
- E. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the Work, materials and equipment of another trade.
- F. This Contractor shall verify roughing-in dimensions for all fixtures and equipment prior to his roughing-in for such fixtures and equipment.

1.15 CUTTING AND PATCHING

- A. Cutting and patching shall be in accordance with Division 1 Section "Execution".
- B. The Plumbing Contractor shall seal all openings he has utilized in fire-rated floors, ceilings or partitions after his work has been installed. The material used for sealing the openings shall have a fire-rating equal to or greater than the rating of the floor, ceiling or partition material.
- C. The Plumbing Contractor shall be responsible for providing all cutting, patching, and finishing of existing construction which is not specifically shown on the Architectural Drawings and which is required for the proper installation of his equipment and materials which are to be installed in the existing portion of this project. This work shall also be provided when removing existing equipment and materials. All cutting shall be kept to an absolute minimum consistent with the requirements of the project.
- D. Cutting, patching and finishing shall be performed by workmen skilled in this type of work. All patching shall be done utilizing materials of the same quality and texture as the adjacent undisturbed areas. All finishing shall match the undisturbed adjacent areas. Painting of the final finished areas, where general construction work occurs, will be the responsibility of the General Contractor. Painting of the final finished areas, where no general construction work occurs, shall be the responsibility of the Plumbing Contractor. The Plumbing Contractor shall paint entire plane in which damage occurs whether the surface is a wall or a ceiling.
- E. No cutting shall be done which may affect the building structurally or architecturally without first consulting with the General Contractor and then securing the approval of the Architect. Cutting shall be accomplished in such a manner as not to cause damage to the building or leave unsightly surfaces which cannot be concealed by plates, escutcheons or other construction. Where such unsightly conditions are caused, the Plumbing Contractor shall be required, at his own expense, to repair the damaged areas. Note all holes or openings in existing concrete or masonry shall be drilled, core bored or saw cut.
- F. Where present equipment or material is removed and unused openings remain in walls, floors, partitions, etc., the Plumbing Contractor shall properly patch all such openings.

1.16 RECORD DRAWINGS

- A. Provide in accordance with Division 01 Section PROJECT RECORD DOCUMENTS and as stated below.
- B. The Plumbing Contractor shall:
 - 1. During the construction period, maintain in good order a complete set of blue line plumbing contract drawings. Record the actual Plumbing installation as the work progresses. Include all changes to the contract and to equipment sizes and types. Keep these drawings available at the site at all times for inspection.
 - 2. Take proper caution against the use of superseded drawings. Check all such copies and mark "void". Where drawings have been corrected by memorandum, assume the responsibility for marking all drawings so affected with the changes; such marked drawings shall remain in use until revised drawings are issued.

1.17 INTENT OF DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable plumbing systems complete in every respect.

- B. Any apparatus, appliance, material or work not shown as standard industry practice on drawings, but mentioned in the specifications, or vice versa, shall be provided by the Plumbing Contractor without additional expense to the Owner.
- C. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.
- D. Due to the small scale of the drawings, all required offsets and fittings may not be shown but shall be provided at no change in Contract price.
- E. As many of the small lines required for the complete installation are shown on the drawings as is practicable, but some may have been omitted. The Contractor shall do all such piping that may be required or directed to effect proper connections to all apparatus, equipment, and fixtures in accordance with the manufacturer's detailed drawings and instructions.
- F. The equipment schedules shown on the drawings list the manufacturer used as the basis of design in the preparation of the Bid Drawings. The equipment specifications list that manufacturer as well as other manufacturers the Engineer, Architect and/or Owner find acceptable from a performance and product quality standpoint. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they have a positive or negative monetary impact on the design shown on the Bid Drawings. In addition, listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether the dimensions of these products will have a negative impact on the space allotted for this equipment. If the Contractor or his Subcontractors decide to use a product or manufacturer that is listed as acceptable in the specifications but is different from the product or manufacturer scheduled on the drawings, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the HVAC system(s) and/or the Plumbing system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, etc., between the scheduled item and the equipment item used.
 - 1. Use of a product or manufacturer not scheduled on the Bid Drawings constitutes a representation that:
 - a. The Plumbing Trade has investigated the proposed product and determined that the product can be installed within the space allotted.
 - b. The Plumbing Trade will coordinate the installation of product used into the work
 - c. The Plumbing Trade will be responsible for making all changes as may be required to make the work complete in all respects; waives all claims for additional costs under his responsibility, which may subsequently become apparent.

1.18 SUBMITTALS

- A. Provide in accordance with Division 01 Section SUBMITTAL PROCEDURES and as stated below.
- B. Submit plans to the Pennsylvania Department of Labor and Industry (L&I) Boiler Division. Install water heaters, fired and unfired pressure vessels in conformance with approved drawings providing all required valves, platforms, ladders, exits and clearances. Submit approved L&I drawings to Architect before construction.
- C. Submit Product Data, shop drawings, and samples in accordance with the General Conditions and Supplementary Conditions, within 60 days of award of contract for every item of material, etc. used.
- D. Designate in the construction schedule, or in a separate coordinated schedule, the dates for submission and the dates that reviewed shop drawings, product data and samples will be needed.

- E. Shop Drawings shall be presented in a clear and thorough manner. Details shall be identified by reference to sheet and detail, schedule or room numbers shown on Contract Drawings.
- F. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
1. Section 22 0519: Meters and Gauges for Plumbing Piping.
 2. Section 22 0523: General Duty Valves for Plumbing Piping.
 3. Section 22 0529: Hangers and Supports for Plumbing Piping and Equipment.
 4. Section 22 0553: Identification for Plumbing Piping and Equipment.
 5. Section 22 0700: Plumbing Insulation.
 6. Section 22 1116: Domestic Water Piping.
 7. Section 22 1119: Domestic Water Piping Specialties.
 8. Section 22 1123: Domestic Water Pumps.
 9. Section 22 1316: Sanitary Waste and Vent Piping.
 10. Section 22 1319: Sanitary Waste Piping Specialties.
 11. Section 22 1413: Storm Drainage Piping.
 12. Section 22 1423: Storm Drainage Piping Specialties.
 13. Section 22 1513: General Service Compressed Air Piping
 14. Section 22 1519: General Service Packaged Air Compressors and Receivers
 15. Section 22 1616: Facility Natural Gas Piping.
 16. Section 22 3400: Fuel Fired Domestic Water Heaters.
 17. Section 22 4000: Plumbing Fixtures.
 18. Section 22 4700: Drinking Fountains and Water Coolers
- G. All drawings prepared by the Plumbing Contractor, for the Plumbing Contractor's use, shall be submitted for approval. Such drawings include, but are not limited to, pipe fabrication and layout drawings, Plumbing piping and layout drawings, equipment layout drawings, coordination drawings, and drawings of miscellaneous details.
- H. Office samples shall be of sufficient size and quantity to clearly illustrate functional characteristics of the product, with integrally related parts and attachment devices, and full range of color, texture and pattern.
- I. The Plumbing Contractor shall be responsible for reviewing shop drawings, product data and samples prior to submission. The Plumbing Contractor shall clearly mark or highlight the submittal to indicate all pertinent information such as model number, dimensions, capacities, clearances, performance characteristics, etc., and shall delete any data which is not relevant to the work. The Plumbing Contractor shall also determine and verify field measurements, field construction criteria, catalog numbers and similar data, and conformance with specifications.
- J. The Plumbing Contractor shall coordinate each submittal with requirements of the work and of the Contract Documents.
- K. The Plumbing Contractor shall notify the Architect in writing, at time of submission, of any deviations in the submittals from requirements of the Contract Documents.
- L. The Plumbing Contractor shall begin no fabrication or work which requires submittals until return of submittals with Architect approval.
- M. The Plumbing Contractor shall make submittals promptly in accordance with approved schedule, and in such sequence as to cause no delay in the work or in the work of any other Contractor.

- N. Unless required otherwise by the General Conditions or the Supplementary Conditions, the number of submittals required shall be as follows:
1. Shop Drawings: Submit the number of opaque reproductions which the Plumbing Contractor requires, plus three copies, one will be retained by the Architect, one copy will be retained by the Engineer, and one copy will be retained by the Owner.
 2. Product Data: Submit the number of copies which the Plumbing Contractor requires, plus three copies; one copy will be retained by the Architect, one copy will be retained by the Engineer, and one copy will be retained by the Owner.
 3. Samples: Submit the number stated in each specification section.
- O. The Plumbing Contractor shall also include in each submittal the date of submission and the dates of any previous submissions; the project title and number; the names of the Plumbing Contractor, the supplier, and the manufacturer; identification of the product, with the specification section number; identification of revisions on resubmittals; and the Plumbing Contractor's stamp, initialed or signed, certifying to review of submittal, verification of products, field measurements and field construction criteria, and coordination of the information within the submittal with requirements of the work and of Contract Documents.
- P. For resubmission requirements, the Plumbing Contractor shall make any corrections or changes in the submittals (i.e., shop drawings, samples or product data) required by the Architect and resubmit until approved.
- Q. The Architect will review submittals with reasonable promptness and in accordance with schedule, affix stamp and initials or signature, and indicate requirements for resubmittal, or approval of submittal, and return submittals to Plumbing Contractor for distribution, or for resubmission.
- R. Submittals for equipment and pumps shall include manufacturer's published performance curves showing flow rate, pressure drop, efficiency, horsepower, NPSH required (for pumps), and operating points.
- S. As soon as practicable, and within 30 days after the date of award of contract, and prior to installation of any equipment or material a completed schedule of equipment and material proposed for installation shall be submitted to the A/E for approval.
- T. All material submitted for approval, excepting special equipment and special adaptation of regular equipment as hereinafter specified and as specifically shown on the drawings, shall be standard printed matter made available by the manufacturer to the public and in effect at the time of opening of bids and shall indicate that the material or equipment is regularly produced and recommended for the service required. In the event any items of material or equipment contained in the schedule fail to comply with the specification requirements, such items may be rejected.
- U. In the event that the contractor fails to submit the required schedule of materials and equipment within the allowed time, the A/E will select a complete line of materials, fixtures, and equipment. The selection made shall be final and binding, and the items shall be furnished and installed by the contractor without any change in contract price or time of completion.
- V. Product data for the following:
1. Transition fittings.
 2. Dielectric fittings.
 3. Mechanical sleeve seals.
 4. Escutcheons.
- W. Welding certificates.

1.19 SUBSTITUTIONS AND PRODUCT OPTIONS

- A. Provide in accordance with Division 01 Section SUBSTITUTION PROCEDURES and as stated below.
- B. It will be the responsibility of this contractor to pay any and all costs associated with any approved substitutions which impact the structure, the electrical system(s), the plumbing system(s) and/or the Plumbing system(s) due to an increase in weight, electrical load, drain requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.
- C. For products specified only by reference standard, select any product meeting that standard. For products specified by naming several products or manufacturers, select any one of the products or manufacturers named, which complies with the drawings and specifications. For products specified by naming one or more products or manufacturers and "or equal", Plumbing Contractor must submit a request as for substitutions for any product or manufacturer not specifically named.
- D. The Architect will consider written requests from the Plumbing Contractor for substitution of products by manufacturers not listed in the Specification for a period up to 10 days prior to the Bid. Within this period, submit a separate request for each product, supported with complete data, with drawings and samples as appropriate and as required under the "submittals" paragraph in this section to include: Comparison of the qualities of the proposed substitution with that specified; changes required in other elements of the work because of the substitution; effect on the construction schedule; cost data comparing the proposed substitution with the product specified; availability of maintenance service, and source of replacement materials.
- E. A request for a substitution constitutes a representation that the Plumbing Contractor has investigated the proposed product and determined that it is equal to or superior in all respects to that specified; can be installed within the space allotted; will provide the same warranties or bonds for the substitution as for the product specified; will coordinate the installation of an accepted substitution into the work, and make such other changes as may be required to make the work complete in all respects; waives all claims for additional costs, under his responsibility, which may subsequently become apparent.
- F. The Plumbing Contractor will compensate the Architect and Engineer on a time and material basis for their costs involved in reviewing a substitution.

1.20 OPERATING AND MAINTENANCE DATA AND OWNER INSTRUCTION

- A. Provide in accordance with Division 01 Section OPERATION AND MAINTENANCE DATA and as stated below.
- B. The manual shall contain as a minimum: models and serial numbers for the equipment; description of the equipment/system and its components; recommended routine, preventative and emergency maintenance; start-up, operating and safety instructions; recommended frequency of inspection; oil type; belt tension adjustment; performance curves, engineering data, and tests; "trouble-shooting guide"; a spare parts list; and names, addresses and telephone numbers for the equipment installer, the maintenance contractor, and the local spare parts source.
- C. Provide complete operating and maintenance information for products specified in:
 - 1. Section 22 1119: Domestic Water Piping Specialties.
 - 2. Section 22 1123: Domestic Water Pumps.
 - 3. Section 22 1319: Sanitary Waste Piping Specialties.
 - 4. Section 221513: General Service Compressed Air Piping
 - 5. Section 221519: General Service Packaged Air Compressors and Receivers
 - 6. Section 22 3400: Fuel Fired Domestic Water Heaters.
 - 7. Section 22 4000: Plumbing Fixtures.
 - 8. Section 22 4700: Drinking Fountains and Water Coolers

1.21 QUALITY ASSURANCE

- A. Provide in accordance with Division 01 Section QUALITY REQUIREMENTS.
- B. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- C. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.22 DELIVERY, STORAGE, HANDLING, AND PROTECTION

- A. Provide in accordance with Division 01 Section PRODUCT REQUIREMENTS and as stated below.
- B. Arrange deliveries of products in accordance with construction schedules. Coordinate to avoid conflict with work and conditions at the site. Deliver products in undamaged condition, in manufacturer's original containers or packaging, with identifying labels intact and legible.
- C. Immediately on delivery, inspect shipments to assure compliance with requirements of Contract Documents and approved submittals, and those products are properly protected and undamaged.
- D. Provide equipment and personnel to handle products by methods to prevent soiling or damage to products or packaging.
- E. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- F. Store new products in accordance with manufacturer's instructions, with seals and labels intact and legible. Store new products or items being re-used in a manner to prevent damage due to the elements, prevent damage due to construction operations at the site, and allow for ease of inspection.
- G. Provide substantial coverings as necessary to protect installed products from damage from traffic and subsequent construction operations. Remove when no longer needed.
- H. The Plumbing Contractor, at his own expense, shall make good to the Architect and the Owner's satisfaction any damage to his work incurred by the action of the elements or any other cause due to the neglect on the part of the Plumbing Contractor or his representatives.
- I. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.23 PROTECTION OF SERVICES AND EQUIPMENT

- A. Repair, replace and maintain in service any utilities, facilities or services (underground, aboveground, interior and/or exterior) which are damaged, broken, or otherwise rendered inoperative during the course of construction. The method used in repairing, replacing or maintaining the services shall be approved by the Architect and/or Engineer.
- B. The Plumbing Contractor shall protect all work, materials and equipment during the construction period. All openings must be securely covered, or otherwise protected, in order to prevent injury due to dropped tools, materials or dirt.

1.24 SPECIAL CONDITIONS RELATED TO PLUMBING WORK

- A. During the course of construction, cap or otherwise seal off, in an approved manner, those portions of the piping system in which work is not being performed, in order to prevent the entry of dirt or dust.
- B. The Plumbing Contractor shall coordinate all utility shut-downs with the Owner.
- C. Install equipment along with control devices and all replaceable fittings with sufficient clearance for operation and maintenance functions.
- D. Do not install piping in transformer vaults or electrical equipment rooms. In accordance with the National Electric Code Article 110-34f, do not install piping adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- E. Exposed piping shall be run so as to allow maximum headroom consistent with proper pitch. Piping shall not interfere with any light, opening, door, window or equipment. Headroom in front of openings, doors and windows shall not be less than the top of the opening. Minimum clearance of 1 inch shall be maintained around all piping, valves and fittings.
- F. Outside, underground piping shall have a minimum of 36 inches of earth cover, except provide greater coverage to equal locally recorded frost penetrations.
- G. Lay out the work and establish all heights and grades required for installation.
- H. All material and equipment to be furnished under this contract shall be new and shall conform to the grade, quality and standards specified herein. Items of equipment shall be the latest standard product as advertised in printed catalogues by reputable manufacturers for the purpose intended and shall have replacement parts available.
- I. Equipment shall be installed in strict accordance with the manufacturer's instructions for type and capacity of each piece of equipment. The Plumbing Contractor shall obtain these instructions from the manufacturer and such instructions shall be considered a part of these specifications. Type, capacity, and application of equipment shall be suitable and capable of satisfactory operation for the purpose intended in the plumbing system.
- J. Equipment and materials of the same general type shall be of the same make throughout the work to provide uniform appearance, operation, and maintenance.
- K. It shall be the responsibility of the Contractor to ensure that the items to be furnished fit the space available. He shall make necessary field measurements to ascertain space requirements, including those for connection, and shall furnish and install such sizes and shapes of equipment that the final installation shall suit the true intent and meaning of the drawings and specifications.

- L. Where equipment requiring different arrangement or connections from those shown is approved, it shall be the responsibility of the Contractor to install that equipment to operate properly and in harmony with the intent of drawings and specifications. When directed by the Architect, the Contractor shall submit drawings showing the proposed installation. If the proposed installation is approved, the Contractor shall make all incidental changes in piping, ductwork, supports, insulation, wiring, heaters, panelboards, etc. He shall provide any additional motors, controllers, valves, fittings, and other additional equipment for the proper operation of the system resulting from the selection of that equipment, including all required changes in affected trades. The Contractor shall be responsible for the proper location of roughing-in and in connections by other trades. All changes shall be made at no increase in the Contract Amount or additional cost to the other trades.
- M. Unless otherwise noted on the drawings or in the specifications, concrete pads and bases for heaters, tanks, and other equipment shall be furnished and installed by the Contractor furnishing the equipment requiring such pad or base. The Contractor shall establish sizes and locations of the various concrete bases required and shall provide all necessary anchor bolts, together with the templates for holding these bolts in position. Anchor bolts shall be placed in steel pipe sleeves to allow for adjustment, with suitable plate at bottom end of sleeve to hold the bolt. Each concrete base shall be not less than 4" high, which shall project 3" on all sides beyond the equipment. Special vibration isolation foundations that are required are specified with the equipment supported.
- N. The Contractor shall support, plumb, rigid and true to line, all work and equipment furnished under each section. The Contractor shall study thoroughly all general, structural, mechanical, and electrical drawings, shop drawings, and catalog data to determine how equipment, fixtures, piping, conduit, ductwork, etc. are to be supported, mounted, or suspended and shall provide extra steel bolts, inserts, pipe standards, brackets and accessories for proper support, whether or not shown on the drawings. When directed, the Contractor shall submit prints showing supports for approval.
- O. Provide safety guards for all pulleys, belt-drives and rotating equipment. Safety requirements of the Pennsylvania Department of Labor and Industry and OSHA shall be met.

1.25 COORDINATION

- A. Sequence of Work
 - 1. Provide in accordance with Division 01 Section SUMMARY.
- B. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for plumbing installations.
- C. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- E. This Plumbing Contractor must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.
- F. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD Format prepared by the Mechanical Contractor. The Mechanical Contractor shall start their drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.

- G. After the Mechanical Contractor has finished, it shall forward one print along with an electronic file to the Plumbing trade that in turn will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Plumbing trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades
- H. Interference plans and elevations shall show in detail the location of the following items which require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the paragraph entitled "Space Priority".
 - 1. In addition, show mechanical and electrical work in equipment rooms.
 - 2. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.
- I. Reproducible copies along with electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
- J. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

1.26 DEMONSTRATION AND TRAINING

- A. Provide in accordance with Division 01 Section DEMONSTRATION AND TRAINING and as stated below.
- B. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 PIPE, TUBE, AND FITTINGS

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

2.03 JOINING MATERIALS

- A. Refer to individual Division 22 piping Sections for special joining materials not listed below.
- B. Pipe Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.

1. ASME B16.21, nonmetallic, flat, asbestos-free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast iron and steel flanges.
 2. AWWA C110, rubber, flat face, 1/8 inch thick, unless otherwise indicated; and full-face or ring type, unless otherwise indicated.
- C. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- D. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- E. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- F. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- G. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- H. Solvent Cements for Joining Plastic Piping:
 1. ABS Piping: ASTM D 2235.
 2. CPVC Piping: ASTM F 493.
 3. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.
 4. PVC to ABS Piping Transition: ASTM D 3138.
- I. Fiberglass Pipe Adhesive: As furnished or recommended by pipe manufacturer.

2.04 TRANSITION FITTINGS

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

- C. Plastic-to-Metal Transition Adaptors: One-piece fitting with manufacturer's SDR 11 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
 - 1. Manufacturers:
 - a. Thompson Plastics, Inc.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, CPVC and PVC four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
 - 1. Manufacturers:
 - a. Nibco, Inc.
 - b. Nibco, Inc.; Chemtrol Division
- E. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Company
 - b. Fernco, Inc.
 - c. Mission Rubber Company
 - d. Plastic Oddities, Inc.

2.05 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory fabricated, union assembly, for 250-psig minimum working pressure at 180°F.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Eclipse, Inc.
 - d. Epco Sales, Inc.
 - e. Hart Industries, International, Inc.
 - f. Watts Industries, Inc.; Water Products Division
 - g. Zurn Industries, Inc.; Wilkins Division
- D. Dielectric Flanges: Factory fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
 - 1. Manufacturers:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Epco Sales, Inc.
 - d. Watts Industries, Inc.; Water Products Division

- E. Dielectric Flange Kits: Companion-flange assembly for field assembly. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or polyethylene bolt sleeves, phenolic washers, and steel backing washers.
 - 1. Manufacturers:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Central Plastics Company
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Separate companion flanges and steel bolts and nuts shall have 150- or 300-psig minimum working pressure where required to suit system pressures.
- F. Dielectric Couplings: Galvanized steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225°F.
 - 1. Manufacturers:
 - a. Calpico, Inc.
 - b. Lochinvar Corporation
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225°F.
 - 1. Manufacturers:
 - a. Perfection Corporation
 - b. Precision Plumbing Products, Inc.
 - c. Sioux Chief Manufacturing Co., Inc.
 - d. Victaulic Company of America

2.06 MECHANICAL SLEEVE SEALS

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

2.07 SLEEVES

- A. Galvanized Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

- C. Cast Iron: Cast or fabricated "wall pipe" equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.
- D. Stack Sleeve Fittings: Manufactured, cast iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.
- E. Molded PVC: Permanent, with nailing flange for attaching to wooden forms.
- F. PVC Pipe: ASTM D 1785, Schedule 40.
- G. Molded PE: Reusable, PE, tapered-cup shaped, and smooth-outer surface with nailing flange for attaching to wooden forms.
- H. Sleeves for Pipes through Non-Fire Rated Walls and Floors: Form with galvanized steel.
- I. Sleeves for Pipes through Exterior Masonry and Concrete Walls and Slabs below Grade: Form with schedule 40 steel pipe with water stops.
- J. Sleeves for Pipes through Masonry and Concrete Walls and Slabs above Grade: Form with Schedule 40 steel pipe.
- K. Sleeves for Pipe through Drywall and Plaster Partitions: Form with galvanized steel.
- L. Provide Link-Seal by Thunderline Corporation for below grade piping penetrations through exterior walls and slabs.

2.08 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- B. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome plated finish.
- C. One-Piece, Cast brass Type: With set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- D. Split-Casting, Cast brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- E. One-Piece, Stamped steel Type: With set screw or spring clips and chrome plated finish.
- F. Split-Plate, Stamped steel Type: With concealed hinge, set screw or spring clips, and chrome plated finish.
- G. One-Piece, Floor plate Type: Cast iron floor plate.
- H. Split-Casting, Floor plate Type: Cast brass with concealed hinge and set screw.

2.09 GROUT

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

2.10 ACCESS PANELS

- A. Where required for access to valves, cleanouts, etc., and where new and existing items require adjustments, inspection or service, removable panels complete with frame shall be furnished and installed by this Contractor. Access panels shall be a minimum of 10" x 10". Panels are required for their intended service and shall be of the type, fire rating, finish, color and material required for the finish and construction into which they are installed. Coordinate with General Contractor and Architect prior to purchasing.
- B. Access panels shall be a minimum of 18" x 18" or larger where needed to remove equipment and allow man access. Doors shall be hinged and removable.

PART 3 - EXECUTION

3.01 CLEANING UP/REMOVAL OF DEBRIS

- A. This Contractor shall periodically, and at such times as directed by the Professional, remove from the premises all trash and debris caused by the performance of his work. At the completion of the work, all parts of the plumbing installation shall be thoroughly cleaned by this Contractor. All piping, flush valves, fixtures, trim, strainers, etc., shall be cleaned of all grease, dirt and metal cuttings. All plumbing fixtures shall be cleaned to restore to their original condition.
- B. Any damage to the building finishes or furnishings due to the failure of this Contractor to afford proper protection during the execution of his work, shall be restored in a manner satisfactory to the Architect/Owner.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 22 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.

- F. Install piping to permit valve servicing.
- G. Install piping at indicated slopes.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install piping to allow application of insulation.
- K. Water piping shall be graded in such a manner as to be completely drain the entire system and to permit air relief of hot water piping systems.
- L. Select system components with pressure rating equal to or greater than system operating pressure.
- M. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Chrome plated Piping: One-piece, cast brass type with polished chrome plated finish.
 - c. Insulated Piping: One-piece, stamped steel type with spring clips.
 - d. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass type with polished chrome plated finish.
 - e. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast brass type with polished chrome plated finish.
 - f. Bare Piping in Unfinished Service Spaces: One-piece, cast brass type with polished chrome plated or rough-brass finish.
 - g. Bare Piping in Equipment Rooms: One-piece, cast brass type.
 - h. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece, floor plate type.
- N. Sleeves are not required for core-drilled holes.
- O. Permanent sleeves are not required for holes formed by removable PE sleeves.
- P. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
- Q. Install sleeves for pipes passing through concrete and masonry walls, gypsum-board partitions, and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 6 (DN 150).
 - b. Steel Sheet Sleeves: For pipes NPS 6 (DN 150) and larger, penetrating gypsum-board partitions.
 - c. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast iron soil pipe to extend sleeve to 2 inches above finished floor level.

- d. Refer to Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - 1) Seal space outside of sleeve fittings with grout.
- 4. Except for underground wall penetrations, seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.
- R. Aboveground, Exterior Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast iron "wall pipes" for sleeves 6 inches and larger in diameter.
 - 3. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- S. Underground, Exterior-Wall Pipe Penetrations: Install cast iron "wall pipes" for sleeves. Seal pipe penetrations using mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- T. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 Section "Penetration Firestopping" for materials.
- U. Verify final equipment locations for roughing-in.
- V. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.
- W. Exposed piping in finished spaces shall be chrome-plated

3.03 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 22 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.

- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID.
- G. 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.
- H. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" article.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- J. Plastic piping solvent-cement joints; clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Non-pressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Non-pressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- K. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- L. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.
- M. PE Piping Heat Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.
 - 1. Plain End Pipe and Fittings: Use butt fusion.
 - 2. Plain End Pipe and Socket Fittings: Use socket fusion.

3.04 PIPING CONNECTIONS

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

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Provide in accordance with Division 01 Section EXECUTION and as stated below.
- B. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.

- C. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- D. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- E. Install equipment to allow right of way for piping installed at required slope.

3.06 STARTING OF PLUMBING SYSTEMS AND EQUIPMENT

- A. Provide material and labor required to perform start-up of each respective item of equipment and system prior to beginning of test, adjust and balance procedures. Refer to the section in Division 22 in which the system or equipment item is specified for specific start-up requirements for that system or equipment item.

3.07 TRAPS

- A. Unless otherwise specified or shown on the drawings, all plumbing fixtures, floor drains, and equipment furnished by this or other current contracts shall be individually trapped with full bore traps. Generally, plumbing fixture traps shall be on the wall outlet type connecting to a sanitary tee drainage fitting, the vent being extended vertically and provided with offsets where shown or specified.
- B. Traps supplied with the plumbing fixtures are specified elsewhere; however, all equipment furnished under other contracts and requiring waste connections and not furnished with traps, shall be provided with traps furnished and installed by this Contractor. All unburied traps shall be cast brass of the sizes shown on the drawings, and shall, where exposed, be chrome plated and connected to the roughing with chrome plated copper tubing. Buried traps shall be cast iron.
- C. Where buried, running traps shall have one vent hub fitted with extension section of pipe to permit cleanout plug to be installed under cover plate, set flush with finished floor. All unburied P-traps shall have cleanout plug on the bottom of the bed of the trap. Buried P-traps shall not have cleanout plugs.

3.08 FLASHING

- A. Openings in roofs for extended soil and vent pipe shall be flashed by the General Contractor. Refer to detail on Architectural drawings.

3.09 PAINTING

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

3.10 CONCRETE BASES

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

3.11 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

3.12 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

3.13 GROUTING

- A. Mix and install grout for plumbing equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.

- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

3.14 MATERIALS PROHIBITED

- A. Absolutely no materials, equipment, etc., containing asbestos and/or lead shall be installed on this construction project. No deviations will be entertained or accepted.

3.15 FINAL CLEANING

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES.

3.16 CERTIFICATION

- A. After a final site observation has been performed by the engineer, the contractor shall provide the Owner with a letter certifying that he did not install any asbestos-containing and/or lead containing materials on this project a result of his construction work. In addition, the contractor shall provide the owner with a letter from each of his sub-contractors certifying the same.

3.17 GUARANTEE OF WORK

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES and as stated below.
- B. Where applicable, furnish manufacturer's written warranty for materials and equipment.
- C. This Plumbing Contractor shall furnish a written warranty stating that all work shall be free from defects of equipment, material for workmanship for a period of one year from date of final acceptance and all defects developing during that period shall be made good without cost to the Owner.
- D. This Plumbing Contractor shall service the installation for one year from date of final acceptance. This shall include all emergency service and adjustment, with the exception of the oiling of motors and cleaning of filters and screens.

3.18 FINAL PLUMBING CONNECTIONS

- A. Provide rough-in and final connection of all Plumbing services needed for equipment provided by the Owner or by other trades. Shop Drawings will be furnished by those providing the equipment. These Drawings shall be checked by the trade responsible for rough-in and final connections before submission to the Architect for approval. The work shall be done in accordance with the approved Shop Drawings.
- B. In general, connection and termination points are given in the Contract Documents. Where not given or where conflicts occur, refer the question to the Architect for a binding decision.

END OF SECTION 22 0500

SECTION 22 0513 - COMMON MOTOR REQUIREMENTS FOR PLUMBING EQUIPMENT

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. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel-cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.03 COORDINATION

- A. Coordinate features of motors, installed units, and accessory devices to be compatible with the following:
 - 1. Motor controllers.
 - 2. Torque, speed, and horsepower requirements of the load.
 - 3. Ratings and characteristics of supply circuit and required control sequence.
 - 4. Ambient and environmental conditions of installation location.
- B. Motors shall be furnished with equipment requiring same. Unless hereinafter specifically specified or specifically noted on the drawings, all motors 1/2 HP and larger shall be designed for three-phase, 60 cycle alternating current at 208/480 volts, as scheduled on the drawings. Motors smaller than 1/2 HP shall be designed for single phase, 60 hertz alternating current at 120 volts. Refer to Equipment Schedules on the drawings for specific motor requirements for all equipment.
- C. Combination motor starters and disconnect switches, and control devices shall be furnished with each motor as required and as hereinafter specified for each particular motor.
- D. Combination motor starters and disconnect switches will be furnished by the Plumbing Contractor and installed by the Contractor for Electrical Work, unless specifically noted otherwise on the drawings.
- E. All fuses shall be "Fusetron" or approved equal.
- F. The Electrical Contractor shall be responsible for proper direction of rotation of all three-phase equipment.
- G. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not over 18" long.
- H. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.
- I. All electrical work required in the Mechanical Contracts shall conform to all applicable requirements of Division 26 of these Specifications.

- J. The Plumbing Contractor shall employ an approved sub-contractor, fully qualified in the trade, to perform all Electrical Work required under the Plumbing Contract.
- K. The Plumbing Contractor shall cooperate with the Contractor for Electrical Work in making all necessary tests and in receiving, storing and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these Contracts.

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in plumbing equipment schedules or Sections.
- B. Comply with efficiency requirements of DOE 10 CFR 431.
- C. Comply with NEMA MG 1 unless otherwise indicated.
- D. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 104°F and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 MOTOR CONTROL RELAYS:

- 1. Provide auxiliary relay for control of associated air compressor equipment
- 2. Provide an adjustable time-delay relay to eliminate nuisance tripping when momentary loss of power occurs.

2.04 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. Multispeed Motors: Variable torque.
 - 1. For motors with 2:1 speed ratio, consequent pole, single winding.
 - 2. For motors with other than 2:1 speed ratio, separate winding for each speed.
- E. Multispeed Motors: Separate winding for each speed.

- F. Rotor: Random-wound, squirrel cage.
- G. Bearings: Re-greasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- H. Temperature Rise: Match insulation rating.
- I. Insulation: Class F.
- J. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- K. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.05 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.
- C. Severe-Duty Motors: Comply with IEEE 841, with 1.15 minimum service factor.
- D. Three-phase equipment controls and wiring shall be as follows:
 - 1. Plumbing Contractor shall furnish and install all control devices, such as contactors, motor starters, thermal and overload protection, pushbuttons, thermostats, etc.
 - 2. Plumbing Contractor shall furnish and install all controls and control wiring from control devices to motor starters and contactors and between control devices.
 - 3. Electrical Contractor will furnish and install all power wiring and conduit to motor starters, contactors, and disconnect switches, and between starters and contactors and motor or other load.

2.06 SINGLE PHASE MOTORS

- A. Motors larger than 1/20 HP shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.

- C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal protection device shall automatically reset when motor temperature returns to normal range.
- F. Single phase equipment controls and wiring shall be as follows:
 - 1. Plumbing Contractor shall furnish and install all control devices, such as motor sentinel switches, thermostats, etc.
 - 2. Plumbing Contractor shall furnish and install all conduit and control wiring from control devices to junction box or to disconnect switch mounted on unit.
 - 3. Electrical Contractor will furnish and install all power wiring and conduit to junction box or to disconnect switch on unit.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 22 0513

SECTION 22 0516 - EXPANSION FITTINGS AND LOOPS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Factory-fabricated flexible pipe loops.
 - 2. Pipe loops and swing connections.
 - 3. Alignment guides and anchors.

1.03 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products shall be suitable for piping system fluids, materials, working pressures, and temperatures.
- B. Capability: Products shall absorb 200 percent of maximum axial movement between anchors.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
 - 1. Factory-fabricated flexible pipe loops.
 - 2. Alignment guides.
- B. Delegated Design Submittals: Each expansion compensator, flexible pipe loop, anchor and alignment guide, including analysis data, shall be signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Design Calculations: Calculate requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
 - 2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
 - 3. Alignment Guide Details: Detail field assembly and attachment to building structure.
 - 4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.
- C. Maintenance Data: For pipe expansion joints to include in maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Welding Qualifications - qualify procedures and personnel according to the following:
 - 1. Steel Shapes and Plates: AWS D1.1, "Structural Welding Code - Steel."
 - 2. Welding to Piping: ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.01 FACTORY FABRICATED FLEXIBLE LOOP

- A. Flex-Hose.
- B. Metra-Flex.
- C. The factory-fabricated flexible loop shall consist of a minimum of 2 equal length sections and shall be fabricated as follows:
 - 1. Piping 2½-inches in size and larger: The flexible loop shall be fabricated of annular corrugated stainless steel close-pitch hose (made in USA) with stainless steel over braid (made in USA) that will absorb or compensate for pipe movements.
 - 2. Piping 2-inches in size and smaller: The flexible loop shall be fabricated of annular corrugated bronze close-pitch hose (made in USA) with bronze over braid (made in USA) that will absorb or compensate for pipe movements.
 - 3. The factory-fabricated flexible loop shall be designed to accommodate a minimum of 4-inches of expansion.
- D. The corrugated metal hose, braid(s), and a stainless-steel ring-ferrule/band (material gauge not less than .048") must be integrally seal-welded using a 100% circumferential, full penetration TIG welds. End fittings shall be selected per application. Fittings must be attached using a 100% circumferential TIG weld.
- E. Braided stainless steel factory-fabricated flexible loops must be suitable for operating temperatures up to 850°F. Braided bronze factory-fabricated flexible loops must be suitable for operating temperatures up to 400°F.
- F. The factory-fabricated flexible loops must be designed for pressure testing to 1.5 times their maximum rated working pressure and a minimum 4:1 (burst to working) safety factor.
- G. Each braided factory-fabricated flexible loop shall be individually leak tested by the manufacturer using air-under-water or hydrostatic pressure.
- H. The factory-fabricated flexible loop shall be prepared for shipment using a cut-to-length metal shipping bar, tacked securely between the elbows of the two parallel legs, to maintain the manufactured length during shipping. The shipping bar must be removed prior to system start-up.
- I. The factory-fabricated flexible loop shall be furnished with a hanger assembly kit that shall be used to support and hang the factory-fabricated flexible loop.
- J. Warranty: The factory-fabricated flexible loop must have a 3-year full replacement warranty when installed in accordance with all specifications and installation instructions as described in the factory-fabricated flexible loop manufacturer's printed "Installation and Maintenance Instructions."
- K. Note: at the Plumbing Trade's option, in lieu of providing factory-fabricated flexible loops he may provide field-fabricated pipe loops and swing connections as described in Part 3 of this Section.

2.02 ALIGNMENT GUIDES AND ANCHORS

A. Alignment Guides

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Adsko Manufacturing LLC.
 - b. Flexicraft Industries.
 - c. Hyspan Precision Products, Inc.
 - d. Metraflex, Inc.
 - e. Unisource Manufacturing, Inc.
2. Description: Steel, factory-fabricated alignment guide, with bolted two-section outer cylinder and base for attaching to structure; with two-section guiding spider for bolting to pipe.
 - a. Minimum Alignment Guide Length: 8-inches.
 - b. Maximum spider travel: 2-inches.

B. Anchor Materials

1. Steel Shapes and Plates: ASTM A 36/A 36M.
2. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel hex head.
3. Washers: ASTM F 844, steel, plain, flat washers.
4. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened portland cement concrete, with tension and shear capacities appropriate for application.
 - a. Stud: Threaded, zinc-coated carbon steel.
 - b. Expansion Plug: Zinc-coated steel.
 - c. Washer and Nut: Zinc-coated steel.

PART 3 - EXECUTION

3.01 FACTORY FABRICATED FLEXIBLE LOOP INSTALLATION

- A. The factory fabricated flexible loop shall be installed and guided in accordance with the manufacturer's printed installation instructions. Other manufactured loops that require pipe alignment guides shall use "Spider" type with outer housing ring. Pipe hangers and/or roller supports shall not be considered acceptable for use as guides.

3.02 PIPE LOOP AND SWING CONNECTION INSTALLATION

- A. Connect risers and branch connections to mains with at least five pipe fittings including tee in main.
- B. Connect risers and branch connections to terminal units with at least four pipe fittings including tee in riser.
- C. Connect mains and branch connections to terminal units with at least four pipe fittings including tee in main.

3.03 ALIGNMENT GUIDE AND ANCHOR INSTALLATION

- A. Install alignment guides to guide expansion and to avoid end-loading and torsional stress.
- B. Install two guides on each side of pipe expansion fittings and loops. Install guides nearest to expansion joint not more than four pipe diameters from expansion joint.

- C. Attach guides to pipe and secure guides to building structure.
- D. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
- E. Anchor Attachments:
 - 1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.
- F. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.
 - 1. Anchor Attachment to Steel Structural Members: Attach by welding.
 - 2. Anchor Attachment to Concrete Structural Members: Attach by fasteners. Follow fastener manufacturer's written instructions.
- G. Use grout to form flat bearing surfaces for guides and anchors attached to concrete.

3.04 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain factory fabricated flexible loops. Refer to Division 01.

END OF SECTION 22 0516

SECTION 22 0519 - METERS AND GAUGES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Thermometers
 - 2. Gauges
 - 3. Test plugs
- B. Related Sections:
 - 1. Division 22 Section 22 1116 "Domestic Water Piping" for domestic and fire protection water service meters inside the building.
 - 2. Division 22 Section 22 1616 "Facility Natural Gas Piping" for gas meters.

1.03 DEFINITIONS

- A. CR: Chlorosulfonated polyethylene synthetic rubber.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated, include performance curves.
- B. Shop Drawings: Schedule for thermometers and gauges indicating manufacturer's number, scale range, and location for each.
- C. Product Certificates: For each type of thermometer and gauge, signed by product manufacturer.

PART 2 - PRODUCTS

2.01 METAL CASE, LIQUID-IN-GLASS THERMOMETERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Palmer - Wahl Instruments Inc.
 - 2. Terice, H. O. Company
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division

- B. Case: Die-cast aluminum, 9 inches long.
- C. Tube: Red or blue reading, mercury or organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, non-reflective aluminum with permanently etched scale markings.
- E. Window: Glass or plastic.
- F. Connector: Adjustable type, 360 degrees in horizontal plane, with locking device.
- G. Stem: Copper plated steel, aluminum, or brass for thermowell installation and of length to suit installation.
- H. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.02 DIRECT MOUNTING, VAPOR ACTUATED DIAL THERMOMETERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Division
 - 2. Terice, H. O. Company
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division
- B. Case: Liquid-filled type, cast aluminum, 4-1/2-inch diameter.
- C. Element: Bourdon tube or other type of pressure element.
- D. Movement: Mechanical, connecting element and pointer.
- E. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
- F. Pointer: Red or other dark-color metal.
- G. Window: Glass or plastic.
- H. Ring: Metal.
- I. Connector: Adjustable type, 360 degrees in horizontal plane, with locking device.
- J. Thermal System: Liquid- or mercury-filled bulb in copper plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.
- K. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.03 REMOTE MOUNTING, VAPOR ACTUATED DIAL THERMOMETERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Division
 - 2. Palmer - Wahl Instruments Inc.
 - 3. Terice, H. O. Company
 - 4. Weiss Instruments, Inc.
 - 5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division

- B. Case: Dry type, cast aluminum, 4-1/2-inch diameter with holes for panel mounting.
- C. Element: Bourdon tube or other type of pressure element.
- D. Movement: Mechanical, connecting element and pointer.
- E. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
- F. Pointer: Red or other dark color metal.
- G. Window: Glass or plastic.
- H. Ring: Metal.
- I. Connector: Bottom union type.
- J. Thermal System: Liquid- or mercury-filled bulb in copper-plated steel, aluminum, or brass stem for thermowell installation and of length to suit installation.
- K. Accuracy: Plus, or minus 1 percent of range or plus or minus 1 scale division to maximum of 1.5 percent of range.

2.04 THERMOWELLS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Division
 - 2. Palmer - Wahl Instruments Inc.
 - 3. Trelice, H. O. Company
 - 4. Weiss Instruments, Inc.
 - 5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division
- B. Manufacturers: Same as manufacturer of thermometer being used.
- C. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.05 PRESSURE GAUGES

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Division
 - 2. Palmer - Wahl Instruments Inc.
 - 3. Trelice, H. O. Company
 - 4. Weiss Instruments, Inc.
 - 5. Weksler Instruments Operating Unit; Dresser Industries; Instrument Division
- B. Direct Mounting, Dial type Pressure Gauges: Indicating-dial type complying with ASME B40.100.
 - 1. Case: Dry type, cast aluminum, 4-1/2-inch diameter.
 - 2. Pressure Element Assembly: Bourdon tube, unless otherwise indicated.
 - 3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.

4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
6. Pointer: Red or other dark-color metal.
7. Window: Glass or plastic.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

C. Remote Mounting, Dial type Pressure Gauges: ASME B40.100, indicating-dial type.

1. Case: Dry type, cast aluminum, 4-1/2-inch diameter with holes for panel mounting.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4 (DN 8), bottom-outlet type unless back-outlet type is indicated.
4. Movement: Mechanical, with link to pressure element and connection to pointer.
5. Dial: Satin-faced, non-reflective aluminum with permanently etched scale markings.
6. Pointer: Red or other dark color metal.
7. Window: Glass or plastic.
8. Ring: Metal.
9. Accuracy: Grade A, plus or minus 1 percent of middle half scale.
10. Vacuum pressure Range: 30-in. Hg of vacuum to 15 psig of pressure.
11. Range for Fluids under Pressure: Two times operating pressure.

D. Pressure Gauge Fittings:

1. Valves: NPS 1/4 (DN 8) brass or stainless-steel needle type.
2. Snubbers: ASME B40.5, NPS 1/4 (DN 8) brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.06 TEST PLUGS

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

1. Flow Design, Inc.
2. MG Piping Products Company
3. National Meter, Inc.
4. Peterson Equipment Company, Inc.
5. Sisco Manufacturing Company
6. Trerice, H. O. Company
7. Watts Industries, Inc.; Water Products Division

B. Description: Corrosion-resistant brass or stainless-steel body with core inserts and gasketed and threaded cap, with extended stem for units to be installed in insulated piping.

C. Minimum Pressure and Temperature Rating: 500 psig at 200°F.

D. Core Inserts: One or two self-sealing rubber valves.

1. Insert material for water service at 20° to 200°F shall be CR.
2. Insert material for water service at -30° to +275°F shall be EPDM.

- E. Test Kit: Furnish one test kit containing one pressure gauge and adaptor, two thermometer(s), and carrying case. Pressure gauge, adapter probes, and thermometer sensing elements shall be of diameter to fit test plugs and of length to project into piping.
1. Pressure Gauge: Small bourdon-tube insertion type with 2- to 3-inch diameter dial and probe. Dial range shall be 0 to 200 psig.
 2. Low Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 25° to 125°F.
High Range Thermometer: Small bimetallic insertion type with 1- to 2-inch diameter dial and tapered-end sensing element. Dial ranges shall be 0° to 220°F.
 3. Carrying case shall have formed instrument padding.

PART 3 - EXECUTION

3.01 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the outlet of each domestic, hot water storage tank.
- B. Install liquid-filled-case-type, vapor actuated dial thermometers at suction and discharge of each pump.
- C. Provide the following temperature ranges for thermometers:
 1. Domestic Hot Water: 30° to 180°F, with 2-degree scale divisions.
 2. Domestic Cold Water: 0° to 100°F, with 2-degree scale divisions.

3.02 GAUGE APPLICATIONS

- A. Install dry case type pressure gauges for discharge of each pressure-reducing valve.
- B. Install dry case type pressure gauges at suction and discharge of each pump.

3.03 INSTALLATIONS

- A. Install direct mounting thermometers and adjust vertical and tilted positions.
- B. Install remote mounting dial thermometers on panel, with tubing connecting panel and thermometer bulb supported to prevent kinks. Use minimum tubing length.
- C. Install thermowells with socket extending a minimum of 2 inches into fluid or to center of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Install direct mounting pressure gauges in piping tees with pressure gauge located on pipe at most readable position.
- E. Install remote mounting pressure gauges on panel.
- F. Install needle valve and snubber fitting in piping for each pressure gauge.
- G. Install test plugs in tees in piping.

- H. Install permanent indicators on walls or brackets in accessible and readable positions.
- I. Install connection fittings for attachment to portable indicators in accessible locations.
- J. Install thermometers and gauges adjacent to machines and equipment to allow service and maintenance for thermometers, gauges, machines, and equipment.
- K. Adjust faces of thermometers and gauges to proper angle for best visibility.

END OF SECTION 22 0519

SECTION 22 0523 - GENERAL - DUTY VALVES FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following general-duty valves:
 - 1. Copper alloy ball valves.
 - 2. Ferrous alloy ball valves.
 - 3. Bronze check valves.
 - 4. Spring-loaded, lift disc check valves.
 - 5. Bronze gate valves.
 - 6. Cast iron plug valves.
 - 7. Stop Valves
- B. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in this section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.
- C. Related Sections include the following:
 - 1. Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment" for valve tags and charts.
 - 2. Division 22 piping Sections for specialty valves applicable to those Sections only.

1.03 DEFINITIONS

- A. The following are standard abbreviations for valves:
 - 1. CWP: Cold working pressure.
 - 2. EPDM: Ethylene-propylene-diene terpolymer rubber.
 - 3. NBR: Acrylonitrile-butadiene rubber.
 - 4. PTFE: Polytetrafluoroethylene plastic.
 - 5. TFE: Tetrafluoroethylene plastic.

1.04 SUBMITTALS

- A. Product Data: For each type of valve indicated. Include body, seating, and trim materials; valve design; pressure and temperature classifications; end connections; arrangement; dimensions; and required clearances. Include list indicating valve and its application. Include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.

1.05 QUALITY ASSURANCE

- A. ASME Compliance for Ferrous Valves: ASME B16.10 and ASME B16.34 for dimension and design criteria.
- B. NSF Compliance: NSF 61 for valve materials for potable-water service.

1.06 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 angle, gate, and globe valves closed to prevent rattling.
 - 4. Set ball and plug valves open to minimize exposure of functional surfaces.
 - 5. Set butterfly valves closed or slightly open.
 - 6. Block check valves in either closed or open position.
- 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 hand wheels or stems as lifting or rigging points.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the manufacturers specified.

2.02 VALVES - GENERAL

- A. Refer to Part 3 "Valve Applications" article for applications of valves.
- B. Bronze Valves: NPS 2 (DN 50) and smaller with threaded ends, unless otherwise indicated.
- C. Ferrous Valves: NPS 2-1/2 (DN 65) and larger with flanged ends, unless otherwise indicated.
- D. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- E. Valve Sizes: Same as upstream pipe, unless otherwise indicated.
- F. Valves shall be of the "LEAD FREE" design.

- G. Valve Actuators:
 - 1. Gear Drive: For quarter-turn valves NPS 8 (DN 200) and larger.
 - 2. Hand wheel: For valves other than quarter-turn types.
 - 3. Lever Handle: For quarter-turn valves NPS 6 (DN 150) and smaller, except plug valves.
 - 4. Wrench: For plug valves with square heads. Furnish Owner with one wrench for every 10 plug valves, for each size square plug head.
- H. Extended Valve Stems: On insulated valves.
- I. Valve Flanges: ASME B16.1 for cast iron valves, ASME B16.5 for steel valves, and ASME B16.24 for bronze valves.
- J. Valve Grooved Ends: AWWA C606.
 - 1. Solder Joint: With sockets according to ASME B16.18.
 - a. Caution: Use solder with melting point below 840°F for angle, check, gate, and globe valves below 421°F for ball valves.
 - 2. Threaded: With threads according to ASME B1.20.1.
- K. Valve Bypass and Drain Connections: MSS SP-45.

2.03 COPPER ALLOY BALL VALVES

- A. Manufacturers
 - 1. Two-Piece, Copper alloy Ball Valves:
 - a. Conbraco Industries, Inc.; Apollo Division
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation
 - d. Hammond Valve
 - e. Milwaukee Valve Company
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
- B. Copper alloy Ball Valves, General: MSS SP-110.
- C. Two-Piece, Copper alloy Ball Valves: Bronze body with regular-port, chrome plated bronze ball; PTFE or TFE seats; and 600-psig minimum CWP rating and blowout proof stem.

2.04 FERROUS ALLOY BALL VALVES

- A. Manufacturers
 - 1. Conbraco Industries, Inc.; Apollo Division
 - 2. Crane Company; Crane Valve Group; Stockham Division
 - 3. Hammond Valve
 - 4. Milwaukee Valve Company
 - 5. Nibco, Inc.
- B. Ferrous alloy Ball Valves, General: MSS SP-72, with flanged ends.
- C. Ferrous alloy Ball Valves: Class 150, full or regular port.

2.05 BRONZE CHECK VALVES

A. Manufacturers

1. Type 3, Bronze, Swing Check Valves with Metal Disc:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation
 - d. Hammond Valve
 - e. Milwaukee Valve Company
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
2. Type 4, Bronze, Swing Check Valves with Nonmetallic Disc:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation
 - d. Hammond Valve
 - e. Milwaukee Valve Company
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division

B. Bronze Check Valves, General: MSS SP-80.

C. Type 3, Class 125, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

D. Type 3, Class 150, Bronze, Swing Check Valves: Bronze body with bronze disc and seat.

E. Type 4, Class 125, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

F. Type 4, Class 150, Bronze, Swing Check Valves: Bronze body with nonmetallic disc and bronze seat.

2.06 SPRING LOADED, LIFT DISC CHECK VALVES

A. Manufacturers

1. Type II, Compact Wafer, Lift disc Check Valves:
 - a. Grinnell Corporation
 - b. Hammond Valve
 - c. Milwaukee Valve Company
 - d. Mueller Steam Specialty
 - e. Nibco, Inc.
2. Type III, Globe Lift disc Check Valves:
 - a. Grinnell Corporation
 - b. Hammond Valve
 - c. Milwaukee Valve Company
 - d. Nibco, Inc.

3. Type IV, Threaded Lift disc Check Valves:
 - a. Grinnell Corporation
 - b. Milwaukee Valve Company
 - c. Mueller Steam Specialty
 - d. Nibco, Inc.
 - e. Watts Industries, Inc.; Water Products Division
- B. Lift disc Check Valves, General: FCI 74-1, with spring-loaded bronze or alloy disc and bronze or alloy seat.
- C. Type II, Class 125, Compact-Wafer, Lift disc Check Valves: Compact-wafer style with cast iron shell with diameter made to fit within bolt circle.
- D. Type IV, Class 125, Threaded Lift disc Check Valves: Threaded style with bronze shell and threaded ends.
- E. Type IV, Class 150, Threaded Lift disc Check Valves: Threaded style with bronze shell and threaded ends.

2.07 BRONZE GATE VALVES

- A. Manufacturers
 1. Type 1, Bronze, Non-rising Stem Gate Valves:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation
 - d. Hammond Valve
 - e. Milwaukee Valve Company
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
 2. Type 2, Bronze, Rising Stem, Solid-Wedge Gate Valves:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation
 - d. Hammond Valve
 - e. Milwaukee Valve Company
 - f. Nibco, Inc.
- B. Bronze Gate Valves, General: MSS SP-80, with ferrous alloy handwheel.
- C. Type 1, Class 125, Bronze Gate Valves: Bronze body with non-rising stem and bronze solid wedge and union-ring bonnet.
- D. Type 1, Class 150, Bronze Gate Valves: Bronze body with non-rising stem and bronze solid wedge and union-ring bonnet.
- E. Type 2, Class 125, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.
- F. Type 2, Class 150, Bronze Gate Valves: Bronze body with rising stem and bronze solid wedge and union-ring bonnet.

2.08 CAST IRON GATE VALVES

A. Manufacturers

1. Type I, Cast iron, non-Rising stem Gate Valves:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation.
 - d. Hammond Valve.
 - e. Milwaukee Valve Company.
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
 2. Type I, Cast Iron, Rising-Stem Gate Valves:
 - a. Cincinnati Valve Company
 - b. Crane Company; Crane Valve Group; Stockham Division
 - c. Grinnell Corporation.
 - d. Hammond Valve.
 - e. Milwaukee Valve Company.
 - f. Nibco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
- B. Cast iron Gate Valves, General: MSS SP-70, Type I.
- C. Class 125, NRS, Bronze mounted, Cast Iron Gate Valves: Cast iron body with bronze trim, non-rising stem, and solid-wedge disc.
- D. Class 125, OS&Y, Bronze mounted, Cast iron Gate Valves: Cast iron body with bronze trim, rising stem, and solid-wedge disc.
- E. Class 125, NRS, All-Iron, Cast iron Gate Valves: Cast iron body with cast iron trim, non-rising stem, and solid-wedge disc.
- F. Class 125, OS&Y, All-Iron, Cast iron Gate Valves: Cast iron body with cast iron trim, rising stem, and solid-wedge disc.

2.09 CAST IRON PLUG VALVES

A. Manufacturers

1. Lubricated Type, Cast Iron Plug Valves:
 - a. Milliken Valve Company, Inc.
 - b. Nordstrom Valves, Inc.
 - c. Olson Technologies; Homestead Division
 - d. R & M Energy Systems (Tomball, TX).
 - e. Walworth Company
- B. Cast iron Plug Valves, General: MSS SP-78.
- C. Class 125 or 150, lubricated type, cast iron plug valves.

2.10 STOP VALVES

- A. Manufacturers
 - 1. BrassCraft Manufacturing Company
 - 2. Mc Guire Manufacturing Company
 - 3. Chicago Faucets

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine piping system for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. 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.
- C. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.
- D. Examine threads on valve and mating pipe for form and cleanliness.
- E. 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.
- F. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE APPLICATIONS

- A. Refer to piping Sections for specific valve applications. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Throttling Service: Angle, ball, butterfly, or globe valves.
 - 3. Pump Discharge: Spring-loaded, lift disc check valves.
- B. If valves with specified CWP ratings are not available, the same types of valves with higher CWP ratings may be substituted.
- C. Domestic Water Piping - use the following types of valves with "LEAD FREE" design:
 - 1. Ball Valves, NPS 2 (DN 50) and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
 - 2. Ball Valves, NPS 2-1/2 (DN 65) and Larger: Class 150, ferrous alloy.
 - 3. Swing Check Valves, NPS 2 (DN 50) and Smaller: Type 4, Class 125 150, bronze.
 - 4. Swing Check Valves, NPS 2-1/2 (DN 65) and Larger: Type II, Class 125, gray iron.
 - 5. Spring-Loaded, Lift disc Check Valves, NPS 2 (DN 50) and Smaller: Type IV, Class 125 minimum 150.
 - 6. Gate Valves, NPS 2-1/2 (DN 65) and Larger: Type I, Class 125, NRS OS&Y where required, bronze mounted cast iron.
 - 7. Plug Valves, NPS 2 (DN 50) and Larger: Class 125 or 150, lubricated-type with FDA-approved-material sealant, cast iron.

- D. Sanitary Waste and Storm Drainage Piping - use the following types of valves:
 - 1. Ball Valves, NPS 2 (DN 50) and Smaller: Two-piece, 600-psig CWP rating, copper alloy.
 - 2. Ball Valves, NPS 2-1/2 (DN 65) and Larger: Class 150, ferrous alloy.

3.03 VALVE INSTALLATION

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- C. Locate valves for easy access and provide separate support where necessary.
- D. Install valves in horizontal piping with stem at or above center of pipe.
- E. Install valves in position to allow full stem movement.
- F. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Dual Plate Check Valves: In horizontal or vertical position, between flanges.
 - 3. Lift Check Valves: With stem upright and plumb.

3.04 JOINT CONSTRUCTION

- A. Refer to Division 22 Section 22 0500 "Common Work Results for Plumbing" for basic piping joint construction.
- B. Grooved Joints: Assemble joints with keyed coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- C. Soldered Joints: Use ASTM B 813, water flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

3.05 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.

END OF SECTION 22 0523

SECTION 22 0529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following hangers and supports for plumbing system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Trapeze pipe hangers.
 - 3. Metal framing systems.
 - 4. Thermal hanger shield inserts.
 - 5. Fastener systems.
 - 6. Pipe stands.
 - 7. Pipe positioning systems.
 - 8. Equipment supports.
- B. Related Sections include the following:
 - 1. Division 22 Section 22 0516 "Expansion Fittings and Loops for Plumbing Piping" for pipe guides and anchors.

1.03 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.04 PERFORMANCE REQUIREMENTS

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

1.05 SUBMITTALS

- A. Product data for the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal hanger shield inserts.
 - 3. Powder actuated fastener systems.
 - 4. Pipe positioning systems.

- B. Welding certificates.

1.06 QUALITY ASSURANCED

- A. Welding - qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.2, "Structural Welding Code--Aluminum."
 - 3. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - 4. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory-fabricated components. Refer to Part 3 "Hanger and Support Applications" article for where to use specific hanger and support types.
- B. Manufacturers:
 - 1. AAA Technology & Specialties Co., Inc.
 - 2. Bergen-Power Pipe Supports
 - 3. B-Line Systems, Inc.; a division of Cooper Industries
 - 4. ERICO/Michigan Hanger Company
 - 5. Globe Pipe Hanger Products, Inc.
 - 6. Grinnell Corporation
 - 7. National Pipe Hanger Corporation
 - 8. PHD Manufacturing, Inc.
 - 9. PHS Industries, Inc.
 - 10. Piping Technology & Products, Inc.
- C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- E. Padded Hangers: Hanger with pipe insulation pad or cushion for support of bearing surface of piping.

2.03 TRAPEZE PIPE HANGERS

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

2.04 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop or field fabricated pipe support assembly made of steel channels and other components.
- B. Manufacturers:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries
 - 2. ERICO/Michigan Hanger Co.; ERISTRUT Division
 - 3. Power-Strut Division; Tyco International, Ltd.
 - 4. Unistrut Corp.; Tyco International, Ltd.
- C. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.05 THERMAL HANGER SHIELD INSERTS

- A. Description: 100-psig minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Manufacturers:
 - 1. ERICO/Michigan Hanger Company
 - 2. PHS Industries, Inc.
 - 3. Pipe Shields, Inc.
- C. Insulation Insert Material for Cold Piping: Water repellent treated, ASTM C 533, Type I calcium silicate with vapor barrier.
- D. Insulation Insert Material for Hot Piping: Water repellent treated, ASTM C 533, Type I calcium silicate.
- E. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- F. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- G. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.06 FASTENER SYSTEMS

- A. Powder Actuated Fasteners: Threaded steel stud, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. Hilti, Inc.
 - b. ITW Ramset/Red Head.
 - c. Masterset Fastening Systems, Inc.
 - d. Powers Fasteners.
- B. Mechanical Expansion Anchors: Insert-wedge-type zinc coated steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.
 - 1. Manufacturers:
 - a. B-Line Systems, Inc.; a division of Cooper Industries
 - b. Hilti, Inc.

- c. ITW Ramset/Red Head
- d. Powers Fasteners

2.07 PIPE STAND FABRICATION

- A. Pipe Stands, General: Shop or field fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.
- B. Compact Pipe Stand: One-piece plastic unit with integral-rod-roller, pipe clamps, or V-shaped cradle to support pipe, for roof installation without membrane penetration.
 - 1. Manufacturers:
 - a. ERICO/Michigan Hanger Company
 - b. MIRO Industries.
- C. Low type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
 - 1. Manufacturers:
 - a. MIRO Industries
- D. High Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Manufacturers:
 - a. ERICO/Michigan Hanger Company
 - b. MIRO Industries
 - c. Portable Pipe Hangers
 - 2. Base: Plastic or Stainless steel.
 - 3. Vertical Members: Two or more cadmium plated steel or stainless steel, continuous-thread rods.
 - 4. Horizontal Member: Cadmium plated steel or stainless steel rod with plastic or stainless steel, roller-type pipe support.
- E. High Type, Multiple-Pipe Stand: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 1. Manufacturers:
 - a. Portable Pipe Hangers.
 - 2. Bases: One or more plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized steel, clevis-type pipe hangers.
- F. Curb Mounting Type Pipe Stands: Shop- or field fabricated pipe support made from structural steel shape, continuous-thread rods, and rollers for mounting on permanent stationary roof curb.

2.08 PIPE POSITIONING SYSTEMS

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

- B. Manufacturers:
 - 1. C & S Mfg. Corporation
 - 2. HOLDRITE Corp.; Hubbard Enterprises
 - 3. Samco Stamping, Inc.

2.09 EQUIPMENT SUPPORTS

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

2.10 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory mixed and packaged, dry, hydraulic cement, non-shrink and nonmetallic grout; suitable for interior and exterior applications.
 - 1. Properties: Non-staining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-58 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field-applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Use padded hangers for piping that is subject to scratching.
- F. Horizontal Piping Hangers and Supports - unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
 - 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120° to 450°F pipes, NPS 4 to NPS 16 (DN 100 to DN 400), requiring up to 4 inches of insulation.
 - 3. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24 (DN 20 to DN 600), requiring clamp flexibility and up to 4 inches of insulation.
 - 4. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24 (DN 15 to DN 600), if little or no insulation is required.
 - 5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4 (DN 15 to DN 100), to allow off-center closure for hanger installation before pipe erection.

6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of non-insulated stationary pipes, NPS 3/4 to NPS 8 (DN 20 to DN 200).
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
 8. Adjustable Band Hangers (MSS Type 9): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 8 (DN 15 to DN 200).
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of non-insulated stationary pipes, NPS 1/2 to NPS 2 (DN 15 to DN 50).
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 8 (DN 10 to DN 200).
 11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of non-insulated stationary pipes, NPS 3/8 to NPS 3 (DN 10 to DN 80).
 12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30 (DN 15 to DN 750).
 13. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 14. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange.
 15. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36 (DN 100 to DN 900), with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 16. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36 (DN 65 to DN 900), if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
 17. Single Pipe Rolls (MSS Type 41): For suspension of pipes, NPS 1 to NPS 30 (DN 25 to DN 750), from 2 rods if longitudinal movement caused by expansion and contraction might occur.
 18. Adjustable Roller Hangers (MSS Type 43): For suspension of pipes, NPS 2-1/2 to NPS 20 (DN 65 to DN 500), from single rod if horizontal movement caused by expansion and contraction might occur.
 19. Complete Pipe Rolls (MSS Type 44): For support of pipes, NPS 2 to NPS 42 (DN 50 to DN 1050), if longitudinal movement caused by expansion and contraction might occur but vertical adjustment is not necessary.
 20. Pipe Roll and Plate Units (MSS Type 45): For support of pipes, NPS 2 to NPS 24 (DN 50 to DN 600), if small horizontal movement caused by expansion and contraction might occur and vertical adjustment is not necessary.
 21. Adjustable Pipe Roll and Base Units (MSS Type 46): For support of pipes, NPS 2 to NPS 30 (DN 50 to DN 750), if vertical and lateral adjustment during installation might be required in addition to expansion and contraction.
- G. Vertical Piping Clamps - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500).
 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20 (DN 20 to DN 500), if longer ends are required for riser clamps.
- H. Hanger Rod Attachments - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.
 2. Steel Clevises (MSS Type 14): For 120° to 450°F piping installations.
 3. Swivel Turnbuckles (MSS Type 15): For use with MSS Type 11, split pipe rings.
 4. Malleable Iron Sockets (MSS Type 16): For attaching hanger rods to various types of building attachments.
 5. Steel Weldless Eye Nuts (MSS Type 17): For 120° to 450°F piping installations.

- I. Building Attachments - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
 13. Side-Beam Brackets (MSS Type 34): For sides of steel or wooden beams.
 14. Plate Lugs (MSS Type 57): For attaching to steel beams if flexibility at beam is required.
 15. Horizontal Travelers (MSS Type 58): For supporting piping systems subject to linear horizontal movement where headroom is limited.
- J. Saddles and Shields - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel Pipe Covering Protection Saddles (MSS Type 39): To fill interior voids with insulation that matches adjoining insulation.
 2. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 3. Thermal hanger Shield Inserts: For supporting insulated pipe.
- K. Spring Hangers and Supports - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Restraint-Control Devices (MSS Type 47): Where indicated to control piping movement.
 2. Spring Cushions (MSS Type 48): For light loads if vertical movement does not exceed 1-1/4 inches.
 3. Spring-Cushion Roll Hangers (MSS Type 49): For equipping Type 41 roll hanger with springs.
 4. Spring Sway Braces (MSS Type 50): To retard sway, shock, vibration, or thermal expansion in piping systems.
 5. Variable-Spring Hangers (MSS Type 51): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from hanger.
 6. Variable-Spring Base Supports (MSS Type 52): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from base support.
 7. Variable-Spring Trapeze Hangers (MSS Type 53): Preset to indicated load and limit variability factor to 25 percent to absorb expansion and contraction of piping system from trapeze support.

8. Constant Supports: For critical piping stress and if necessary to avoid transfer of stress from one support to another support, critical terminal, or connected equipment. Include auxiliary stops for erection, hydrostatic test, and load-adjustment capability.
9. These supports include the following types:
 - a. Horizontal (MSS Type 54): Mounted horizontally.
 - b. Vertical (MSS Type 55): Mounted vertically.
 - c. Trapeze (MSS Type 56): Two vertical-type supports and one trapeze member.
- L. Comply with MSS SP-58 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- M. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- N. Use powder actuated fasteners or mechanical expansion anchors instead of building attachments where required in concrete construction.
- O. Use pipe positioning systems in pipe spaces behind plumbing fixtures to support supply and waste piping for plumbing fixtures.

3.02 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-58 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field fabricated trapeze pipe hangers.
 1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field assembled metal framing systems.
- D. Thermal hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 1. Install powder actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder-actuated tool manufacturer. Install fasteners according to powder actuated tool manufacturer's operating manual.
 2. Install mechanical expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 1. Pipe Stand Types except Curb-Mounting Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 2. Curb-Mounting-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb. Refer to Division 07 Section "Roof Accessories" for curbs.

- G. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section 22 4000 "Plumbing Fixtures" for plumbing fixtures.
- H. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- I. Equipment Support Installation: Fabricate from welded structural steel shapes.
- J. Install hangers and supports to allow controlled thermal and seismic movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- K. Install lateral bracing with pipe hangers and supports to prevent swaying.
- L. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 (DN 65) and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- M. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- N. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- O. Insulated Piping - comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits according to ASME B31.9 for building services piping.
 - 2. Install MSS SP-58, Type 39, protection saddles if insulation without vapor barrier is indicated. Fill interior voids with insulation that matches adjoining insulation.
 - a. Option: Thermal hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 3. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 (DN 100) and larger if pipe is installed on rollers.
 - 4. Shield Dimensions for Pipe - not less than the following:
 - a. NPS 1/4 to NPS 3-1/2 (DN 8 to DN 90): 12 inches long and 0.048 inch thick.
 - b. NPS 4 (DN 100): 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6 (DN 125 and DN 150): 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14 (DN 200 to DN 350): 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24 (DN 400 to DN 600): 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 (DN 200) and Larger: Include wood inserts.
 - 6. Insert Material: Length at least as long as protective shield.
 - 7. Thermal hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

- A. Fabricate structural steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding - comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous thread hanger and support rods to 1-1/2 inches.

3.06 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touch Up: Cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal are specified in Division 09 painting Sections.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 22 0529

SECTION 22 0553 - IDENTIFICATION FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Equipment labels
 - 2. Warning signs and labels
 - 3. Pipe labels
 - 4. Valve tags
 - 5. Warning tags

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Samples: For color, letter style, and graphic representation required for each identification material and device.
- C. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- D. Valve numbering scheme.
- E. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 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

2.01 EQUIPMENT LABELS

A. Metal Labels for Equipment:

1. Material and Thickness: Brass, 0.032-inch, Stainless steel, 0.025-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having pre-drilled or stamped holes for attachment hardware.
2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
3. 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.
4. Fasteners: Stainless steel rivets or self-tapping screws.
5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

B. Plastic Labels for Equipment:

1. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 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°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.
8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.

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

D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2 x 11-inch (A4) bond paper. Tabulate equipment identification number and identify Drawing numbers where equipment is indicated (plans, details, and schedules), plus the Specification Section number and title where equipment is specified. Equipment schedule shall be included in operation and maintenance data.

2.02 WARNING SIGNS AND LABELS

- A. Material and Thickness: Multilayer, multicolor, plastic labels for mechanical engraving, 1/8 inch thick, and having predrilled holes for attachment hardware.
- B. Letter Color: Black.
- C. Background Color: Yellow.
- D. Maximum Temperature: Able to withstand temperatures up to 160°F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.

- G. Fasteners: Stainless steel rivets or self-tapping screws.
- H. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- I. Label Content: Include caution and warning information, plus emergency notification instructions.

2.03 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. Self-Adhesive Pipe Labels: Printed plastic with contact-type, permanent adhesive backing.
- D. Pipe Label Contents: Include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction.
 - 1. Flow Direction Arrows: Integral with piping system service lettering to accommodate both directions, or as separate unit on each pipe label to indicate flow direction.
 - 2. Lettering Size: At least 1-1/2 inches high.

2.04 VALVE TAGS

- A. Valve Tags: Stamped or engraved with 1/4-inch letters for piping system abbreviation and 1/2-inch numbers.
 - 1. Tag Material: Brass, 0.032-inch, Stainless steel, 0.025-inch, Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link or beaded chain; or S-hook.
- B. Valve Schedules: For each piping system, on 8-1/2-by-11-inch (A4) bond paper. Tabulate valve number, piping system, system abbreviation (as shown on valve tag), location of valve (room or space), normal-operating position (open, closed, or modulating), and variations for identification. Mark valves for emergency shutoff and similar special uses.
 - 1. Valve tag schedule shall be included in operation and maintenance data.

2.05 WARNING TAGS

- A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags, of plasticized card stock with matte finish suitable for writing.
 - 1. Size: Approximately 4 by 7 inches.
 - 2. Fasteners: Brass grommet and wire.
 - 3. Nomenclature: Large size primary caption such as "DANGER," "CAUTION," or "DO NOT OPERATE."
 - 4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 EQUIPMENT LABEL INSTALLATION

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

3.03 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 25 feet along each run. Reduce intervals to 10 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- C. Pipe Label Color Schedule
 - 1. Cold Water Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
 - 2. Hot Water Supply Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black.
 - 3. Hot Water Re-circulation Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black.
 - 4. Storm Drainage Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.

5. Sanitary Waste Drainage Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
6. Natural Gas Piping:
 - a. Background Color: Yellow.
 - b. Letter Color: Black.
7. Low Pressure, Compressed Air Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.

3.04 VALVE TAG INSTALLATION

- A. Install tags on valves and control devices in piping systems, except check valves; valves within factory fabricated equipment units; shutoff valves; faucets; convenience and lawn watering hose connections; and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.
- B. Valve Tag Application Schedule
 1. Valve Tag Size and Shape:
 - a. Cold Water: 2 inches round.
 - b. Hot Water: 2 inches round.
 - c. Low Pressure Compressed Air: 2 inches round
 2. Valve Tag Color:
 - a. Cold Water: Green.
 - b. Hot Water: Green.
 - c. Low Pressure Compressed Air: Green.
 3. Letter Color:
 - a. Cold Water: White.
 - b. Hot Water: White.
 - c. Low Pressure Compressed Air: White.

3.05 WARNING TAG INSTALLATION

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

END OF SECTION 22 0553

SECTION 22 0700 - PLUMBING INSULATION

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. Section Includes
 - 1. Insulation Materials:
 - a. Mineral fiber.
 - 2. Insulating cements.
 - 3. Adhesives.
 - 4. Lagging adhesives.
 - 5. Sealants.
 - 6. Factory applied jackets.
 - 7. Tapes.
 - 8. Securements.
 - 9. Corner angles.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets.
- B. Qualification Data: For qualified Installer.
- C. Field quality control reports.

1.04 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. Fire Test Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated, as determined by testing identical products per ASTM E 84, by a testing and inspecting 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 and inspecting 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.

1.05 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.

1.06 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application and equipment Installer for equipment insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field applied jackets and finishes and for space required for maintenance.
- C. Coordinate installation and testing of heat tracing.

1.07 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

2.01 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Products that come in contact with stainless steel shall have a leachable chloride content of less than 50 ppm when tested according to ASTM C 871.
- D. Insulation materials for use on austenitic stainless steel shall be qualified as acceptable according to ASTM C 795.
- E. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- F. Mineral Fiber, Preformed Pipe Insulation:
 - 1. Products - subject to compliance with requirements, provide one of the following:
 - a. Fibrex Insulations Inc.; Coreplus 1200.
 - b. Johns Manville; Micro-Lok.
 - c. Knauf Insulation; 1000 Pipe Insulation.
 - d. Manson Insulation Inc.; Alley-K.

2. Type I, 850°F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory applied ASJ. Factory applied jacket requirements are specified in "Factory Applied Jackets" article.
- G. Mineral Fiber, Pipe and Tank Insulation: Mineral or glass fibers bonded with a thermosetting resin. Semi-rigid board material with factory applied ASJ complying with ASTM C 1393, Type II or Type IIIA Category 2, or with properties similar to ASTM C 612, Type IB. Nominal density is 2.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100°F is 0.29 Btu x in./h x sq. ft. x degree F or less. Factory applied jacket requirements are specified in "Factory Applied Jackets" article.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; CrimpWrap.
 - b. Johns Manville; MicroFlex.
 - c. Knauf Insulation; Pipe and Tank Insulation.
 - d. Manson Insulation Inc.; AK Flex.
 - e. Owens Corning; Fiberglas Pipe and Tank Insulation.

2.02 INSULATING CEMENTS

- A. Mineral Fiber Insulating Cement: Comply with ASTM C 195.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Insulco, Division of MFS, Inc.; Triple I.
 - b. P. K. Insulation Mfg. Co., Inc.; Super-Stik.
- B. Mineral fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Insulco, Division of MFS, Inc.; SmoothKote.
 - b. P. K. Insulation Mfg. Co., Inc.; PK No. 127, and Quik-Cote.
 - c. Rock Wool Manufacturing Company; Delta One Shot.

2.03 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

- C. PVC Jacket Adhesive: Compatible with PVC jacket.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Red Devil, Inc.; Celulon Ultra Clear.
 - e. Speedline Corporation; Speedline Vinyl Adhesive.

2.04 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-52.
 - b. Foster Products Corporation, H. B. Fuller Company; 81-42.
 - c. Marathon Industries, Inc.; 130.
 - d. Mon-Eco Industries, Inc.; 11-30.
 - e. Vimasco Corporation; 136.
 2. Fire-resistant, water based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
 3. Service Temperature Range: Minus 50° to plus 180°F.
 4. Color: White.

2.05 SEALANTS

- A. Metal Jacket Flashing Sealants
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
 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°F.
 5. Color: Aluminum.
- B. PVC Jacket Flashing Sealants
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Childers Products, Division of ITW; CP-76.
 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°F.
 5. Color: White.

2.06 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. FSK Jacket: Aluminum foil, fiberglass reinforced scrim with Kraft paper backing; complying with ASTM C 1136, Type II.

2.07 TAPES

- A. ASJ Tape: White 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. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0835.
 - b. Compac Corp.; 104 and 105.
 - c. Ideal Tape Co., Inc., an American Bilrite Company; 428 AWF ASJ.
 - d. Venture Tape; 1540 CW Plus, 1542 CW Plus, and 1542 CW Plus/SQ.
 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.

2.08 SECUREMENTS

- A. Bands
1. Products - subject to compliance with requirements, provide one of the following:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.
 2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
 3. Springs: Twin spring set constructed of stainless steel with ends flat and slotted to accept metal bands. Spring size determined by manufacturer for application.
- B. Insulation Pins and Hangers
1. Cupped-Head, Capacitor-Discharge-Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor-discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon-steel washer.
 - a. Products - subject to compliance with requirements, provide one of the following:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 - 4) Nelson Stud Welding; CHP.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick, aluminum sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
 - a. Products - subject to compliance with requirements, provide one of the following:
 - 1) AGM Industries, Inc.; RC-150.
 - 2) GEMCO; R-150.
 - 3) Midwest Fasteners, Inc.; WA-150.
 - 4) Nelson Stud Welding; Speed Clips.
 - b. Protect ends with capped self-locking washers incorporating a spring steel insert to ensure permanent retention of cap in exposed locations.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.
 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. C & F Wire
 - b. Childers Products
 - c. PABCO Metals Corporation
 - d. RPR Products, Inc.

2.09 CORNER ANGLES

- A. PVC Corner Angles: 30 mils thick, minimum 1 by 1 inch, PVC according to ASTM D 1784, Class 16354-C. White or color-coded to match adjacent surface.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
 1. Verify that systems and equipment 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.

3.02 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.03 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment and piping including fittings, valves, and specialties.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment and 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 and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor barrier mastic over staples.
 - 4. Cover joints and seams with tape as recommended by insulation material manufacturer to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor barrier mastic on seams and joints and at ends adjacent to pipe flanges and fittings.
- M. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.

- N. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- O. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- P. For above ambient services, do not install insulation to the following:
 - 1. Vibration control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.
 - 7. Gas Piping.

3.04 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at Underground Exterior Wall Penetrations: Terminate insulation flush with sleeve seal. Seal terminations with flashing sealant.
- C. Insulation Installation at Aboveground Exterior Wall Penetrations: Install insulation continuously through wall penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation inside wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside wall flashing and overlap wall flashing at least 2 inches.
 - 4. Seal jacket to wall flashing with flashing sealant.
- D. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.
- E. Insulation Installation at Fire rated Wall and Partition Penetrations: Install insulation continuously through penetrations of fire rated walls and partitions.
 - 1. Comply with requirements in Division 07 Section "Penetration Firestopping" and fire-resistive joint sealers.
- F. 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."

3.05 EQUIPMENT, TANK, AND VESSEL INSULATION INSTALLATION

- A. Mineral Fiber, Pipe, and Tank Insulation Installation for Tanks and Vessels: Secure insulation with adhesive and anchor pins and speed washers.
1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of tank and vessel surfaces.
 2. Groove and score insulation materials to fit as closely as possible to equipment, including contours. Bevel insulation edges for cylindrical surfaces for tight joints. Stagger end joints.
 3. Protect exposed corners with secured corner angles.
 4. Install adhesively attached or self-sticking insulation hangers and speed washers on sides of tanks and vessels as follows:
 - a. Do not weld anchor pins to ASME-labeled pressure vessels.
 - b. Select insulation hangers and adhesive that are compatible with service temperature and with substrate.
 - c. On tanks and vessels, maximum anchor-pin spacing is 3 inches from insulation end joints, and 16 inches o.c. in both directions.
 - d. Do not over compress insulation during installation.
 - e. Cut and miter insulation segments to fit curved sides and domed heads of tanks and vessels.
 - f. Impale insulation over anchor pins and attach speed washers.
 - g. 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.
 5. Secure each layer of insulation with stainless steel or aluminum bands. Select band material compatible with insulation materials.
 6. Where insulation hangers on equipment and vessels are not permitted or practical and where insulation support rings are not provided, install a girdle network for securing insulation. Stretch pre-stressed aircraft cable around the diameter of vessel and make taut with clamps, turnbuckles, or breather springs. Place one circumferential girdle around equipment approximately 6 inches from each end. Install wire or cable between two circumferential girdles 12 inches o.c. Install a wire ring around each end and around outer periphery of center openings, and stretch pre-stressed aircraft cable radially from the wire ring to nearest circumferential girdle. Install additional circumferential girdles along the body of equipment or tank at a minimum spacing of 48 inches o.c. Use this network for securing insulation with tie wire or bands.
 7. Stagger joints between insulation layers at least 3 inches.
 8. Install insulation in removable segments on equipment access doors, manholes, handholes, and other elements that require frequent removal for service and inspection.
 9. Bevel and seal insulation ends around manholes, handholes, ASME stamps, and nameplates.
 10. For equipment with surface temperatures below ambient, apply mastic to open ends, joints, seams, breaks, and punctures in insulation.
- B. Insulation Installation on Pumps:
1. Fabricate metal boxes lined with insulation. Fit boxes around pumps and coincide box joints with splits in pump casings. Fabricate joints with outward bolted flanges. Bolt flanges on 6-inch centers, starting at corners. Install 3/8-inch diameter fasteners with wing nuts. Alternatively, secure the box sections together using a latching mechanism.
 2. Fabricate boxes from aluminum, at least 0.050 inch thick.
 3. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

3.06 GENERAL PIPE INSULATION INSTALLATION

- A. Requirements in this article generally apply to all insulation materials except where more specific requirements are specified in various pipe insulation material installation articles.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. 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 and polyolefin, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
 9. 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 gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement 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.

3.07 MINERAL FIBER INSULATION INSTALLATION

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 but 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.

3.08 FINISHES

A. Equipment and Pipe Insulation with 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. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- C. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.
- D. Do not field paint aluminum or stainless-steel jackets.

3.09 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 field insulated equipment, 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 type of equipment defined in the "Equipment Insulation Schedule" article. For large equipment, remove only a portion adequate to determine compliance.
 - 2. 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.

3.10 PIPING INSULATION SCHEDULE - GENERAL

- A. Acceptable preformed pipe and tubular insulation materials and thicknesses are identified for each piping system and pipe size range. If more than one material is listed for a piping system, selection from materials listed is Contractor's option.
- B. Items Not Insulated - unless otherwise indicated, do not install insulation on the following:
 - 1. Drainage piping located in crawl spaces.
 - 2. Underground piping.
 - 3. Chrome plated pipes and fittings unless there is a potential for personnel injury.

3.11 INDOOR PIPING INSULATION SCHEDULE

- A. Domestic Cold Water
 - 1. NPS 1-1/4 (DN 32) and Smaller - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1/2 inch thick.
 - 2. NPS 1-1/2 (DN 40) and Larger - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick.

- B. Domestic Hot and Recirculated Hot Water
 - 1. NPS 1-1/4 (DN 32) and Smaller - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
 - 2. NPS 1-1/2 (DN 40) and Larger - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1-1/2 inch thick.
- C. Storm water and Overflow
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- D. Roof Drain and Overflow Drain Bodies
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- E. Exposed Sanitary Drains, Domestic Water, Domestic Hot Water, and Stops for Plumbing Fixtures for People with Disabilities:
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick.
- F. Storm water Piping Where Heat Tracing Is Installed
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1-1/2 inches thick.
- G. Floor Drains, Traps, and Sanitary Drain Piping within 10 Feet of Drain Receiving Condensate and Equipment Drain Water below 60°F:
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 1 inch thick
- H. Hot Service Drains
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe, Type I or II: 1 inch thick.
- I. Hot Service Vents
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe, Type I or II: 1 inch thick.

3.12 OUTDOOR, ABOVEGROUND PIPING INSULATION SCHEDULE If Applicable

- A. Storm water Piping Where Heat Tracing Is Installed
 - 1. All Pipe Sizes - insulation shall be the following:
 - a. Mineral fiber, Preformed Pipe Insulation, Type I: 2 inches thick.

3.13 OUTDOOR, UNDERGROUND PIPING INSULATION SCHEDULE

- A. Loose-fill insulation, for belowground piping, is specified in Division 33 piping distribution Sections.
- B. Storm Water Piping, All Sizes, Where Heat Tracing Is Installed: Cellular glass, 2 inches thick.

END OF SECTION 22 0700

SECTION 22 1116 - DOMESTIC WATER PIPING

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 domestic water piping inside the building.
- B. Related Sections include the following:
 - 1. Division 22 Section 22 1119 "Domestic Water Piping Specialties" for water distribution piping specialties.

1.03 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing domestic water piping systems with 125 psig unless otherwise indicated.

1.04 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Water Samples: Specified in Part 3 "Cleaning" article.
- C. Field quality control test reports.

1.05 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping System Components and Related Materials," for plastic, potable domestic water piping and components. Include marking "NSF-pw" on piping.
- C. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for potable domestic water piping and components.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 PIPING MATERIALS

- A. Refer to Part 3 "Pipe and Fitting Applications" article for applications of pipe, tube, fitting, and joining materials.
- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.03 COPPER TUBE AND FITTINGS

- A. Soft Copper Tube: ASTM B 88, Types K and L (ASTM B 88M, Types A and B), water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast copper alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- B. Hard Copper Tube: ASTM B 88, Types L, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast copper alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Copper Pressure Seal Joint Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, press seal-joint fittings by Viega or Nibco. Furnish wrought-copper fittings if indicated. Stainless steel teeth and EPDM-rubber, O-ring seal in each end instead of solder joint end.
 - 3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends. Furnish Class 300 flanges if required to match piping.
 - 4. Copper Unions: MSS SP-123, cast copper alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.

2.04 VALVES

- A. Bronze and cast iron, general duty valves are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- B. Balancing and drain valves are specified in Division 22 Section 22 1119 "Domestic Water Piping Specialties."
- C. Valves shall be of the "LEAD FREE" design.

PART 3 - EXECUTION

3.01 EXCAVATION

- A. Excavating, trenching, and backfilling are specified in Division 31 Section "Earth Moving."

3.02 PIPE AND FITTING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground piping, unless otherwise indicated.
- C. Grooved joints may be used on aboveground grooved-end piping.
- D. Domestic Water Piping on Service Side of Water Meter inside the Building - use the following piping materials for each size range:
 - 1. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
- E. Under-Building-Slab, Domestic Water Piping on House Side of Water Meter, NPS 4 (DN 100) and Smaller: Soft copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
- F. Aboveground Domestic Water Piping - use any of the following piping materials for each size range:
 - 1. NPS 1 (DN 25) and Smaller: Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
 - 2. NPS 1-1/4 and NPS 1-1/2 (DN 32 and DN 40): Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
 - 3. NPS 2 (DN 50): Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
 - 4. NPS 2 (DN 50): Hard copper tube, Type L (Type B) with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.
 - 5. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.
 - 6. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Hard copper tube, Type L (Type B) with grooved ends; copper grooved-end fittings; grooved-end-tube couplings; and grooved joints.
 - 7. NPS 4 to NPS 6 (DN 100 to DN 150): Hard copper tube, Type L (Type B); copper pressure fittings; and soldered joints.

3.03 VALVE APPLICATIONS

- A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:
 - 1. Shutoff Duty: Use bronze ball or gate valves for piping NPS 2 (DN 50) and smaller. Use cast iron butterfly or gate valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - 2. Throttling Duty: Use bronze ball or globe valves for piping NPS 2 (DN 50) and smaller. Use cast iron butterfly valves with flanged ends for piping NPS 2-1/2 (DN 65) and larger.
 - 3. Hot Water Piping, Balancing Duty: Calibrated or Memory-stop balancing valves.
 - 4. Drain Duty: Hose end drain valves.
- B. Cast iron, grooved end valves may be used with grooved-end piping.
- C. Install shutoff valve close to water main on each branch and riser serving plumbing fixtures or equipment, on each water supply to equipment, and on each water supply to plumbing fixtures that do not have supply stops. Use ball or gate valves for piping NPS 2 (DN 50) and smaller. Use butterfly or gate valves for piping NPS 2-1/2 (DN 65) and larger.

- D. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
 - 1. Install hose end drain valves at low points in water mains, risers, and branches.
 - 2. Install stop and waste drain valves where indicated.
- E. Valves shall be of the "LEAD FREE" design.

3.04 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Install under-building-slab copper tubing according to CDA's "Copper Tube Handbook."
- C. Install cast iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Wall penetration systems are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- E. Install shutoff valve, hose end drain valve, strainer, pressure gauge, and test tee with valve, inside the building at each domestic water service entrance. Pressure gauges are specified in Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping," and drain valves and strainers are specified in Division 22 Section 22 1119 "Domestic Water Piping Specialties."
- F. Install water-pressure regulators downstream from shutoff valves. Water-pressure regulators are specified in Division 22 Section 22 1119 "Domestic Water Piping Specialties."
- G. Install domestic water piping level with 0.25 percent slope downward toward drain and plumb.
- H. Install ductile-iron, water service piping according to AWWA C600 and AWWA M41.
 - 1. Install PE corrosion protection encasement according to ASTM A 674 or AWWA C105.

3.05 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- C. Grooved Joints: Assemble joints with grooved-end-pipe or grooved-end-tube coupling housing, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.

3.06 HANGER AND SUPPORT INSTALLATION

- A. Pipe hanger and support devices are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42 clamps.
 - 2. Individual, Straight, Horizontal Piping Runs - according to the following:
 - a. 100 feet and less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer than 100 feet: MSS Type 43, adjustable roller hangers.
 - c. Longer than 100 feet: MSS Type 49, spring cushion rolls, if indicated.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Install supports according to Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch
- F. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 (DN 32) and Smaller: 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 (DN 40): 108 inches with 3/8-inch rod.
 - 3. NPS 2 (DN 50): 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2 (DN 65): 11 feet with 1/2-inch rod.
 - 5. NPS 3 and NPS 3-1/2 (DN 80 and DN 90): 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet with 5/8-inch rod.
 - 7. NPS 6 (DN 150): 12 feet with 3/4-inch rod.
 - 8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet with 7/8-inch rod.
- G. Install supports for vertical steel piping every 15 feet.
- H. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 3/4 (DN 20) and smaller: 60 inches with 3/8-inch rod.
 - 2. NPS 1 and NPS 1-1/4 (DN 25 and DN 32): 72 inches with 3/8-inch rod.
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches with 3/8-inch rod.
 - 4. NPS 2-1/2 (DN 65): 108 inches with 1/2-inch rod.
 - 5. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet with 1/2-inch rod.
 - 6. NPS 6 (DN 150): 10 feet with 5/8-inch rod.
 - 7. NPS 8 (DN 200): 10 feet with 3/4-inch rod.
- I. Install supports for vertical copper tubing every 10 feet.

3.07 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment and machines to allow service and maintenance.

- C. Connect domestic water piping to exterior water service piping. Use transition fitting to join dissimilar piping materials.
- D. Connect domestic water piping to water service piping with shutoff valve, and extend and connect to the following:
 - 1. Plumbing Fixtures: Cold and hot water supply piping in sizes indicated, but not smaller than required by plumbing code. Refer to Division 22 Section 22 4000 "Plumbing Fixtures."
 - 2. Equipment: Cold and hot water supply piping as indicated, but not smaller than equipment connections. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 (DN 65) and larger.

3.08 FIELD QUALITY CONTROL

- A. Inspect domestic water piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it has been inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange final inspection for authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
 - 3. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- B. Test domestic water piping as follows:
 - 1. Fill domestic water piping. Check components to determine that they are not air bound and that piping is full of water.
 - 2. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 3. Leave new, altered, extended, or replaced domestic water piping uncovered and unconcealed until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 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 to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 - 5. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 - 6. Prepare reports for tests and required corrective action.

3.09 ADJUSTING

- A. Perform the following adjustments before operation:
 - 1. Close drain valves, hydrants, and hose bibbs.
 - 2. Open shutoff valves to fully open position.
 - 3. Open throttling valves to proper setting.

4. Adjust balancing valves in hot water-circulation return piping to provide adequate flow.
 - a. Manually adjust ball-type balancing valves in hot water-circulation return piping to provide flow of hot water in each branch.
 - b. Adjust calibrated balancing valves to flows indicated.
5. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
6. Remove and clean strainer screens. Close drain valves and replace drain plugs.
7. Remove filter cartridges from housings and verify that cartridges are as specified for application where used and are clean and ready for use.
8. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.10 CLEANING

- A. Clean and disinfect potable and non-potable domestic water piping as follows:
 1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following:
 - 1) Fill system or part thereof with water/chlorine solution with at least 50 ppm of chlorine. Isolate with valves and allow to stand for 24 hours.
 - 2) Fill system or part thereof with water/chlorine solution with at least 200 ppm of chlorine. Isolate and allow to stand for three hours.
 - c. Flush system with clean, potable water until no chlorine is in water coming from system after the standing time.
 - d. Submit water samples in sterile bottles to authorities having jurisdiction. Repeat procedures if biological examination shows contamination.
- B. Prepare and submit reports of purging and disinfecting activities.
- C. Clean interior of domestic water piping system. Remove dirt and debris as work progresses.

END OF SECTION 22 1116

SECTION 22 1119 - DOMESTIC WATER PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following domestic water piping specialties:
 - 1. Vacuum breakers.
 - 2. Backflow preventers.
 - 3. Water pressure reducing valves.
 - 4. Balancing valves.
 - 5. Temperature actuated water mixing valves.
 - 6. Strainers.
 - 7. Outlet boxes.
 - 8. Hose bibbs.
 - 9. Wall hydrants.
 - 10. Drain valves.
 - 11. Water hammer arresters.
 - 12. Air vents.
 - 13. Trap seal primer valves.
 - 14. Hose Reels
 - 15. Hot Water Power Washers
- B. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in this section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.
- C. Related Sections include the following
 - 1. Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping" for thermometers, pressure gauges, and flow meters in domestic water piping.
 - 2. Division 22 Section 22 1116 "Domestic Water Piping" for water meters.
 - 3. Division 22 Section 22 4700 "Drinking Fountains and Water Coolers" for water filters for water coolers.

1.03 PERFORMANCE REQUIREMENTS

- A. Minimum Working Pressure for Domestic Water Piping Specialties: 125 psig unless otherwise indicated.

1.04 SUBMITTALS

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

- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Field quality control test reports.
- D. Operation and Maintenance Data: For domestic water piping specialties to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. NSF Compliance:
 - 1. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components.
 - 2. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9."

PART 2 - PRODUCTS

2.01 VACUUM BREAKERS

- A. Pipe Applied, Atmospheric Type Vacuum Breakers
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Ames Company
 - b. Conbraco Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Division
 - d. Zurn Plumbing Products Group; Wilkins Division
 - 2. Standard: ASSE 1001.
 - 3. Size: NPS 1/4 to NPS 3 (DN 8 to DN 80), as required to match connected piping.
 - 4. Body: Bronze.
 - 5. Inlet and Outlet Connections: Threaded.
 - 6. Finish: Chrome plated.
- B. Hose Connection Vacuum Breakers
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Legend Valve
 - c. Watts Industries, Inc.; Water Products Division
 - d. Woodford Manufacturing Company
 - e. Zurn Plumbing Products Group; Light Commercial Operation
 - f. Zurn Plumbing Products Group; Wilkins Division
 - 2. Standard: ASSE 1011.
 - 3. Body: Bronze, non-removable, with manual drain.
 - 4. Outlet Connection: Garden hose threaded complying with ASME B1.20.7.
 - 5. Finish: Chrome or nickel-plated.

C. Spill Resistant Vacuum Breakers

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Division
2. Standard: ASSE 1056.
3. Operation: Continuous pressure applications.
4. Size: NPS 3/4 (DN 20).
5. Accessories:
 - a. Valves: Ball type, on inlet and outlet.

2.02 BACKFLOW PREVENTERS

A. Intermediate Atmospheric Vent Backflow Preventers

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Legend Valve.
 - c. Watts Industries, Inc.; Water Products Division
 - d. Zurn Plumbing Products Group; Wilkins Division
2. Standard: ASSE 1012.
3. Product shall be of the "LEAD FREE" design.
4. Operation: Continuous pressure applications.
5. Size: NPS 1/2 (DN 15) or NPS 3/4 (DN 20).
6. Body: Bronze.
7. End Connections: Union, solder joint.
8. Finish: Chrome plated.

B. Reduced Pressure Principle Backflow Preventers

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Ames Company
 - b. Conbraco Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Division
 - d. Zurn Plumbing Products Group; Wilkins Division
2. Standard: ASSE 1013.
3. Product shall be of the "LEAD FREE" design.
4. Operation: Continuous pressure applications.
5. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
6. Size: 3"
7. Design Flow Rate: 70 gpm
8. Pressure Loss at Design Flow Rate: 10 psig > for sizes NPS 2 (DN 50) and smaller; 10 psig > for NPS 2-1/2 (DN 65) and larger.
9. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 (DN 65) and larger.
10. End Connections: Threaded for NPS 2 (DN 50) and smaller flanged for NPS 2-1/2 (DN 65) and larger.
11. Configuration: Designed for horizontal, straight through flow.

12. Accessories:

- a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 (DN 50) and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 (DN 65) and larger.
- b. Air Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.

C. Carbonated Beverage Dispenser, Dual Check Valve Backflow Preventers

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Watts Industries, Inc.; Water Products Division
2. Standard: ASSE 1032.
3. Product shall be of the "LEAD FREE" design.
4. Operation: Continuous-pressure applications.
5. Size: NPS 1/4 or NPS 3/8 (DN 8 or DN 10).
6. Body: Stainless steel.
7. End Connections: Threaded.

D. Hose Connection Backflow Preventers

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Division
 - c. Woodford Manufacturing Company.
2. Standard: ASSE 1052.
3. Product shall be of the "LEAD FREE" design.
4. Operation: Up to 10-foot head of water back pressure.
5. Inlet Size: NPS 1/2 or NPS 3/4 (DN 15 or DN 20).
6. Outlet Size: Garden hose thread complying with ASME B1.20.7.
7. Capacity: At least 3-gpm flow.

E. Backflow Preventer Test Kits

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Division
 - c. Zurn Plumbing Products Group; Wilkins Division
2. Description: Factory calibrated, with gauges, fittings, hoses, and carrying case with test-procedure instructions.

2.03 WATER PRESSURE REDUCING VALVES

A. Water Regulators **(Confirm pressure on site before determining if this is required. If the pressure is below 80 psi, the pressure reducing valve shall not be required.)**

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Division
 - c. Zurn Plumbing Products Group; Wilkins Division
2. Standard: ASSE 1003.
3. Product shall be of the "LEAD FREE" design.
4. Pressure Rating: Initial working pressure of 150 psig.

5. Size: 3"
6. Design Flow Rate: 70 gpm
7. Design Outlet Pressure Setting: 60-65 psig.
8. Body: Bronze with chrome plated finish for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or that is FDA approved for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).
9. End Connections: Threaded for NPS 2 (DN 50) and smaller; flanged for NPS 2-1/2 and NPS 3 (DN 65 and DN 80).

2.04 BALANCING VALVES

A. Copper Alloy Calibrated Balancing Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong International, Inc.
 - b. Flo Fab Inc.
 - c. ITT Industries; Bell & Gossett Division
 - d. Nibco Inc.
 - e. TAC Americas
 - f. Taco, Inc.
 - g. Watts Industries, Inc.; Water Products Division
2. Type: Ball or Y-pattern globe valve with two readout ports and memory setting indicator.
3. Product shall be of the "LEAD FREE" design.
4. Body: Brass or bronze,
5. Size: Same as connected piping, but not larger than NPS 2 (DN 50).
6. Accessories: Meter hoses, fittings, valves, differential pressure meter, and carrying case.

B. Memory Stop Balancing Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Crane Co.; Crane Valve Group; Stockham Division
 - c. Hammond Valve.
 - d. Milwaukee Valve Company.
 - e. Nibco Inc.
2. Standard: MSS SP-110 for two-piece, copper-alloy ball valves.
3. Product shall be of the "LEAD FREE" design.
4. Pressure Rating: 400-psig minimum CWP.
5. Size: NPS 2 (DN 50) or smaller.
6. Body: Copper alloy.
7. Port: Standard or full port.
8. Ball: Chrome plated brass.
9. Seats and Seals: Replaceable.
10. End Connections: Solder joint or threaded.
11. Handle: Vinyl covered steel with memory-setting device.

C. Self-Actuating Thermostatic Balancing Valve

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. CircuitSolver by ThermOmegaTech.
 - b. Thermosetter by Caleffi NA, Inc.
 - c. TempFlow by Acorn Controls.

2. Description: Thermostatic self-actuating balancing valve to continuously adjust the flow through hot water return branch of recirculation system. In line valve of corrosion resistant construction (stainless steel, brass, copper). Return temperature set to 130°F (adjustable). Valve shall never fully close.
3. Product shall be of the "LEAD FREE" design.
4. Valve shall have internal check valve and strainer assembly.
5. Size: NPS 2 (DN 50) or smaller.
6. End Connections: Threaded.

2.05 TEMPERATURE ACTUATED WATER MIXING VALVES

A. Primary Water Tempering Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Holby Valve Co., Inc.
 - b. Powers
 - c. Symmons
2. Standard: ASSE 1017, thermostatically controlled tempering valve, listed as tempering valve.
3. Product shall be of the "LEAD FREE" design.
4. Pressure Rating: 125 psig minimum, unless otherwise indicated.
5. Body: Bronze.
6. Temperature Control: Manual.
7. Inlets and Outlet: Threaded.
8. Selected Primary Water Tempering Valve Size: See drawings
9. Tempered water Outlet Setting: 135°F.
10. Tempered water Design Flow Rate: See drawings
11. Pressure Drop at Design Flow Rate: See drawings
12. Tempered water Outlet Size: See drawings.
13. Cold water Inlet Size: See drawings
14. Hot water Inlet Size: See drawings
15. Valve Finish: Rough bronze.

B. Individual Fixture, Water Tempering Valves (To be provided under all lavatories and sinks):

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Lawler Manufacturing Company, Inc.
 - c. Leonard Valve Company
 - d. Powers; a Watts Industries Company
 - e. Watts Industries, Inc.; Water Products Division
 - f. Zurn Plumbing Products Group; Wilkins Division
2. Standard: ASSE 1070, thermostatically controlled water tempering valve.
3. Product shall be of the "LEAD FREE" design.
4. Pressure Rating: 125 psig minimum, unless otherwise indicated.
5. Body: Brass body with corrosion-resistant interior components.
6. Temperature Control: Adjustable.
7. Inlets and Outlet: Threaded.
8. Finish: Rough or chrome plated bronze.
9. Model 8210CK "Maxline" manufactured by Symmons.

2.06 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 (DN 50) and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 (DN 65) and larger.
3. Product shall be of the "LEAD FREE" design.
4. End Connections: Threaded for NPS 2 (DN 50) and smaller flanged for NPS 2-1/2 (DN 65) and larger.
5. Screen: Stainless steel with round perforations, unless otherwise indicated.
6. Drain: Factory installed; hose end drain valve.

2.07 OUTLET BOXES (WOB-1)

A. Icemaker Outlet Boxes:

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company
 - b. IPS Corporation
 - c. LSP Products Group, Inc.
 - d. Oatey
 - e. Plastic Oddities; a division of Diverse Corporate Technologies
2. Mounting: Recessed.
3. Product shall be of the "LEAD FREE" design
4. Provided with water hammer arrestor.
5. Material and Finish: Enameled steel or epoxy painted steel or plastic box and faceplate.
6. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 (DN 15) or smaller copper tube outlet.
7. Supply Shutoff Fitting: NPS 1/2 ball valve and NPS 1/2 water tubing.

2.08 HOSE BIBS (HB-1)

A. Hose Bibbs

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: NPS 1/2 or NPS 3/4 (DN 15 or DN 20) threaded or solder-joint inlet.
5. Outlet Connection: Garden hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral, non-removable, drainable, hose connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Service Areas: Chrome or nickel plated.
10. Finish for Finished Rooms: Chrome or nickel plated.
11. Operation for Equipment Rooms: Wheel handle or operating key.
12. Operation for Service Areas: Wheel handle.
13. Operation for Finished Rooms: Operating key.
14. Include operating key with each operating-key hose bibb.
15. Include integral wall flange with each chrome or nickel-plated hose bibb.
16. Based on Woodford Model 24

2.09 WALL HYDRANTS

A. Non-freeze Wall Hydrants (WH-1)

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Woodford Manufacturing Company.
 - f. Zurn Plumbing Products Group; Light Commercial Operation.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
3. Pressure Rating: 125 psig.
4. Operation: Loose key.
5. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
6. Inlet: NPS 3/4 or NPS 1 (DN 20 or DN 25).
7. Outlet: Concealed, with integral vacuum breaker and garden hose thread complying with ASME B1.20.7.
8. Box: Deep, flush mounting with cover.
9. Box and Cover Finish: Polished nickel bronze.
10. Outlet: Exposed, with integral vacuum breaker and garden hose thread complying with ASME B1.20.7.
11. Nozzle and Wall Plate Finish: Polished nickel bronze.
12. Operating Keys(s): Two with each wall hydrant.
13. Based On: Z1320 XL by Zurn

2.10 DRAIN VALVES

A. Ball Valve Type, Hose End Drain Valves:

1. Standard: MSS SP-110 for standard-port, two-piece ball valves.
2. Pressure Rating: 400-psig minimum CWP.
3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy.
5. Ball: Chrome plated brass.
6. Seats and Seals: Replaceable.
7. Handle: Vinyl covered steel.
8. Inlet: Threaded or solder joint.
9. Outlet: Threaded, short nipple with garden hose thread complying with ASME B1.20.7 and cap with brass chain.

B. Gate Valve Type, Hose End Drain Valves

1. Standard: MSS SP-80 for gate valves.
2. Pressure Rating: Class 125.
3. Size: NPS 3/4 (DN 20).
4. Body: ASTM B 62 bronze.
5. Inlet: NPS 3/4 (DN 20) threaded or solder joint.
6. Outlet: Garden hose thread complying with ASME B1.20.7 and cap with brass chain.

C. Stop-and-Waste Drain Valves

1. Standard: MSS SP-110 for ball valves or MSS SP-80 for gate valves.
2. Pressure Rating: 200-psig minimum CWP or Class 125.

3. Size: NPS 3/4 (DN 20).
4. Body: Copper alloy or ASTM B 62 bronze.
5. Drain: NPS 1/8 (DN 6) side outlet with cap.

2.11 WATER HAMMER ARRESTERS

A. Water Hammer Arresters

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. AMTROL, Inc.
 - b. Josam Company.
 - c. PPP Inc.
 - d. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - e. Tyler Pipe; Wade Division
 - f. Watts Drainage Products Inc.
 - g. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASSE 1010 or PDI-WH 201.
3. Type: Copper tube with piston.
4. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.

2.12 AIR VENTS

A. Bolted Construction Automatic Air Vents

1. Body: Bronze.
2. Pressure Rating: 125-psig minimum pressure rating at 140°F.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 (DN 10) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

B. Welded Construction Automatic Air Vents

1. Body: Stainless steel.
2. Pressure Rating: 150-psig minimum pressure rating.
3. Float: Replaceable, corrosion-resistant metal.
4. Mechanism and Seat: Stainless steel.
5. Size: NPS 3/8 (DN 10) minimum inlet.
6. Inlet and Vent Outlet End Connections: Threaded.

2.13 TRAP SEAL PRIMER VALVES

A. Supply Type, Trap Seal Primer Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. PPP Inc.
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Watts Industries, Inc.; Water Products Division
2. Standard: ASSE 1018.
3. Pressure Rating: 125 psig minimum.

4. Body: Bronze.
5. Inlet and Outlet Connections: NPS 1/2 (DN 15) threaded, union, or solder joint.
6. Gravity Drain Outlet Connection: NPS 1/2 (DN 15) threaded or solder joint.
7. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.14 HOSE REELS (HR-1)

A. Retractable Air hose reels (HR-1)

1. Standard: ASSE 1056
2. Body Material: Chrome-plated brass body
3. Supply Connections: 1/2" air
4. Outlet Connection: 1/2" x 50' feet heavy-duty non-marking hose rated at 300 psi
5. Pressure Rating: 300 psig.
6. Swivel assembly
7. Bumper stop
8. Quick disconnect
9. Open powder coated steel hose reel
10. Steel multi-fit wall/ceiling mounted swing bracket and adjustable hose bumper
11. Ratcheting system holds length of hose in place until tugged and retracts automatically.
12. Bracket support
13. Provide pipe supports for air connector to hose reel to prevent pipe sagging.
14. Based on Model 7850 OLP manufactured Reelcraft

B. Manual rewind hot water pressure water hose reels (HR-2)

1. Standard: ISO 175
2. Body Material: Stainless Steel
3. Supply Connections: 3/8" HW
4. Outlet Connection: 1/2" x 50' feet heavy-duty non-marking hose rated at 3000 psi with high flow stainless steel water gun w/ rubber cover, front trigger style with wand
5. Inlet: Full-flow swivel joint with 1/2" NPT fitting
6. Outlet: 1/2" female NPT fitting, supplied with 1/2" MNPT to 3/8" FNPT reducing bushing
7. Pressure Rating: up to 3000 psig.
8. 90° ball bearing swivel joint, 1/2" female NPT threads
9. 36" flexible water hose connector with stainless steel quick disconnect
10. Open stainless steel hose reel
11. Continuous pressure vacuum breaker ASSE 1056
12. Direct crank rewind permanently attached, adjustable cam-lock brake, ratcheting system holds length of hose in place until tugged and retracts automatically.
13. Swing Bracket (-SSB)
14. Provide pipe supports for water connector to hose reel to prevent pipe sagging.
15. Provide all connection fittings
16. Provide mounting bracket and mounting kit
17. Installed 48" above finished floor.
18. Based on Model SS1500 Series manufactured by Hannay Manufacturing

C. Retractable water hose reels (HR-3)

1. Standard: ASSE 1056
2. Body Material: Chrome-plated brass body
3. Supply Connections: 3/4" HW & CW
4. Outlet Connection: 3/8" x 50' feet heavy-duty non-marking hose rated at 300 psi with high flow stainless steel water gun w/blue rubber cover, front trigger style & swivel

5. Pressure Rating: 300 psig.
6. Quarter-turn ceramic cartridges
7. Lever handles w/color coded indexes on faucet
8. 3/6" flexible water hose connector with stainless steel quick disconnect
9. Open stainless steel hose reel
10. Stainless steel multi-fit wall/ceiling mounted swing bracket and adjustable hose bumper
11. Continuous pressure vacuum breaker ASSE 1056
12. Ratcheting system holds length of hose in place until tugged and retracts automatically.
13. Swing Bracket (-SSB)
14. Provide pipe supports for water connector to hose reel to prevent pipe sagging.
15. Based on Model B-1439-CR-HW-2B-48-SSB manufactured by T & S Brass

2.15 HOT WATER PRESSURE WASHER (PW-1)

1. Standard: UL 60335-1 & 60335-2-79, CSA C22.2 #60335-1 & CSA E60335-2-79
2. Body Material: Stainless Steel cabinet style
3. Supply Connections: 3/4" HW & CW
4. Outlet Connection: 3/8" x 50' feet heavy-duty non-marking hose rated at 3000 psi with high flow stainless steel water gun w/blue rubber cover, front trigger style & wand
5. Flow Rate: 5 GPM
6. Steam Capacity: 150 gal/hr
7. Motor Voltage: 230V/3/60
8. Amp: 30
9. Motor Power: 10 HP
10. Fuel Source: Natural Gas
11. BTU Capacity: 415,000
12. Coil type: Vertical Schedule 80
13. Coil Construction type: Hydro insulated cold water wrap
14. Coil Pipe Diameter: 1/2"
15. Float Tank: Stainless Steel
16. Exhaust Stack: 12"
17. Exhaust vent material: SS Steel meeting Category type II, III, and IV, NFPA 54, ANSI Z223.1 requirements and all fittings.
18. Pressure Washer Dimensions: 55" L x 26" W x 57" H
19. Adjustable temperature control
20. Electronic Ignition
21. 50 feet of hose with shut-off gun and wand
22. Water temperatures between 180°-200° F
23. Provide Stainless Steel Draft Diverter
24. Model based on Alkota 5301D

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer to Division 22 Section 22 0500 "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

- B. Install backflow preventers in each water supply to mechanical equipment and systems and to other equipment and water systems that may be sources of contamination. Comply with authorities having jurisdiction.
 - 1. Locate backflow preventers in same room as connected equipment or system.
 - 2. Install drain for backflow preventers with atmospheric vent drain connection with air gap fitting, fixed air gap fitting, or equivalent positive pipe separation of at least two pipe diameters in drain piping and pipe to floor drain. Locate air gap device attached to or under backflow preventer. Simple air brakes are not acceptable for this application.
 - 3. Do not install bypass piping around backflow preventers.
- C. Install water regulators with inlet and outlet shutoff valves and bypass with memory-stop balancing valve. Install pressure gauges on inlet and outlet.
- D. Install balancing valves in locations where they can easily be adjusted.
- E. Install temperature-actuated water mixing valves with check stops or shutoff valves on inlets and with shutoff valve on outlet.
 - 1. Install thermometers and water regulators if specified.
 - 2. Install cabinet-type units recessed in or surface mounted on wall as specified.
- F. Install Y-pattern strainers for water on supply side of each control valve, water pressure-reducing valve, solenoid valve, and pump.
- G. Install outlet boxes recessed in wall. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire retardant treated wood blocking is specified in Division 06 Section "Rough Carpentry."
- H. Install hose stations with check stops or shutoff valves on inlets and with thermometer on outlet.
 - 1. Install shutoff valve on outlet if specified.
 - 2. Install cabinet-type units recessed in or surface mounted on wall as specified. Install 2-by-4-inch fire-retardant-treated-wood blocking wall reinforcement between studs. Fire-retardant-treated-wood blocking is specified in Division 06 Section "Rough Carpentry."
- I. Install draining type post hydrants with 1 cubic yard of crushed gravel around drain hole. Set post hydrants in concrete paving or in 1 cubic foot of concrete block at grade.
- J. Install water hammer arresters in water piping according to PDI-WH 201.
- K. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.
- L. Install supply type, trap-seal primer valves with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor drain body, trap, or inlet fitting. Adjust valve for proper flow.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping and specialties.
- B. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."

3.03 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs - install engraved plastic-laminate equipment nameplate or sign on or near each of the following:
 - 1. Pressure vacuum breakers.
 - 2. Intermediate atmospheric vent backflow preventers.
 - 3. Reduced pressure principle backflow preventers.
 - 4. Double check backflow prevention assemblies.
 - 5. Carbonated beverage machine backflow preventers.
 - 6. Dual check valve backflow preventers.
 - 7. Reduced pressure detector, fire protection backflow preventer assemblies.
 - 8. Double check, detector assembly backflow preventers.
 - 9. Water pressure reducing valves.
 - 10. Calibrated balancing valves.
 - 11. Primary water tempering valves.
 - 12. Outlet boxes.
 - 13. Hose stations.
 - 14. Supply type, trap seal primer valves.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.04 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 - 1. Test each pressure vacuum breaker, reduced pressure principle backflow preventer, double check backflow prevention assembly, and double check, detector assembly backflow preventer according to authorities having jurisdiction and the device's reference standard.
- B. Remove and replace malfunctioning domestic water piping specialties and retest as specified above.

3.05 ADJUSTING

- A. Set field adjustable pressure set points of water pressure-reducing valves.
- B. Set field adjustable flow set points of balancing valves.
- C. Set field adjustable temperature set points of thermostatic water mixing valves.

END OF SECTION 22 1119

SECTION 22 1123 - DOMESTIC WATER PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following all-bronze and bronze-fitted centrifugal pumps for domestic cold and hot water circulation:
 - 1. Close coupled, horizontally mounted, in-line centrifugal pumps.
 - 2. Close coupled, vertically mounted, in-line centrifugal pumps.

1.03 SUBMITTALS

- A. Product Data: For each type and size of domestic water pump specified. Include certified performance curves with operating points plotted on curves; and rated capacities of selected models, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For domestic water pumps to include in emergency, operation, and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of domestic water pumps and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor operated water pumps.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.
- C. Comply with pump manufacturer's written rigging instructions for handling.

1.06 COORDINATION

- A. Coordinate size and location of concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 CLOSE COUPLED, HORIZONTALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers
 - 1. Armstrong Pumps Inc.
 - 2. Bell & Gossett Domestic Pump; ITT Industries.
 - 3. Paco Pumps, Inc.
 - 4. Thrush Company, Inc.
- B. Description: Factory assembled and tested, overhung impeller, single-stage, close-coupled, horizontally mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted horizontally.
 - 1. Pump Construction: All bronze.
 - a. Casing: Radially split, cast iron, with threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - c. Shaft and Shaft Sleeve: Steel shaft, with copper-alloy shaft sleeve.
 - d. Seal: Mechanical, with carbon steel rotating ring, stainless steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Bearings: Oil-lubricated; bronze-journal or ball type.
 - 2. Shaft Coupling: Rigid type if pump is provided with coupling.
 - 3. Motor: Single speed, with grease-lubricated ball bearings. Comply with requirements in Division 22 Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
- C. Capacities and Characteristics:
 - 1. Refer to schedule on drawing

2.03 CLOSE COUPLED, VERTICALLY MOUNTED, IN-LINE CENTRIFUGAL PUMPS

- A. Manufacturers
 - 1. Armstrong Pumps Inc.
 - 2. Bell & Gossett Domestic Pump; ITT Industries
 - 3. Grundfos Pumps Corporation
 - 4. Paco Pumps, Inc.
 - 5. Sterling Peerless; Sterling Fluid Systems Group
 - 6. Thrush Company, Inc.

- B. Description: Factory assembled and tested, overhung impeller, single-stage, close coupled, vertically mounted, in-line centrifugal pumps as defined in HI 1.1-1.2 and HI 1.3; and designed for installation with pump and motor shafts mounted vertically.
1. Pump Construction: Bronze fitted.
 - a. Casing: Radially split, cast iron, with wear rings and threaded companion-flange connections for pumps with NPS 2 (DN 50) pipe connections and flanged connections for pumps with NPS 2-1/2 (DN 65) pipe connections.
 - b. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, closed, and keyed to shaft.
 - c. Shaft and Shaft Sleeve: Stainless steel or steel shaft, with copper-alloy shaft sleeve.
 - d. Seal: Mechanical, with carbon steel rotating ring, stainless steel spring, ceramic seat, and rubber bellows and gasket. Include water slinger on shaft between motor and seal.
 - e. Bearings: Oil-lubricated; bronze-journal or ball type.
 2. Shaft Coupling: Rigid type if pump is provided with coupling.
 3. Motor: Single speed, with grease-lubricated ball bearings; and directly mounted to pump casing. Comply with requirements in Division 22 Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
 - a. Lifting and Supporting Lug: Factory mounted in top of motor enclosure.
- C. Capacities and Characteristics
1. Refer to schedule on drawings

2.04 CONTROLS

- A. Thermostats: Electric; adjustable for control of hot water circulation pump.
1. Manufacturers
 - a. Honeywell International, Inc.
 - b. Square D
 - c. White-Rodgers Division; Emerson Electric Company
 2. Type: Water-immersion sensor, for installation in hot water circulation piping.
 3. Range: 65° to 200°F.
 4. Operation of Pump: On or off.
 5. Transformer: Provide if required.
 6. Power Requirement: 24 V, ac.
 7. Settings: Start pump at 110°F and stop pump at 120°F.
- B. Timers: Electric time clock for control of hot water circulation pump.
1. Manufacturers:
 - a. Honeywell International, Inc.
 - b. Intermatic, Inc.
 - c. Johnson Controls, Inc.
 - d. Maple Chase Company
 - e. TORK
 2. Type: Programmable, seven-day clock with manual override on-off switch.
 3. Enclosure: Suitable for wall mounting.
 4. Operation of Pump: On or off.
 5. Transformer: Provide if required.
 6. Power Requirement: 24 V, ac.
 7. Programmable Sequence of Operation: Up to two on-off cycles each day for seven days.

C. Time Delay Relay: Control for hot water storage tank circulation pump.

1. Manufacturers:
 - a. Honeywell International, Inc.
 - b. Intermatic, Inc.
 - c. Johnson Controls, Inc.
 - d. Maple Chase Company
 - e. Square D
 - f. White-Rodgers Div.; Emerson Electric Company
2. Type: Adjustable time delay relay.
3. Range: Up to five minutes.
4. Setting: Five minutes.
5. Operation of Pump: On or off.
6. Transformer: Provide if required.
7. Power Requirement: 24 V, ac.
8. Programmable Sequence of Operation: Limit pump operation to periods of burner operation plus maximum five minutes after the burner stops.

2.05 FLEXIBLE CONNECTORS

- A. Manufacturers
1. Anamet, Inc.
 2. Flex-Hose Co., Inc.
 3. Flexicraft Industries
 4. Flex-Pression, Ltd.
 5. Flex-Weld, Inc.
 6. Hyspan Precision Products, Inc.
 7. Mercer Rubber
 8. Metraflex, Inc.
 9. Proco Products, Inc.
 10. Tozen America Corporation
 11. Unaflex Inc.
- B. Description: Corrugated, bronze inner tubing covered with bronze wire braid. Include copper-tube ends or bronze flanged ends, braze-welded to tubing. Include 125-psig minimum working pressure rating and ends matching pump connections.

2.06 BUILDING AUTOMATION SYSTEM INTERFACE

- A. Provide auxiliary contacts in pump controllers for interface to building automation system. Include the following:
1. On-off status of each pump.
 2. Alarm status.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 CONCRETE BASES

- A. Install concrete bases of dimensions indicated for pumps and controllers. Refer to Division 22 Section 22 0500 "Common Work Results for Plumbing."
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around full perimeter of base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Cast-in-place concrete materials and placement requirements are specified in Division 03.

3.03 PUMP INSTALLATION

- A. Comply with HI 1.4.
- B. Install pumps with access for periodic maintenance including removal of 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. Install close-coupled, horizontally mounted, in-line centrifugal pumps with motor and pump shafts horizontal.
- E. Install continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Fabricate brackets or supports as required. Hanger and support materials are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- F. Suspend vertically mounted, in-line centrifugal pumps independent of piping. Install pumps with motor and pump shafts vertical. Use continuous-thread hanger rods and spring hangers with vertical-limit stop of sufficient size to support pump weight. Hanger and support materials are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- G. Install vertical in-line pumps on concrete bases. Install pumps with motor and pump shafts vertical.

3.04 CONTROL INSTALLATION

- A. Install immersion-type thermostats in hot water return piping.
- B. Install timers **on wall in engineer's office.**

3.05 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to pumps to allow service and maintenance.
- C. Connect domestic water piping to pumps. Install suction and discharge piping equal to or greater than size of pump nozzles. Refer to Division 22 Section 22 1116 "Domestic Water Piping."
 - 1. Install flexible connectors adjacent to pumps in suction and discharge piping of the following pumps:
 - a. Close coupled, horizontally mounted, in-line centrifugal pumps.
 - b. Close coupled, vertically mounted, in-line centrifugal pumps.
 - 2. Install shutoff valve and strainer on suction side of pumps, and check valve and throttling valve on discharge side of pumps. Install valves same size as connected piping. Refer to Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" for general-duty valves for domestic water piping and Division 22 Section 22 1119 "Domestic Water Piping Specialties" for strainers.
 - 3. Install pressure gauges at suction and discharge of pumps. Install at integral pressure-gauge tapings where provided or install pressure gauge connectors in suction and discharge piping around pumps. Refer to Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping" for pressure gauges and gauge connectors.
- D. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."
- F. Connect **thermostats and timers** to pumps that they control.
- G. Interlock pump with water heater burner and time delay relay.

3.06 STARTUP SERVICE

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

3.07 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain pumps. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 1123

SECTION 22 1316 - SANITARY WASTE AND VENT PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following for soil, waste, and vent piping inside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.
 - 3. Encasement for underground metal piping.

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. EPDM: Ethylene-propylene-diene terpolymer rubber.
- C. LLDPE: Linear, low-density polyethylene plastic.
- D. NBR: Acrylonitrile-butadiene rubber.
- E. PE: Polyethylene plastic.
- F. PVC: Polyvinyl chloride plastic.
- G. TPE: Thermoplastic elastomer.

1.04 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working pressure, unless otherwise indicated:
 - 1. Soil, Waste, and Vent Piping: 10-foot head of water.
 - 2. Sanitary Sewer, Force-Main Piping: 100 psig.

1.05 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field quality control inspection and test reports.

1.06 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-dwv" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.
- C. Cast Iron soil pipe and fittings shall be marked with the collective trademark of Cast Iron Soil Pipe Institute (CISPI) and listed by NSF International.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" article for applications of pipe, tube, fitting, and joining materials.

2.03 HUB-AND-SPIGOT, CAST IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 74, Service class(es).
- B. Gaskets: ASTM C 564, rubber.
- C. Calking Materials: ASTM B 29, pure lead and oakum or hemp fiber.

2.04 HUBLESS CAST IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Sovent Stack Fittings: ASME B16.45 or ASSE 1043, hubless, cast iron aerator and deaerator drainage fittings.
- C. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - 1. Heavy Duty, Shielded, Stainless steel Couplings: Heavy Duty Couplings shall conform to CISPI 310 and ASTM C 1277. Shield Assemblies shall consist of a stainless steel bi-directional corrugated shield; stainless steel bands and tightening devices; and an ASTM C 564, rubber sleeve with integral center stop. Couplings shall bear the NSF Trademark, and be manufactured in the USA.
 - 2. Manufacturers:
 - a. Clamp-All Corporation
 - b. Husky
 - c. Mission Rubber Company
 - d. Tyler Pipe; Soil Pipe Division

2.05 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.
- B. Pressure Fittings:
 - 1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.
 - 3. Gray iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
 - 4. Cast iron Flanges: ASME B16.1, Class 125.
 - 5. Cast iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.
- C. Grooved Joint Systems
 - 1. Manufacturers:
 - a. Anvil International.
 - b. Star Pipe Products; Star Fittings Division
 - c. Victaulic Company.
 - d. Ward Manufacturing, Inc.
 - 2. Grooved End, Steel piping Fittings: ASTM A 47/A 47M, galvanized, malleable iron casting; ASTM A 106, galvanized steel pipe; or ASTM A 536, galvanized, ductile iron casting; with dimensions matching steel pipe.
 - 3. Grooved end, Steel piping Couplings: AWWA C606, for steel pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.06 DUCTILE IRON PIPE AND FITTINGS

- A. Mechanical Joint, Ductile iron Pipe: AWWA C151, with mechanical joint bell and plain spigot end, unless grooved or flanged ends are indicated.
 - 1. Mechanical-Joint, Ductile iron Fittings: AWWA C110, ductile- or gray iron standard pattern or AWWA C153, ductile iron compact pattern.
 - 2. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray iron glands, rubber gaskets, and steel bolts.
- B. Push-on-Joint, Ductile iron Pipe: AWWA C151, with push-on-joint bell and plain spigot end, unless grooved or flanged ends are indicated.
 - 1. Push-on-Joint, Ductile iron Fittings: AWWA C110, ductile- or gray iron standard pattern or AWWA C153, ductile iron compact pattern.
 - 2. Gaskets: AWWA C111, rubber.
- C. Grooved Joint Systems
 - 1. Manufacturers:
 - a. Victaulic Company.
 - 2. Grooved end, ductile iron Fittings: ASTM A 47/A 47M, malleable iron castings or ASTM A 536, ductile iron castings with dimensions matching pipe.
 - 3. Grooved end, ductile iron Piping Couplings: AWWA C606, for ductile iron-pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.
- D. Flanges: ASME 16.1, Class 125, cast iron.

2.07 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
 - 1. Copper Drainage Fittings: ASME B16.23, cast copper or ASME B16.29, wrought copper, solder-joint fittings.

2.08 PVC PIPE AND FITTINGS (NOT USED ABOVEGROUND)

- A. Solid Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.09 OIL WASTE AND VENT PIPING (Below Grade Only)

- A. Solid Wall PVC Pipe DWV: ASTM D 2665, drain, waste, and vent.
 - 1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.10 SPECIAL PIPE FITTINGS

- A. Flexible, Non-pressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion resistant metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. Dallas Specialty & Mfg. Company
 - b. Fernco, Inc.
 - c. Logan Clay Products Company (The).
 - d. Mission Rubber Company
 - e. NDS, Inc.
 - 2. Sleeve Materials:
 - 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.
- B. Shielded Non-pressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Company
 - b. Mission Rubber Company
- C. Rigid, Unshielded, Non-pressure Pipe Couplings: ASTM C 1461, sleeve-type reducing- or transition-type mechanical coupling molded from ASTM C 1440, TPE material with corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. ANACO

- D. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
1. Manufacturers:
 - a. Cascade Waterworks Mfg. Company
 - b. Dresser, Inc.; DMD Division
 - c. EBAA Iron Sales, Inc.
 - d. Ford Meter Box Company, Inc. (The); Pipe Products Division
 - e. JCM Industries, Inc.
 - f. Romac Industries, Inc.
 - g. Smith-Blair, Inc.
 - h. Viking Johnson
 2. Center-Sleeve Material: Manufacturer's standard.
 3. Gasket Material: Natural or synthetic rubber.
 4. Metal Component Finish: Corrosion-resistant coating or material.
- E. Flexible Ball Joints: Ductile iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile iron gland, rubber gasket, and steel bolts.
1. Manufacturers:
 - a. EBAA Iron Sales, Inc.
- F. Expansion Joints: Two or three-piece, ductile iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile iron glands, rubber gaskets, and steel bolts.
1. Manufacturers:
 - a. EBAA Iron Sales, Inc.
 - b. Romac Industries, Inc.
 - c. Star Pipe Products; Star Fittings Division
- G. Wall Penetration Fittings: Compound, ductile iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile iron glands, rubber gaskets, and steel bolts.
1. Manufacturers:
 - a. SIGMA Corporation

2.11 ENCASEMENT FOR UNDERGROUND METAL PIPING

- A. Description: ASTM A 674 or AWWA C105, high-density, cross-laminated PE film of 0.004-inch or LLDPE film of 0.008-inch minimum thickness.
- B. Form: Sheet or tube.
- C. Color: Black or natural.

PART 3 - EXECUTION

3.01 EXCAVATION

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING APPLICATIONS

- A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
- B. Aboveground, soil and waste piping NPS 4 (DN 100) and smaller shall be the following:
 - 1. Hubless cast iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless coupling joints.
 - 2. Copper DWV tube, copper drainage fittings, and soldered joints.
 - 3. Dissimilar Pipe Material Couplings: Shielded, Non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- C. Aboveground, soil and waste piping NPS 5 (DN 125) and larger shall be the following:
 - 1. Hubless cast iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless coupling joints.
 - 2. Dissimilar Pipe-Material Couplings: Shielded, Non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- D. Aboveground, vent piping NPS 4 (DN 100) and smaller shall be the following:
 - 1. Hubless cast iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless coupling joints.
 - 2. Copper DWV tube, copper drainage fittings, and soldered joints.
 - 3. Dissimilar Pipe-Material Couplings: Shielded, Non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- E. Aboveground, vent piping NPS 5 (DN 125) and larger shall be the following:
 - 1. Hubless cast iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and hubless coupling joints.
 - 2. Dissimilar Pipe Material Couplings: Shielded, Non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- F. Underground buried within 5' of the building, soil, waste, and vent piping NPS 4 (DN 100) and smaller shall be the following:
 - 1. Service class, cast iron soil piping; gaskets; and gasketed joints.
 - 2. Solid wall PVC pipe, PVC socket fittings, and solvent-cemented joints.
- G. Underground buried within 5' of the building, soil and waste piping NPS 5 (DN 125) and larger shall be the following:
 - 1. Service class, cast iron soil piping; gaskets; and gasketed joints.
 - 2. Solid-wall, Schedule 40, PVC pipe; PVC socket fittings; and solvent-cemented joints.

3.03 PIPING INSTALLATION

- A. Basic piping installation requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Install cleanouts at grade and extend to where building sanitary drains connect to building sanitary sewers.
- C. Install cleanout fitting with closure plug inside the building in sanitary force-main piping.
- D. Install underground, ductile iron, force-main piping according to AWWA C600. Install buried piping inside the building between wall and floor penetrations and connection to sanitary sewer piping outside the building with restrained joints. Anchor pipe to wall or floor. Install thrust-block supports at vertical and horizontal offsets.
 - 1. Install encasement on piping according to ASTM A 674 or AWWA C105.
- E. Install underground, ductile iron, special pipe fittings according to AWWA C600.
 - 1. Install encasement on piping according to ASTM A 674 or AWWA C105.
- F. Install cast iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section 220500 "Common Work Results for Plumbing."
- G. Install wall-penetration fitting at each service pipe penetration through foundation wall. Make installation watertight.
- H. Install cast iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- I. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if two fixtures are installed back-to-back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- J. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- K. Install soil and waste drainage and vent piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Sanitary Drain: Two percent downward in direction of flow for piping NPS 3 (DN 80) and smaller; 1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 2. Horizontal Sanitary Drainage Piping (2-1/2" and less): Two percent downward in direction of flow.
 - 3. Horizontal Sanitary Drainage Piping (3" and larger): One percent downward in direction of flow.
 - 4. Vent Piping: 1 percent down toward vertical fixture vent or toward vent stack.
- L. Sleeves are not required for cast iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- M. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.

- N. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.04 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Join hub-and-spigot, cast iron soil piping with gasket joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Join hubless cast iron soil piping according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless coupling joints.
- D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- E. Grooved Joints: Assemble joint with keyed coupling, gasket, lubricant, and bolts according to coupling and fitting manufacturer's written instructions.
- F. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.
- G. Anchorage shall be provided to restrain drainage piping from axial movement.
 - 1. For pipe sizes greater than 4 inches, restraints shall be provided from drain pipes at all changes in direction and at all changes in diameter greater than two pipe sizes. Braces, blocks, rodding and other suitable methods as specified by the coupling manufacturer shall be utilized.

3.05 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- B. Shutoff Valves: Install shutoff valve on each sewage pump discharge.
 - 1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
 - 2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sewage pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to sewage backflow.
 - 1. Horizontal Piping: Horizontal backwater valves.
 - 2. Floor Drains: Drain outlet backwater valves, unless drain has integral backwater valve.
 - 3. Install backwater valves in accessible locations.
 - 4. Backwater valve are specified in Division 22 Section 22 1319 "Sanitary Waste Piping Specialties."

3.06 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42 clamps.
 - 2. Install individual, straight, horizontal piping runs according to the following:
 - a. 100 feet and less: MSS Type 1, adjustable, steel clevis hangers.
 - b. Longer than 100 feet: MSS Type 43, adjustable roller hangers.
 - c. Longer than 100 feet if indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52, spring hangers.
- C. Install supports according to Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced one size for double-rod hangers, with 3/8-inch minimum rods.
- F. Install hangers for cast iron soil piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches with 3/8-inch rod.
 - 2. NPS 3 (DN 80): 60 inches with 1/2-inch rod.
 - 3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches with 5/8-inch rod.
 - 4. NPS 6 (DN 150): 60 inches with 3/4-inch rod.
 - 5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches with 7/8-inch rod.
- G. Install supports for vertical cast iron soil piping every 15 feet.
- H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 (DN 32): 84 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 (DN 40): 108 inches with 3/8-inch rod.
 - 3. NPS 2 (DN 50): 10 feet with 3/8-inch rod.
 - 4. NPS 2-1/2 (DN 65): 11 feet with 1/2-inch rod.
 - 5. NPS 3 (DN 80): 12 feet with 1/2-inch rod.
 - 6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet with 5/8-inch rod.
 - 7. NPS 6 (DN 150): 12 feet with 3/4-inch rod.
 - 8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet with 7/8-inch rod.
- I. Install supports for vertical steel piping every 15 feet.
- J. Install hangers for copper tubing with the following maximum horizontal spacing and minimum rod diameters:
 - 1. NPS 1-1/4 (DN 32): 72 inches with 3/8-inch rod.
 - 2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches with 3/8-inch rod.
 - 3. NPS 2-1/2 (DN 65): 108 inches with 1/2-inch rod.
 - 4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet with 1/2-inch rod.
 - 5. NPS 6 (DN 150): 10 feet with 5/8-inch rod.
 - 6. NPS 8 (DN 200): 10 feet with 3/4-inch rod.

- K. Install supports for vertical copper tubing every 10 feet.
- L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.07 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect soil and waste piping to exterior sanitary sewerage piping. Use transition fitting to join dissimilar piping materials.
- C. Connect drainage and vent piping to the following:
 - 1. Plumbing Fixtures: Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.
 - 2. Plumbing Fixtures and Equipment: Connect atmospheric vent piping in sizes indicated, but not smaller than required by authorities having jurisdiction.
 - 3. Plumbing Specialties: Connect drainage and vent piping in sizes indicated, but not smaller than required by plumbing code.
 - 4. Equipment: Connect drainage piping as indicated. Provide shutoff valve, if indicated, and union for each connection. Use flanges instead of unions for connections NPS 2-1/2 (DN 65) and larger.

3.08 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test sanitary drainage and vent piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Roughing-in Plumbing Test Procedure: Test drainage and vent piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.

4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
6. Prepare reports for tests and required corrective action.

3.09 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

3.10 PROTECTION

- A. Exposed PVC Piping: Protect plumbing vents exposed to sunlight with two coats of water-based latex paint.

END OF SECTION 22 1316

SECTION 22 1319 - SANITARY WASTE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following sanitary drainage piping specialties:
 - 1. Backwater valves.
 - 2. Cleanouts.
 - 3. Floor drains.
 - 4. Roof flashing assemblies.
 - 5. Through penetration firestop assemblies.
 - 6. Miscellaneous sanitary drainage piping specialties.
 - 7. Flashing materials.
 - 8. Oil interceptors.
 - 9. Trench Drains
 - 10. Safe waste Drains.
 - 11. Fresh Air Inlets
- B. Related Sections include the following:
 - 1. Division 22 Section 22 1423 "Storm Drainage Piping Specialties" for trench drains for storm water, channel drainage systems for storm water, roof drains, and catch basins.
 - 2. Division 22 Section 22 4000 "Plumbing Fixtures" for hair interceptors.

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. FOG: Fats, oils, and greases.
- C. FRP: Fiberglass reinforced plastic.
- D. HDPE: High-density polyethylene plastic.
- E. PE: Polyethylene plastic.
- F. PP: Polypropylene plastic.
- G. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Grease interceptors.
- B. Shop Drawings: Show fabrication and installation details for frost resistant vent terminals.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- C. Field quality control test reports.
- D. Operation and Maintenance Data: For drainage piping specialties to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic sanitary piping specialty components.

1.06 COORDINATION

- A. Coordinate size and location of concrete bases. Cast anchor bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- B. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.01 BACKWATER VALVES

- A. Horizontal, Cast-iron Backwater Valves
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
 - 2. Standard: ASME A112.14.1.
 - 3. Size: Same as connected piping.
 - 4. Body: Cast iron.

5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
8. Extension: ASTM A 74, Service class; full-size, cast iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain Outlet Backwater Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Size: Same as floor drain outlet.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.02 CLEANOUTS

A. Exposed Metal Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: plastic plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.

B. Exposed Exterior Surfaced Area Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: cast iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.
8. Model: ZN-1400-HD manufactured by Zurn.

C. Exposed Exterior Un-Surfaced Area Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: cast iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.
8. Model: Z-1474 manufactured by Zurn.

D. Metal Floor Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Light Commercial Operation.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Plastic plug.
9. Adjustable Housing Material: Cast iron.
10. Frame and Cover Material and Finish: Polished nickel bronze.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless steel drainage pipe fitting to cleanout.
19. Model: ZN-1400 manufactured by Zurn.

E. Cast Iron Wall Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.

2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: drilled-and-threaded plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome plated brass or stainless steel cover plate with screw.
8. Wall Access: Round stainless steel wall installation frame and cover.

2.03 FLOOR DRAINS

A. Cast Iron Floor Drains

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Light Commercial Operation.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Floor Drain (FD-1):
 - a. Standard: ASME A112.6.3.
 - b. Pattern: Floor drain.
 - c. Body Material: Gray iron.
 - d. Seepage Flange: Required.
 - e. Anchor Flange: Required.
 - f. Clamping Device: Required.
 - g. Outlet: Bottom.
 - h. Backwater Valve: Not required.
 - i. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant epoxy.
 - j. Sediment Bucket: Required.
 - k. Top or Strainer Material: Nickel bronze.
 - l. Top of Body and Strainer Finish: Durra-Coated Cast Iron.
 - m. Top Shape: Round.
 - n. Top Loading Classification: Medium Duty.
 - o. Funnel: Not required.
 - p. Trap Material: Cast iron.
 - q. Trap Pattern: Standard P-trap.
 - r. Trap Features: Trap-seal primer valve drain connection, where required.
 - s. Model: ZN415-NH -6B-AR-P-Y manufactured by Zurn.
3. Floor Drain flooring alternate (FD-1):
 - a. Standard: ASME A112.6.3.
 - b. Floor Type: Astro Turf
 - c. Pattern: Floor drain.
 - d. Body Material: Gray iron.
 - e. Seepage Flange: Required.
 - f. Anchor Flange: Required.
 - g. Clamping Device: Required.
 - h. Outlet: Bottom.
 - i. Backwater Valve: Not required.

- j. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant epoxy.
 - k. Sediment Bucket: Required.
 - l. Top or Strainer Material: Nickel bronze.
 - m. Top of Body and Strainer Finish: Durra-Coated Cast Iron.
 - n. Top Shape: Round.
 - o. Top Loading Classification: Medium Duty.
 - p. Funnel: Not required.
 - q. Flash Clamping Device: Required
 - r. Trap Material: Cast iron.
 - s. Trap Pattern: Standard P-trap.
 - t. Trap Features: Trap-seal primer valve drain connection, where required.
 - u. Model: ZN415H-NH -6B-AR-P-Y manufactured by Zurn.
4. Floor Drain (FD-2):
- a. Standard: ASME A112.6.3.
 - b. Pattern: Floor drain.
 - c. Body Material: Gray iron.
 - d. Seepage Flange: Required.
 - e. Anchor Flange: Required.
 - f. Clamping Device: Required.
 - g. Outlet: Bottom.
 - h. Backwater Valve: Not required.
 - i. Coating on Interior and Exposed Exterior Surfaces: Acid-resistant epoxy.
 - j. Sediment Bucket: Required.
 - k. Top or Strainer Material: Nickel bronze with raised lip set flush with floor.
 - l. Top of Body and Strainer Finish: Durra-Coated Cast Iron.
 - m. Top Shape: Round.
 - n. Top Loading Classification: Medium Duty.
 - o. Funnel: Not required.
 - p. Trap Material: Cast iron.
 - q. Trap Pattern: Standard P-trap.
 - r. Trap Features: Trap-seal primer valve drain connection, where required.
 - s. Model: ZN415-NH -7I-Y-AR manufactured by Zurn.

2.04 ROOF FLASHING ASSEMBLIES

- A. Roof Flashing Assemblies
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Acorn Engineering Company; Elmdor/Stoneman Division
 - b. Thaler Metal Industries Ltd.
- B. Description: Manufactured assembly made of 6.0-lb/sq. ft., 0.0938-inch thick, flashing collar and skirt extending at least 8 inches from pipe, with galvanized steel boot reinforcement and counterflashing fitting.
 - 1. Open-Top Vent Cap: Without cap.
 - 2. Low-Silhouette Vent Cap: With vandal proof vent cap.
 - 3. Extended Vent Cap: With field installed, vandal proof vent cap.

2.05 THROUGH PENETRATION FIRESTOP ASSEMBLIES

A. Through penetration Firestop Assemblies

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. ProSet Systems Inc.
2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected soil, waste, or vent stack.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray iron, hubless-pattern, wye branch with neoprene O-ring at base and gray iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.06 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains

1. Description: Shop or field fabricate from ASTM A 74, Service class, hub-and-spigot, cast iron, soil-pipe fittings. Include P-trap, hub-and-spigot riser section; and where required, increaser fitting joined with ASTM C 564, rubber gaskets.
2. Size: Same as connected waste piping.

B. Deep Seal Traps

1. Description: Cast iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
2. Size: Same as connected waste piping.
 - a. NPS 2 (DN 50): 4-inch minimum water seal.
 - b. NPS 2-1/2 (DN 65) and Larger: 5-inch minimum water seal.

C. Floor Drain, Trap-Seal Primer Fittings

1. Description: Cast iron, with threaded inlet and threaded or spigot outlet, and trap-seal primer valve connection.
2. Size: Same as floor drain outlet with NPS 1/2 (DN 15) side inlet.

D. Air Gap Fittings

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Body: Bronze or cast iron.
3. Inlet: Opening in top of body.
4. Outlet: Larger than inlet.
5. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.

E. Sleeve Flashing Device

1. Description: Manufactured, cast iron fitting, with clamping device that forms sleeve for pipe floor penetrations of floor membrane. Include galvanized steel pipe extension in top of fitting that will extend 1 inch above finished floor and galvanized-steel pipe extension in bottom of fitting that will extend through floor slab.
2. Size: As required for close fit to riser or stack piping.

F. Stack Flashing Fittings

1. Description: Counterflashing-type, cast iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
2. Size: Same as connected stack vent or vent stack.

G. Vent Caps

1. Description: Cast iron body with threaded or hub inlet and vandal proof design. Include vented hood and setscrews to secure to vent pipe.
2. Size: Same as connected stack vent or vent stack.

H. Frost-Resistant Vent Terminals

1. Description: Manufactured or shop-fabricated assembly constructed of copper or galvanized steel.
2. Design: To provide 1-inch enclosed air space between outside of pipe and inside of flashing collar extension, with counterflashing.

I. Expansion Joints

1. Standard: ASME A112.21.2M.
2. Body: Cast iron with bronze sleeve, packing, and gland.
3. End Connections: Matching connected piping.
4. Size: Same as connected soil, waste, or vent piping.

J. Safe waste Drains

1. Description: Coated cast iron combination funnel and trap drain with cleanout plug.
2. Size: 4-inch diameter funnel top with dome strainer and 2-inch threaded outlet.
3. Model: Z-1019-DS manufactured by Zurn.

K. Vent Caps

1. Description: FAI-1, wall type, round chrome plated nickel bronze, crowned and perforated, with 4-point locking device. Model: Z-1471-CP manufactured by Zurn.
2. Description: FAI-2, wall type, round chrome plated nickel bronze with securing cover, 4-inch pipe size, female threaded connection. Model: Z-1472-CP manufactured by Zurn.

2.07 FLASHING MATERIALS

A. Copper Sheet: ASTM B 152/B 152M, of the following minimum weights and thicknesses, unless otherwise indicated:

1. General Applications: 12 oz./sq. ft.
2. Vent Pipe Flashing: 8 oz./sq. ft.

B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.

C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.

D. Fasteners: Metal compatible with material and substrate being fastened.

E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation matching or compatible with material being installed.

F. Solder: ASTM B 32, lead-free alloy.

- G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

2.08 OIL INTERCEPTORS

A. Oil Interceptors

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Schier Products
 - b. Striem Products.
 - c. MiFab
2. Type: Factory fabricated interceptor for separating and removing light oil from wastewater.
3. Certified to IAPMO IGC 183-2016, UPC
4. Body Material: Polyethylene.
5. Interior Lining: Polyethylene.
6. Exterior Coating: Polyethylene
7. Body Dimensions: 103" L x 59" or higher (depending on finished grade) x 49-3/4" OD
8. Flow Rate: Max. 314 GPM
9. Solids Capacity: 162 Gallons
10. Inlet and Outlet Size: 4"
11. End Connections: Hub.
12. Cleanout: Field installed on inlet and outlet.
13. Mounting: Below Grade
14. Extensions to Grade required
15. (2) 24" Cast iron manhole covers that meet AASHTO-H- 20 HD traffic rating (C24-HP)
16. Oil Storage Tank: Liquid Capacity 562 gallons and Oil Capacity of 285 gallons
17. Hold down kit required
18. All required concrete, backfill, rebar and anchoring materials required by oil interceptor manufacturer

2.09 TRENCH DRAINS

A. Trench Drains (TD-1, Bus Bay & Wash Bay):

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.6.3 for trench drains.
3. Material: Ductile or gray iron.
4. Flange: Seepage.
5. Clamping Device: Required.
6. Outlet: 4 in
7. Grate Material: Heel-Proof Ductile Slotted – Class C – 12" Wide
8. Grate Finish: Painted.
9. Top Loading Classification: Heavy Duty
10. Trap Material: Cast iron.
11. Trap Pattern: Standard P-trap.
12. Model: Z882-HD-P12-DGC-USA manufactured by Zurn. **(Refer to schematics on drawing P001)**

2.10 MOTORS

- A. General requirements for motors are specified in Division 22 Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Electrical devices and connections are specified in Division 26 Sections.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer to Division 22 Section 22 0500 "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.
- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 (DN 100) and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install floor drains at low points of surface areas to be drained. Set grates of drains flush with finished floor, unless otherwise indicated.
 - 1. Position floor drains for easy access and maintenance.
 - 2. Set floor drains below elevation of surrounding finished floor to allow floor drainage. Set with grates depressed according to the following drainage area radii:
 - a. Radius, 30 Inches or Less: Equivalent to 1 percent slope, but not less than 1/4-inch total depression.
 - b. Radius, 30 to 60 Inches: Equivalent to 1 percent slope.
 - c. Radius, 60 Inches or Larger: Equivalent to 1 percent slope, but not greater than 1-inch total depression.
 - 3. Install floor drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 - 4. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.
- F. Install trench drains at low points of surface areas to be drained. Set grates of drains flush with finished surface, unless otherwise indicated.

- G. Assemble FRP channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
- H. Assemble plastic channel drainage system components according to manufacturer's written instructions. Install on support devices so that top will be flush with adjacent surface.
- I. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- J. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- K. Install through penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
- L. Install deep-seal traps on floor drains and other waste outlets, if indicated.
- M. Install floor drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.
 - 1. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - 2. Size: Same as floor drain inlet.
- N. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- O. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- P. Install vent caps on each vent pipe passing through roof.
- Q. Install frost-resistant vent terminals on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- R. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- S. Install frost-proof vent caps on each vent pipe passing through roof. Maintain 1-inch clearance between vent pipe and roof substrate.
- T. Install wood-blocking reinforcement for wall mounting type specialties.
- U. Install traps on plumbing specialty drain outlets. Omit traps on indirect wastes unless trap is indicated.
- V. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.
- W. Install oil interceptors, including trapping, venting, and flow control fitting, according to authorities having jurisdiction and with clear space for servicing.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Oil Interceptors: Connect inlet, outlet, vent, to unit.

- D. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- E. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."

3.03 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches, and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.
- E. Install flashing for piping passing through roofs with counterflashing or commercially made flashing fittings, according to Division 07 Section "Sheet Metal Flashing and Trim."
- F. Extend flashing up vent pipe passing through roofs and turn down into pipe, or secure flashing into cast iron sleeve having calking recess.
- G. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs - install engraved plastic laminate equipment nameplate or sign on or near each of the following:
 - 1. Oil interceptors.
 - 2. Solid's interceptors.
 - 3. Floor drains in concealed spaces.
- B. Distinguish among multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations, in addition to identifying unit. Nameplates and signs are specified in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.05 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.06 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1319

SECTION 22 1413 - STORM DRAINAGE PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following storm drainage piping inside and outside the building:
 - 1. Pipe, tube, and fittings.
 - 2. Special pipe fittings.
 - 3. Encasement for underground metal piping.

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. LLDPE: Linear, low density polyethylene plastic.
- C. PE: Polyethylene plastic.
- D. PVC: Polyvinyl chloride plastic.
- E. TPE: Thermoplastic elastomer.

1.04 PERFORMANCE REQUIREMENTS

- A. Components and installation shall be capable of withstanding the following minimum working-pressure, unless otherwise indicated:
 - 1. Storm Drainage Piping: 10-foot head of water.
- B. Seismic Performance: Soil, waste, and vent piping and support and installation shall be capable of withstanding the effects of seismic events determined according to ASCE 7, "Minimum Design Loads for Buildings and Other Structures."

1.05 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field quality control inspection and test reports.

1.06 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-drain" for plastic drain piping and "NSF-sewer" for plastic sewer piping.
- C. Cast Iron soil pipe and fittings shall be marked with the collective trademark of Cast Iron Soil Pipe Institute (CISPI) and listed by NSF International.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" article for applications of pipe, tube, fitting, and joining materials.

2.03 HUBLESS CAST IRON SOIL PIPE AND FITTINGS

- A. Pipe and Fittings: ASTM A 888 or CISPI 301.
- B. Shielded Couplings: ASTM C 1277 assembly of metal shield or housing, corrosion-resistant fasteners, and rubber sleeve with integral, center pipe stop.
 - 1. Heavy Duty, Shielded, Stainless steel Couplings: Heavy Duty Couplings shall conform to CISPI 310 and ASTM C 1277. Shield Assemblies shall consist of a stainless steel bi-directional corrugated shield; stainless steel bands and tightening devices; and an ASTM C 564, rubber sleeve with integral center stop. Couplings shall bear the NSF Trademark, and be manufactured in the USA.
 - 2. Manufacturers:
 - a. ANACO
 - b. Clamp-All Corporation
 - c. Ideal Div.; Stant Corporation
 - d. Mission Rubber Company
 - e. Tyler Pipe; Soil Pipe Division

2.04 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, Type E or S, Grade A or B, Standard Weight or Schedule 40, galvanized. Include ends matching joining method.
- B. Drainage Fittings: ASME B16.12, galvanized, threaded, cast iron drainage pattern.
- C. Pressure Fittings
 - 1. Steel Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, galvanized, seamless steel pipe. Include ends matching joining method.
 - 2. Malleable-Iron Unions: ASME B16.39; Class 150; hexagonal-stock body with ball-and-socket, metal-to-metal, bronze seating surface; and female threaded ends.

3. Gray iron, Threaded Fittings: ASME B16.4, Class 125, galvanized, standard pattern.
4. Cast iron Flanges: ASME B16.1, Class 125.
5. Cast iron, Flanged Fittings: ASME B16.1, Class 125, galvanized.

D. Grooved Joint Systems

1. Manufacturers:
 - a. Anvil International.
 - b. Star Pipe Products; Star Fittings Division
 - c. Victaulic Company of America
 - d. Ward Manufacturing, Inc.
2. Grooved-End, Steel piping Fittings: ASTM A 47/A 47M, galvanized, malleable-iron casting; ASTM A 106, galvanized steel pipe; or ASTM A 536, galvanized, ductile iron casting; with dimensions matching steel pipe.
3. Grooved-End, Steel piping Couplings: AWWA C606, for steel pipe dimensions. Include ferrous housing sections, gasket suitable for water, and bolts and nuts.

2.05 COPPER TUBE AND FITTINGS

- A. Copper DWV Tube: ASTM B 306, drainage tube, drawn temper.
1. Copper Drainage Fittings: ASME B16.23, cast-copper or ASME B16.29, wrought-copper, solder-joint fittings.
- B. Hard Copper Tube: ASTM B 88, Types L and M (ASTM B 88M, Types B and C), water tube, drawn temper.
1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 2. Copper Flanges: ASME B16.24, Class 150, cast copper with solder-joint end.
 3. Copper Unions: MSS SP-123, copper-alloy, hexagonal-stock body with ball-and-socket, metal-to-metal seating surfaces, and solder-joint or threaded ends.
- C. Soft Copper Tube: ASTM B 88, Type L (ASTM B 88M, Type B), water tube, annealed temper.
1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.

2.06 PVC PIPE AND FITTINGS (UNDERGROUND ONLY)

- A. Solid Wall PVC Pipe: ASTM D 2665, drain, waste, and vent.
1. PVC Socket Fittings: ASTM D 2665, socket type, made to ASTM D 3311, drain, waste, and vent patterns.

2.07 SPECIAL PIPE FITTINGS

- A. Flexible, Non-pressure Pipe Couplings: Comply with ASTM C 1173, elastomeric, sleeve-type, reducing or transition pattern. Include shear ring, ends of same sizes as piping to be joined, and corrosion-resistant-metal tension band and tightening mechanism on each end.
1. Manufacturers:
 - a. Dallas Specialty & Mfg. Company
 - b. Fernco, Inc.
 - c. Mission Rubber Company

- d. NDS, Inc.
 - e. Plastic Oddities, Inc.
- 2. Sleeve Materials:
 - 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.
- B. Shielded Non-pressure Pipe Couplings: ASTM C 1460, elastomeric or rubber sleeve with full-length, corrosion-resistant outer shield and corrosion-resistant-metal tension band and tightening mechanism on each end.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Company
 - b. Mission Rubber Company
- C. Pressure Pipe Couplings: AWWA C219 metal, sleeve-type same size as, with pressure rating at least equal to, and ends compatible with, pipes to be joined.
 - 1. Manufacturers:
 - a. Cascade Waterworks Mfg. Company
 - b. Dresser, Inc.; DMD Division
 - c. EBAA Iron Sales, Inc.
 - d. Romac Industries, Inc.
 - e. Smith-Blair, Inc.
 - f. Viking Johnson
 - 2. Center Sleeve Material: Manufacturer's standard.
 - 3. Gasket Material: Natural or synthetic rubber.
 - 4. Metal Component Finish: Corrosion-resistant coating or material.
- D. Flexible Ball Joints: Ductile iron fitting with combination of flanged and mechanical-joint ends complying with AWWA C110 or AWWA C153. Include gasketed ball-joint section and ductile iron gland, rubber gasket, and steel bolts.
 - 1. Manufacturers:
 - a. EBAA Iron Sales, Inc.
- E. Expansion Joints: Two or three-piece, ductile iron assembly consisting of telescoping sleeve(s) with gaskets and restrained-type, ductile iron, bell-and-spigot end sections complying with AWWA C110 or AWWA C153. Select and assemble components for expansion indicated. Include AWWA C111, ductile iron glands, rubber gaskets, and steel bolts.
 - 1. Manufacturers:
 - a. EBAA Iron Sales, Inc.
 - b. Romac Industries, Inc.
 - c. Star Pipe Products; Star Fittings Division
- F. Wall Penetration Fittings: Compound, ductile iron coupling fitting with sleeve and flexing sections for up to 20-degree deflection, gaskets, and restrained-joint ends complying with AWWA C110 or AWWA C153. Include AWWA C111, ductile iron glands, rubber gaskets, and steel bolts.
 - 1. Manufacturers:
 - a. SIGMA Corporation

2.08 ENCASEMENT FOR UNDERGROUND METAL PIPING

- A. Description: ASTM A 674 or AWWA C105, high-density, cross-laminated PE film of 0.004-inch or LLDPE film of 0.008-inch minimum thickness.
- B. Form: Sheet or tube.
- C. Color: Black or natural.

PART 3 - EXECUTION

3.01 EXCAVATION

- A. Refer to Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.

3.02 PIPING APPLICATIONS

- A. Flanges and unions may be used on aboveground pressure piping, unless otherwise indicated.
- B. Above ground storm drainage piping shall be the following:
 - 1. Hubless cast iron soil pipe and fittings; heavy-duty shielded, stainless-steel couplings; and coupled joints.
 - 2. Copper DWV tube, copper drainage fittings, and soldered joints.
 - 3. Dissimilar Pipe Material Couplings: Shielded non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.
- C. Underground storm drainage piping shall be the following:
 - 1. Service class, cast iron soil pipe and fittings; gaskets; and gasketed joints.
 - 2. Solid wall PVC pipe, PVC socket fittings, and solvent cemented joints.
 - 3. Dissimilar Pipe material Couplings: Shielded, non-pressure pipe couplings for joining dissimilar pipe materials with small difference in OD.

3.03 PIPING INSTALLATION

- A. Storm sewer and drainage piping outside the building are specified in Division 33 Section "Storm Utility Drainage Piping."
- B. Basic piping installation requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- C. Install cleanouts at grade and extend to where building storm drains connect to building storm sewers. Cleanouts are specified in Division 22 Section 22 1423 "Storm Drainage Piping Specialties."
- D. Install cleanout fitting with closure plug inside the building in storm drainage force-main piping.
- E. Install underground, steel, force-main piping. Install encasement on piping according to ASTM A 674 or AWWA C105.

- F. Install underground, copper, force-main tubing according to CDA's "Copper Tube Handbook."
 - 1. Install encasement on piping according to ASTM A 674 or AWWA C105.
- G. Install cast iron sleeve with water stop and mechanical sleeve seal at each service pipe penetration through foundation wall. Select number of interlocking rubber links required to make installation watertight. Sleeves and mechanical sleeve seals are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- H. Install wall penetration fitting system at each service pipe penetration through foundation wall. Make installation watertight.
- I. Install cast iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
 - 1. Install encasement on underground piping according to ASTM A 674 or AWWA C105.
- J. Make changes in direction for storm drainage piping using appropriate branches, bends, and long-sweep bends. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- K. Lay buried building storm drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- L. Install storm drainage piping at the following minimum slopes, unless otherwise indicated:
 - 1. Building Storm Drain: 1 percent downward in direction of flow for piping NPS 3 (DN 80) and smaller.
1 percent downward in direction of flow for piping NPS 4 (DN 100) and larger.
 - 2. Horizontal Storm Drainage Piping: 2 percent downward in direction of flow.
- M. Sleeves are not required for cast iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- N. Install underground PVC storm drainage piping according to ASTM D 2321.
- O. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.

3.04 JOINT CONSTRUCTION

- A. Basic piping joint construction requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Hub-and-Spigot, cast iron Soil Piping Gasketed Joints: Join according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for compression joints.
- C. Hubless Cast iron Soil Piping Coupled Joints: Join according to CISPI 310 and CISPI's "Cast Iron Soil Pipe and Fittings Handbook" for hubless-coupling joints.
- D. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.

- E. Grooved Joints: Cut groove ends of pipe and assemble grooved ends of pipes, grooved-end fittings, and grooved-end-piping couplings according to AWWA C606.
- F. PVC Non-pressure Piping Joints: Join piping according to ASTM D 2665.
- G. Anchorage shall be provided to restrain drainage piping from axial movement.
 - 1. For pipe sizes greater than 4 inches, restraints shall be provided from drain pipes at all changes in direction and at all changes in diameter greater than two pipe sizes. Braces, blocks, rodding and other suitable methods as specified by the coupling manufacturer shall be utilized.

3.05 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- B. Shutoff Valves: Install shutoff valve on each sump pump discharge.
 - 1. Install gate or full-port ball valve for piping NPS 2 (DN 50) and smaller.
 - 2. Install gate valve for piping NPS 2-1/2 (DN 65) and larger.
- C. Check Valves: Install swing check valve, between pump and shutoff valve, on each sump pump discharge.
- D. Backwater Valves: Install backwater valves in piping subject to backflow.
 - 1. Horizontal Piping: Horizontal backwater valves. Use normally closed type, unless otherwise indicated.
 - 2. Install backwater valves in accessible locations.
 - 3. Backwater valve are specified in Division 22 Section 22 1423 "Storm Drainage Piping Specialties."

3.06 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- B. Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42 clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: According to the following:
 - a. 100 feet and less: MSS Type 1 adjustable, steel clevis hangers.
 - b. Longer than 100 feet: MSS Type 43 adjustable roller hangers.
 - c. Longer than 100 feet if indicated: MSS Type 49, spring cushion rolls.
 - 3. Multiple, Straight, Horizontal Piping Runs 100 feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze.
 - 4. Base of Vertical Piping: MSS Type 52 spring hangers.
- C. Install supports according to Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment."
- D. Support vertical piping and tubing at base and at each floor.
- E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

F. Install hangers for cast iron soil piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 60 inches with 3/8-inch rod.
2. NPS 3 (DN 80): 60 inches with 1/2-inch rod.
3. NPS 4 and NPS 5 (DN 100 and DN 125): 60 inches with 5/8-inch rod.
4. NPS 6 (DN 150): 60 inches with 3/4-inch rod.
5. NPS 8 to NPS 12 (DN 200 to DN 300): 60 inches with 7/8-inch rod.
6. Spacing for 10-foot lengths may be increased to 10 feet. Spacing for fittings is limited to 60 inches.

G. Install supports for vertical cast iron soil piping every 15 feet.

H. Install hangers for steel piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 1-1/4 (DN 32): 84 inches with 3/8-inch rod.
2. NPS 1-1/2 (DN 40): 108 inches with 3/8-inch rod.
3. NPS 2 (DN 50): 10 feet with 3/8-inch rod.
4. NPS 2-1/2 (DN 65): 11 feet with 1/2-inch rod.
5. NPS 3 (DN 80): 12 feet with 1/2-inch rod.
6. NPS 4 and NPS 5 (DN 100 and DN 125): 12 feet with 5/8-inch rod.
7. NPS 6 (DN 150): 12 feet with 3/4-inch rod.
8. NPS 8 to NPS 12 (DN 200 to DN 300): 12 feet with 7/8-inch rod.

I. Install supports for vertical steel piping every 15 feet.

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

1. NPS 1-1/4 (DN 32): 72 inches with 3/8-inch rod.
2. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): 96 inches with 3/8-inch rod.
3. NPS 2-1/2 (DN 65): 108 inches with 1/2-inch rod.
4. NPS 3 to NPS 5 (DN 80 to DN 125): 10 feet with 1/2-inch rod.
5. NPS 6 (DN 150): 10 feet with 5/8-inch rod.
6. NPS 8 (DN 200): 10 feet with 3/4-inch rod.

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

L. Support piping and tubing not listed above according to MSS SP-69 and manufacturer's written instructions.

3.07 CONNECTIONS

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

B. Connect interior storm drainage piping to exterior storm drainage piping. Use transition fitting to join dissimilar piping materials.

C. Connect storm drainage piping to roof drains and storm drainage specialties.

D. Connect force main piping to the following:

1. Storm Sewer: To exterior force main or storm manhole.
2. Sump Pumps: To sump pump discharge.

3.08 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- C. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- D. Test storm drainage piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 - 2. Leave uncovered and unconcealed new, altered, extended, or replaced storm drainage piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 - 3. Test Procedure: Test storm drainage piping, except outside leaders, on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 - 4. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
 - 5. Prepare reports for tests and required corrective action.

3.09 CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
- C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 22 1413

SECTION 22 1423 - STORM DRAINAGE PIPING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following storm drainage piping specialties:
 - 1. Backwater valves.
 - 2. Cleanouts.
 - 3. Through penetration firestop assemblies.
 - 4. Floor drains.
 - 5. Miscellaneous storm drainage piping specialties.
 - 6. Flashing materials.
- B. Related Sections include the following:
 - 1. Division 22 Section 22 1319 "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains and channel drainage systems connected to sanitary sewer, air admittance valves, FOG disposal systems, grease interceptors and removal devices, oil interceptors, and solid interceptors.

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. FRP: Fiberglass reinforced plastic.
- C. HDPE: High density polyethylene plastic.
- D. PE: Polyethylene plastic.
- E. PP: Polypropylene plastic.
- F. PUR: Polyurethane plastic.
- G. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

- A. Product data for each type of product indicated.

1.05 QUALITY ASSURANCE

- A. Drainage piping specialties shall bear label, stamp, or other markings of specified testing agency.

1.06 COORDINATION

- A. Coordinate size and location of roof penetrations.

PART 2 - PRODUCTS

2.01 BACKWATER VALVES

A. Horizontal, Cast-Iron Backwater Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.14.1.
3. Size: Same as connected piping.
4. Body: Cast iron.
5. Cover: Cast iron with bolted or threaded access check valve.
6. End Connections: Hub and spigot or hubless.
7. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed or open for airflow unless subject to backflow condition.
8. Extension: ASTM A 74, Service class; full-size, cast iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.

B. Drain Outlet Backwater Valves

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 - c. Watts Drainage Products Inc.
 - d. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Size: Same as floor drain outlet.
3. Body: Cast iron or bronze made for vertical installation in bottom outlet of floor drain.
4. Check Valve: Removable ball float.
5. Inlet: Threaded.
6. Outlet: Threaded or spigot.

2.02 CLEANOUTS

A. Exposed Metal Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: plastic plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.

B. Exposed Exterior Surfaced Area Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: cast iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.
8. Model: ZN-1400-HD manufactured by Zurn.

C. Exposed Exterior Unsurfaced Area Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for cast iron for cleanout test tee.
3. Size: Same as connected drainage piping
4. Body Material: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: cast iron plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Closure: Stainless steel plug with seal.
8. Model: Z-1474 manufactured by Zurn.

D. Metal Floor Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Light Commercial Operation.
 - f. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M for adjustable housing cleanout.
3. Size: Same as connected branch.
4. Type: Adjustable housing.
5. Body or Ferrule: Cast iron.
6. Clamping Device: Required.
7. Outlet Connection: Inside calk.
8. Closure: Plastic plug.
9. Adjustable Housing Material: Cast iron.
10. Frame and Cover Material and Finish: Polished nickel bronze.
11. Frame and Cover Shape: Round.
12. Top Loading Classification: Medium Duty.
13. Riser: ASTM A 74, Service class, cast iron drainage pipe fitting and riser to cleanout.
14. Standard: ASME A112.3.1.
15. Size: Same as connected branch.
16. Housing: Stainless steel.
17. Closure: Stainless steel with seal.
18. Riser: Stainless steel drainage pipe fitting to cleanout.
19. Model: ZN-1400 manufactured by Zurn.

E. Cast Iron Wall Cleanouts

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Josam Company; Josam Division
 - b. Smith, Jay R. Mfg. Co.; Division of Smith Industries, Inc.
 - c. Tyler Pipe; Wade Division
 - d. Watts Drainage Products Inc.
 - e. Zurn Plumbing Products Group; Specification Drainage Operation.
2. Standard: ASME A112.36.2M. Include wall access.
3. Size: Same as connected drainage piping.
4. Body: Hubless, cast iron soil pipe test tee as required to match connected piping.
5. Closure: drilled-and-threaded plug.
6. Closure Plug Size: Same as or not more than one size smaller than cleanout size.
7. Wall Access: Round, flat, chrome plated brass or stainless steel cover plate with screw.
8. Wall Access: Round stainless steel wall installation frame and cover.

2.03 THROUGH PENETRATION FIRESTOP ASSEMBLIES

A. Through Penetration Firestop Assemblies

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. ProSet Systems Inc.

2. Standard: UL 1479 assembly of sleeve and stack fitting with firestopping plug.
3. Size: Same as connected pipe.
4. Sleeve: Molded PVC plastic, of length to match slab thickness and with integral nailing flange on one end for installation in cast-in-place concrete slabs.
5. Stack Fitting: ASTM A 48/A 48M, gray iron, hubless pattern, wye branch with neoprene O-ring at base and gray iron plug in thermal-release harness. Include PVC protective cap for plug.
6. Special Coating: Corrosion resistant on interior of fittings.

2.04 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

- A. Expansion Joints
 1. Standard: ASME A112.21.2M.
 2. Body: Cast iron with bronze sleeve, packing, and gland.
 3. End Connections: Matching connected piping.
 4. Size: Same as connected piping.
- B. Downspout Boot (DSB-1)
 1. Description: Cast Iron body with cleanout plug.
 2. Size: Same as connected conductor.
 3. Model: 1785 manufactured by J.R.Smith

2.05 FLASHING MATERIALS

- A. Copper Sheet: ASTM B 152/B 152M, 12 oz./sq. ft. thickness.
- B. Zinc-Coated Steel Sheet: ASTM A 653/A 653M, with 0.20 percent copper content and 0.04-inch minimum thickness, unless otherwise indicated. Include G90 (Z275) hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- C. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- D. Fasteners: Metal compatible with material and substrate being fastened.
- E. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- F. Solder: ASTM B 32, lead free alloy.
- G. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Refer to Division 22 Section 22 0500 "Common Work Results for Plumbing" for piping joining materials, joint construction, and basic installation requirements.

- B. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated:
 - 1. Size same as drainage piping up to NPS 4 (DN 100). Use NPS 4 (DN 100) for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. Locate at minimum intervals of 50 feet for piping NPS 4 (DN 100) and smaller and 100 feet for larger piping.
 - 4. Locate at base of each vertical soil and waste stack.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- E. Install through penetration firestop assemblies in plastic conductors and stacks at floor penetrations.
- F. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- G. Install expansion joints on vertical stacks and conductors. Position expansion joints for easy access and maintenance.
- H. Install manufactured, gray iron downspout boots at grade with top 12 inches to 18 inches above grade. Secure to building wall.
- I. Install cast iron soil pipe downspout boots at grade with top of hub 12 inches to 18 inches above grade.
- J. Install escutcheons at wall, floor, and ceiling penetrations in exposed finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding pipe fittings.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

3.03 FLASHING INSTALLATION

- A. Fabricate flashing from single piece unless large pans, sumps, or other drainage shapes are required. Join flashing according to the following if required:
 - 1. Copper Sheets: Solder joints of copper sheets.
- B. Install sheet flashing on pipes, sleeves, and specialties passing through or embedded in floors and roofs with waterproof membrane.
 - 1. Pipe Flashing: Sleeve type, matching pipe size, with minimum length of 10 inches and skirt or flange extending at least 8 inches around pipe.
 - 2. Sleeve Flashing: Flat sheet, with skirt or flange extending at least 8 inches around sleeve.
 - 3. Embedded Specialty Flashing: Flat sheet, with skirt or flange extending at least 8 inches around specialty.
- C. Set flashing on floors and roofs in solid coating of bituminous cement.
- D. Secure flashing into sleeve and specialty clamping ring or device.

- E. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 PROTECTION

- A. Protect drains during remainder of construction period to avoid clogging with dirt or debris and to prevent damage from traffic or construction work.
- B. Place plugs in ends of uncompleted piping at end of each day or when work stops.

END OF SECTION 22 1423

SECTION 22 1513 - GENERAL SERVICE COMPRESSED AIR PIPING

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 piping and related specialties for general-service compressed-air systems operating at 200 psig or less.
- B. Related Sections include the following:
 - 1. Division 22 Section 22 1519 "General Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. CR: Chlorosulfonated polyethylene synthetic rubber.
- C. EPDM: Ethylene-propylene-diene terpolymer rubber.
- D. HDPE: High-density polyethylene plastic.
- E. NBR: Acrylonitrile-butadiene rubber.
- F. PE: Polyethylene plastic.
- G. PVC: Polyvinyl chloride plastic.
- H. Low-Pressure Compressed-Air Piping: System of compressed-air piping and specialties operating at pressures of 150 psig or less.

1.04 SUBMITTALS

- A. Product data for the following:
 - 1. Compressed air tubes and fittings
 - 2. Compressed air valves
 - 3. Dielectric fittings.
 - 4. Flexible pipe connectors.
 - 5. Safety valves.

6. Pressure regulators. Include rated capacities and operating characteristics.
 7. Automatic drain valves.
 8. Filters. Include rated capacities and operating characteristics.
 9. Lubricators. Include rated capacities and operating characteristics.
 10. Quick couplings.
 11. Hose assemblies.
- B. Brazing and welding certificates.
 - C. Qualification Data: For Installers.
 - D. Field quality-control test reports.
 - E. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An independent testing agency, with the experience and capability to conduct the vacuum piping testing indicated, that is a member of the Medical Gas Professional Healthcare Organization or is an NRTL, and that is acceptable to authorities having jurisdiction.
 1. Qualify testing personnel according to ASSE Standard #6020 for inspectors and ASSE Standard #6030 for verifiers.
- B. Source Limitations: Obtain compressed-air service connections of same type and from same manufacturer as service connections provided for in Division 22 Section 226313 "Gas Piping for Laboratory and Healthcare Facilities."
- C. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."
- D. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
- E. ASME Compliance:
 1. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

- A. Comply with ASME B31.9 for laboratory air piping operating at 150 psig or less.
- B. Copper Tube: ASTM B 88, Type K, seamless, drawn temper.
 1. Copper Fittings: copper alloy or wrought-copper, ASME B16.22, solder-joint pressure type.

2.02 JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.
- C. 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.

2.03 VALVES

- A. General Requirements for Valves: Manufacturer cleaned, purged, and bagged according to CGA G-4.1 for oxygen service.
- B. Ball Valves: MSS SP-110, 3-piece body, brass or bronze.
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Amico Corporation
 - b. Apollo Valves
 - c. Conbraco Industries, Inc.
 - d. Nibco Inc.
 - 2. Pressure Rating: 300 psig minimum.
 - 3. Ball: Full-port, chrome-plated brass.
 - 4. Seats: PTFE or TFE.
 - 5. Handle: Lever type with locking device.
 - 6. Stem: Blowout proof with PTFE or TFE seal.
 - 7. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
- C. Check Valves: In-line pattern, bronze.
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Amico Corporation
 - b. Apollo Valves
 - c. Conbraco Industries, Inc.
 - d. Nibco Inc.
 - 2. Pressure Rating: 300 psig minimum.
 - 3. Operation: Spring loaded.
 - 4. Ends: Manufacturer-installed ASTM B 819, copper-tube extensions.
- D. Pressure Regulators: Bronze body and trim; spring-loaded, diaphragm-operated relieving type; manual pressure-setting adjustment; rated for 250-psig minimum inlet pressure; and capable of controlling delivered air pressure within 0.5 psig for each 10-psig inlet pressure.
- E. Automatic Drain Valves: Stainless steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate.

2.04 DIELECTRIC FITTINGS

- A. General Requirements for Dielectric Fittings: Combination fitting of copper alloy and ferrous materials with insulating material; suitable for system fluid, pressure, and temperature. Include threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.

2.05 FLEXIBLE PIPE CONNECTORS

- A. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Flex-Hose Co., Inc.
 - 2. Flexicraft Industries.
 - 3. Hyspan Precision Products, Inc.
 - 4. Mercer Rubber Co.
 - 5. Metraflex, Inc.
- C. Bronze-Hose Flexible Pipe Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - 1. Working-Pressure Rating: **200 psig** minimum.
 - 2. End Connections, NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
- D. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.
 - 1. Working-Pressure Rating: **200 psig** minimum.
 - 2. End Connections, NPS 2 and Smaller: Threaded steel pipe nipple.

2.06 SLEEVES

- A. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Stack Sleeve Fittings: Manufactured, cast-iron sleeve with integral clamping flange. Include clamping ring and bolts and nuts for membrane flashing.
 - 1. Underdeck Clamp: Clamping ring with set screws.

2.07 ESCUTCHEONS

- A. General Requirements: Manufactured wall and ceiling escutcheons and floor plates, with ID to closely fit around pipe and tube and OD that completely covers opening.
- B. One-Piece, Deep-Pattern Escutcheons: Deep-drawn, box-shaped brass with polished chrome-plated finish.
- C. One-Piece, Cast-Brass Escutcheons: With set screw.
 - 1. Finish: Polished chrome-plated

- D. Split-Casting, Cast-Brass Escutcheons: With concealed hinge and set screw.
 - 1. Finish: Polished chrome-plated.
- E. One-Piece, Stamped-Steel Escutcheons: With set screw or spring clips and chrome-plated finish.
- F. Split-Plate, Stamped-Steel Escutcheons: With concealed, set screw or spring clips, and chrome-plated finish.
- G. One-Piece, Floor-Plate Escutcheons: Cast iron.
- H. Split-Casting, Floor-Plate Escutcheons: Cast brass with concealed hinge and set screw.

2.08 SPECIALTIES

- A. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service.
 - 1. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.
- B. Air-Main Pressure Regulators: Bronze body, direct acting, spring-loaded manual pressure-setting adjustment, and rated for **250-psig** inlet pressure, unless otherwise indicated.
 - 1. Type: Pilot operated.
- C. Air Line Filter Regulator, lubricator combination: Regulating assembly with line pressure adjusting knob, lubricator, metal bowl with sight glass, 2-inch diameter line pressure gage, 5-micron filter unit and automatic drain. Based on Model 27FRL4-DG manufactured by Coilhose
- D. Air Line Filter Regulator, lubricator combination: Regulating assembly with line pressure adjusting knob, lubricator, metal bowl with sight glass, 2-inch diameter line pressure gage, 5-micron filter unit and automatic drain. Based on Model 2000 manufactured by ARO (Ingersoll Rand)
- E. Automatic Drain Valves: Stainless-steel body and internal parts, rated for **200-psig** minimum working pressure, capable of automatic discharge of collected condensate. **Include mounting bracket if wall mounting**

2.09 QUICK COUPLINGS

- A. Available Manufacturers - subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
- B. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Aeroquip Corporation; Eaton Corp.
 - 2. Bowes Manufacturing Inc.
 - 3. Foster Manufacturing, Inc.
 - 4. Milton Industries, Inc.
 - 5. Parker Hannifin Corp.; Fluid Connectors Group; Quick Coupling Division
 - 6. Rectus Corporation
 - 7. Schrader-Bridgeport; Amflo Division
 - 8. Schrader-Bridgeport/Standard Thomson.
 - 9. Snap-Tite, Inc.; Quick Disconnect & Valve Division.

- C. General Requirements for Quick Couplings: Assembly with locking-mechanism feature for quick connection and disconnection of compressed-air hose.
- D. Automatic-Shutoff Quick Couplings: Straight-through brass body with O-ring or gasket seal and stainless-steel or nickel-plated-steel operating parts.
 - 1. Socket End: With one-way valve and threaded inlet for connection to piping or threaded hose fitting.
 - 2. Plug End: Straight-through type with barbed outlet for attaching hose.
- E. Valveless Quick Couplings: Straight-through brass body with stainless-steel or nickel-plated-steel operating parts.
 - 1. Socket End: With O-ring or gasket seal, without valve, and with barbed inlet for attaching hose.
 - 2. Plug End: With barbed outlet for attaching hose.

2.10 HOSE ASSEMBLIES

- A. Description: Compatible hose, clamps, couplings, and splicers suitable for compressed-air service, of nominal diameter indicated, and rated for 300-psig minimum working pressure, unless otherwise indicated.
 - 1. Hose: Reinforced double-wire-braid, CR-covered hose for compressed-air service.
 - 2. Hose Clamps: Stainless-steel clamps or bands.
 - 3. Hose Couplings: Two-piece, straight-through, threaded brass or stainless-steel O-ring or gasket-seal swivel coupling with barbed ends for connecting two sections of hose.
 - 4. Hose Splicers: One-piece, straight-through brass or stainless-steel fitting with barbed ends for connecting two sections of hose.
 - 5. Brass Hose Barb Fittings with barbed and threaded end

2.11 GROUT

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

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

- A. Compressed-Air Piping between Air Compressors and Receivers: Use the following piping materials for each size range:
 - 1. NPS 2 size and Smaller: Schedule 40, galvanized-steel pipe; threaded, malleable-iron fittings; and threaded joints.
 - 2. NPS 2 and Smaller: Type K, copper tube; wrought-copper fittings; and brazed joints.
- B. Low-Pressure Compressed-Air Distribution Piping: Use the following piping materials for each size range:
 - 1. NPS 2 and Smaller: Type K, copper tube; wrought-copper fittings; and brazed joints.

C. Drain Piping: Use the following piping materials:

1. NPS 2 and Smaller: Type K copper tube; wrought-copper fittings; and brazed or soldered joints.

3.02 VALVE APPLICATIONS

A. General-Duty Valves: Comply with requirements in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" for metal general-duty valves. Use metal valves, unless otherwise indicated.

1. Metal General-Duty Valves: Use valve types specified in "Valve Applications" article in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" according to the following:
 - a. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.
 - b. Equipment Isolation NPS 2 and Smaller: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

3.03 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping concealed from view and protected from physical contact by building occupants, 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 otherwise indicated.
- D. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.
- E. Install piping adjacent to equipment and machines to allow service and maintenance.
- F. Install air and drain piping with 1 percent slope downward in direction of flow.
- G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.
- H. Equipment and Specialty Flanged Connections:
1. Use steel companion flange with gasket for connection to steel pipe.
 2. Use cast-copper-alloy companion flange with gasket and brazed joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.
- I. Flanged joints may be used instead of specified joint for any piping or tubing system.
- J. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

- K. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main and branch and at low points.
- L. Install thermometer and pressure gage on discharge piping from each air compressor and on each receiver. Comply with requirements in Division 22 Section 22 0519 "Meters and Gages for Plumbing Piping."
- M. Install piping to permit valve servicing.
- N. Install piping free of sags and bends.
- O. Install fittings for changes in direction and branch connections.

3.04 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints: 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.
- D. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- E. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Join according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.05 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- B. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.
- C. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.
- D. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.06 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. NPS 2 and Smaller: Use dielectric unions.

3.07 FLEXIBLE PIPE CONNECTOR INSTALLATION

- A. Install flexible pipe connectors in discharge piping and in inlet air piping from remote air-inlet filter of each air compressor.
- B. Install bronze-hose flexible pipe connectors in copper compressed-air tubing.
- C. Install stainless-steel-hose flexible pipe connectors in steel compressed-air piping.

3.08 SPECIALTY INSTALLATION

- A. Install safety valves on receivers in quantity and size to relieve at least the capacity of connected air compressors.
- B. Install air-main pressure regulators in compressed-air piping at or near air compressors.
- C. Install air-line pressure regulators in branch piping to equipment and tools.
- D. Install automatic drain valves on aftercoolers, receivers, and dryers. Discharge condensate onto nearest floor drain.
- E. Install air-line lubricators in branch piping to machine tools.
- F. Install quick couplings at piping terminals for hose connections.
- G. Install hose assemblies at hose connections.

3.09 CONNECTIONS

- A. Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment and machine.

3.10 SLEEVE INSTALLATION

- A. Sleeves are not required for core-drilled holes.
- B. Permanent sleeves are not required for holes formed by removable PE sleeves.
- C. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs using galvanized-steel pipe.
- D. Install sleeves for pipes passing through concrete and masonry walls, gypsum board partitions, and concrete floor and roof slabs.
 - 1. Wall Penetrations: Cut sleeves to length for mounting flush with both surfaces.
 - 2. Floor Penetrations: Extend sleeves installed in floors of mechanical equipment areas or other wet areas 2 inches above finished floor level. Extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
- E. Install sleeves in new walls and slabs as new walls and slabs are constructed.

- F. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - 1. Steel Pipe Sleeves: For pipes smaller than NPS 6.
 - 2. Stack Sleeve Fittings: For pipes penetrating floors with membrane waterproofing. Secure flashing between clamping flanges. Install section of cast-iron soil pipe to extend sleeve to 2 inches above finished floor level. Comply with requirements in Division 07 Section "Sheet Metal Flashing and Trim" for flashing.
 - a. Seal space outside of sleeve fittings with grout.
- G. 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 in Division 07 Section "Penetration Firestopping."

3.11 ESCUTCHEON INSTALLATION

- A. Install escutcheons for penetrations of walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern.
 - b. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One piece, **cast** brass with polished chrome-plated finish.
 - c. Bare Piping at Ceiling Penetrations in Finished Spaces: Split casting, cast brass with polished chrome-plated finish.
 - d. Bare Piping in Unfinished Service Spaces: One piece, cast brass with polished chrome-plated finish.
 - e. Bare Piping in Equipment Rooms: One-piece, stamped steel with setscrew or spring clips.
 - f. Bare Piping at Floor Penetrations in Equipment Rooms: One-piece floor plate.

3.12 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.
- B. Vertical Piping: MSS Type 8 or 42, clamps.
- C. Individual, Straight, Horizontal Piping Runs:
 - 1. 100 feet and less: MSS Type 1, adjustable, steel, clevis hangers.
 - 2. Longer than 100 Feet: MSS Type 43, adjustable, roller hangers.
- D. Multiple, Straight, Horizontal Piping Runs 100 Feet or Longer: MSS Type 44, pipe rolls. Support pipe rolls on trapeze. Comply with requirements in Division 22 Section 22 0529 "Hangers and Supports for Plumbing Piping and Equipment" for trapeze hangers.
- E. Base of Vertical Piping: MSS Type 52, spring hangers.
- F. Support horizontal piping within 12 inches of each fitting and coupling.
- G. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

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

1. NPS 1/4: 60 inches with 3/8-inch rod.
2. NPS 3/8 and NPS 1/2: 72 inches with 3/8-inch rod.
3. NPS 3/4: 84 inches with 3/8-inch rod.
4. NPS 1: 96 inches with 3/8-inch rod.
5. NPS 1-1/4: 108 inches with 3/8-inch rod.
6. NPS 1-1/2: 10 feet with 3/8-inch rod.
7. NPS 2: 11 feet with 3/8-inch rod.
8. NPS 2-1/2: 13 feet with 1/2-inch rod.
9. NPS 3: 14 feet with 1/2-inch rod.

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

3.13 LABELING AND IDENTIFICATION

- A. Install identifying labels and devices for nonmedical laboratory compressed-air piping, valves, and specialties. Comply with requirements in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment."
- B. Install identifying labels and devices for medical compressed air piping systems according to NFPA 99. Use the following or similar captions and color-coding for piping products where required by NFPA 99:
1. Medical Laboratory Air: Black letters on yellow-and-white checkerboard background.

3.14 FIELD QUALITY CONTROL FOR COMPRESSED-AIR PIPING IN NONMEDICAL LABORATORY FACILITIES

- A. Testing Agency: Engage qualified testing agency to perform field tests and inspections of compressed air piping in nonmedical laboratory facilities and prepare test reports.
- B. Perform tests and inspections of compressed-air piping in nonmedical laboratory facilities and prepare test reports.
- C. Tests and Inspections:
1. Piping Leak Tests for Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
 2. Repair leaks and retest until no leaks exist.
 3. Inspect filters and pressure regulators for proper operation.

3.15 DEMONSTRATION

- A. Engage factory-authorized service representative to train Client Agency's maintenance personnel to adjust, operate, and maintain medical compressed-air alarm systems. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 1513

SECTION 22 1519 - GENERAL - SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

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. Section Includes:
 - 1. Air-cooled, compressed-air aftercoolers.
 - 2. Refrigerant compressed-air dryers.
 - 3. Desiccant compressed-air dryers.
 - 4. Computer interface cabinet.

1.03 DEFINITIONS

- A. Actual Air: Air delivered from air compressors. Flow rate is delivered compressed air measured in ACFM.
- B. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling power-limited circuits.
- C. Standard Air: Free air at 68°F and 1 atmosphere before compression or expansion and measured in SCFM.

1.04 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design compressed-air equipment mounting, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Seismic Performance: Compressed-air equipment shall withstand the effects of earthquake motions determined according to **SEI/ASCE 7**
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified"

1.05 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

- B. Delegated-Design Submittal: For compressed-air equipment mounting indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of supports.
 - 2. Design Calculations: Calculate requirements for selecting vibration isolators and for designing vibration isolation bases.
- C. Seismic Qualification Certificates: For compressed-air equipment, accessories, and components, from manufacturers.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Operation and Maintenance Data: For compressed-air equipment to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASME Compliance: Fabricate and label receivers to comply with ASME Boiler and Pressure Vessel Code.

1.07 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.

1.08 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Air-Compressor, Inlet-Air-Filter Elements: Equal to 10 percent of amount installed.
 - 2. Belts: Two for each belt-driven compressor.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PACKAGED AIR COMPRESSORS AND RECEIVERS

- A. General Description: Factory-assembled, -wired, -piped, and -tested; electric-motor-driven; air-cooled; continuous-duty air compressors and receivers that deliver air of quality equal to intake air.

- B. Control Panels: Automatic control station with load control and protection functions. Comply with NEMA ICS 2 and UL 508.
1. Enclosure: NEMA ICS 6, Type 12 control panel unless otherwise indicated.
 2. Motor Controllers: Full-voltage, combination magnetic type with undervoltage release feature and motor-circuit-protector-type disconnecting means and short-circuit protective device.
 3. Control Voltage: 120-V ac or less, using integral control power transformer.
 4. Motor Overload Protection: Overload relay in each phase.
 5. Starting Devices: Hand-off-automatic selector switch in cover of control panel, plus pilot device for automatic control.
 6. Automatic control switches to air compressors.
 7. Instrumentation: Include discharge-air pressure gauge, air-filter maintenance indicator, hour meter, compressor discharge-air and coolant temperature gauges, and control transformer.
 8. Alarm Signal Device: For connection to alarm system to indicate when backup air compressor is operating.
 9. Provide auxiliary relay for control of associated air compressor equipment
 10. Provide an adjustable time-delay relay to eliminate nuisance tripping when momentary loss of power occurs.
- C. Receivers: Steel tank constructed according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
1. Pressure Rating: At least as high as highest discharge pressure of connected compressors, and bearing appropriate code symbols.
 2. Interior Finish: Corrosion-resistant coating.
 3. Accessories: Include safety valve, pressure gauge, drain, and pressure-reducing valve.
- D. Mounting Frame: Fabricate mounting and attachment to pressure vessel with reinforcement strong enough to resist packaged equipment movement during a seismic event when base is anchored to building structure.

2.02 LUBRICATED, RECIPROCATING AIR COMPRESSORS

- A. Basis-of-Design Product - subject to compliance with requirements, provide or comparable product by one of the following:
1. Ingersoll-Rand; Air Solutions Group.
 2. Gardner Denver, Inc.
 3. General Air Products, Inc.
- B. Compressor(s): Lubricated, reciprocating-piston type with lubricated compression chamber and crankcase.
1. Submerged gear-type oil pump.
 2. Oil filter.
 3. Combined high discharge-air temperature and low lubrication-oil pressure switch.
 4. Belt guard totally enclosing pulleys and belts.
- C. Capacities and Characteristics:
1. Air Compressor(s): Two stage.
 - a. Intercooler between stages of two-stage units.
 2. Discharge-Air Pressure: 100 psig
 3. Mounting: Tank mounted.
 4. Motor (Each Air Compressor):
 - a. Horsepower: 25
 - b. Speed: 550 rpm.

5. Unit Electrical Characteristics:
 - a. Volts: 208
 - b. Phase(s): Three
 - c. Hertz: 60 Hz.
 - d. KW: 18.6
6. Receiver: ASME construction steel tank.
 - a. Arrangement: Horizontal
 - b. Capacity: 240 gal.
 - c. Interior Finish: Steel
 - d. Pressure Rating: 150 psig minimum.
 - e. Drain: Automatic valve.

2.03 INLET-AIR FILTERS

- A. Description: Combination inlet-air filter-silencer, suitable for remote installation, for each air compressor.
 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 2. Capacity: Match capacity of air compressor, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.
- B. Description: Combination inlet-air filter-silencer, suitable for remote installation, for multiple air compressors.
 1. Construction: Weatherproof housing for replaceable, dry-type filter element, with silencer tubes or other method of sound reduction.
 2. Capacity: Match total capacity of connected air compressors, with filter having collection efficiency of 99 percent retention of particles larger than 10 micrometers.

2.04 REFRIGERANT COMPRESSED AIR DRYERS

- A. Basis-of-Design Product - subject to compliance with requirements, provide or comparable product by one of the following:
 1. Ingersoll-Rand; Air Solutions Group
 2. Hankison International
 3. Wilkerson Operations; Pneumatic Division
- B. Description: Noncycling, air-cooled, electric-motor-driven unit with steel enclosure and capability to deliver 35°F, 100-psig air at dew point. Include automatic ejection of condensate from airstream, step-down transformers, disconnect switches, inlet and outlet pressure gauges, thermometers, automatic controls, and filters.
- C. Capacities and Characteristics:
 1. Standard-Air Capacity of Each Compressed-Air Dryer: 100 SCFM free air.
 2. Pressure: 203 psig
 3. Entering-Air Temperature: 100°F
 4. Ambient-Air Temperature: 100°F
 5. Maximum Air-Pressure Drop: 1.5 psig
 6. Motor Horsepower: 1.14

- 7. Electrical Characteristics:
 - a. Volts: 115
 - b. Phase: Single
 - c. Hertz: 60 Hz.
 - d. KW: 0.85

2.05 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 22 Section 22 0513 "Common Motor Requirements for Plumbing Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - 2. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in Division 26 Sections.

PART 3 - EXECUTION

3.01 EQUIPMENT INSTALLATION

- A. Equipment Mounting: Install air compressors **and air dryers** on concrete bases. Comply with requirements in Division 03 Section "**Cast-in-Place Concrete.**"
 - 1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to supported equipment.
- B. Install Ingersoll Rand 1heavy duty isolation pads arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
- C. Arrange equipment so controls and devices are accessible for servicing.
- D. Maintain manufacturer's recommended clearances for service and maintenance.
- E. Install the following devices on compressed-air equipment:
 - 1. Thermometer, Pressure Gauge, and Safety Valve: Install on each compressed-air receiver.
 - 2. Pressure Regulators: Install downstream from air compressors and dryers.
 - 3. Automatic Drain Valves: Install on aftercoolers, receivers, and dryers. Discharge condensate over nearest floor drain.

3.02 CONNECTIONS

- A. Comply with requirements for piping specified in Division 22 Section 22 1513 "General - Service Compressed Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.

3.03 IDENTIFICATION

- A. Identify general-service air compressors and components. Comply with requirements for identification specified in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment."

3.04 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check for lubricating oil in lubricated-type equipment.
 - 3. Check belt drives for proper tension.
 - 4. Verify that air-compressor inlet filters and piping are clear.
 - 5. Check for equipment vibration-control supports and flexible pipe connectors and verify that equipment is properly attached to substrate.
 - 6. Check safety valves for correct settings. Ensure that settings are higher than air-compressor discharge pressure but not higher than rating of system components.
 - 7. Check for proper seismic restraints.
 - 8. Drain receiver tanks.
 - 9. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 10. Test and adjust controls and safeties.

3.05 DEMONSTRATION

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

END OF SECTION 22 1519

SECTION 22 1616 - FACILITY NATURAL GAS PIPING

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. Section Includes:
 - 1. Pipes, tubes, and fittings.
 - 2. Piping specialties.
 - 3. Piping and tubing joining materials.
 - 4. Valves.
 - 5. Pressure regulators.
 - 6. Mechanical sleeve seals.
 - 7. Grout.
 - 8. Concrete bases.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

1.04 PERFORMANCE REQUIREMENTS

- A. Minimum Operating Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 100 psig minimum unless otherwise indicated.
 - 3. Minimum Operating Pressure of Service Meter: 5 psig
- B. Natural Gas System Pressure within Buildings: 0.5 psig or less.

1.05 SUBMITTALS

- A. Product data for each type of the following:
 - 1. Piping.
 - 2. Piping specialties.
 - 3. Valves. Include pressure rating, capacity, settings, and electrical connection data of selected models.
 - 4. Pressure regulators. Indicate pressure ratings and capacities.
 - 5. Dielectric fittings.
 - 6. Mechanical sleeve seals.
 - 7. Escutcheons.
- B. Coordination Drawings: Plans and details, drawn to scale, on which natural gas piping is shown and coordinated with other installations, using input from installers of the items involved.
- C. Site Survey: Plans, drawn to scale, on which natural gas piping is shown and coordinated with other services and utilities.
- D. Qualification Data: For qualified professional engineer.
- E. Welding certificates.
- F. Field quality control reports.
- G. Operation and Maintenance Data: For motorized gas valves, pressure regulators and service meters to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Steel Support Welding Qualifications: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Pipe Welding Qualifications: Qualify procedures and operators according to ASME Boiler and Pressure Vessel Code.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and dispose of liquids from existing natural gas piping according to requirements of authorities having jurisdiction.
- B. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- C. Store and handle pipes and tubes having factory applied protective coatings to avoid damaging coating, and protect from direct sunlight.
- D. Protect stored PE pipes and valves from direct sunlight.

1.08 PROJECT CONDITIONS

- A. Perform site survey, research public utility records, and verify existing utility locations. Contact utility locating service for area where Project is located.
- B. Interruption of Existing Natural gas Service: Do not interrupt natural gas service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide purging and startup of natural gas supply according to requirements indicated:
 - 1. Notify Architect, Construction Manager, or Owner no fewer than two days in advance of proposed interruption of natural gas service.
 - 2. Do not proceed with interruption of natural gas service without Architect's, Construction Manager's, or Owner's written permission.

1.09 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided.
- B. Coordinate requirements for access panels and doors for valves installed concealed behind finished surfaces. Comply with requirements in Division 08 Section "Access Doors and Frames."

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
 - 1. Malleable Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. Wrought Steel Welding Fittings: ASTM A 234/A 234M for butt welding and socket welding.
 - 3. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends.
 - 4. Forged Steel Flanges and Flanged Fittings: ASME B16.5, minimum Class 150, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - a. Material Group: 1.1.
 - b. End Connections: Threaded or butt welding to match pipe.
 - c. Lapped Face: Not permitted underground.
 - d. Gasket Materials: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - e. Bolts and Nuts: ASME B18.2.1, carbon steel aboveground and stainless-steel underground.
 - 5. Protective Coating for Underground Piping: Factory applied, three-layer coating of epoxy, adhesive, and PE.
 - a. Joint Cover Kits: Epoxy paint, adhesive, and heat shrink PE sleeves.
 - 6. Mechanical Couplings:
 - a. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1) Dresser Piping Specialties; Division of Dresser, Inc.
 - 2) Smith-Blair, Inc.
 - b. Steel flanges and tube with epoxy finish.
 - c. Buna-nitrile seals.
 - d. Steel bolts, washers, and nuts.

- e. Coupling shall be capable of joining PE pipe to PE pipe, steel pipe to PE pipe, or steel pipe to steel pipe.
- f. Steel body couplings installed underground on plastic pipe shall be factory equipped with anode.

2.02 PIPING SPECIALTIES

- A. Appliance Flexible Connectors:
 - 1. Indoor, Fixed Appliance Flexible Connectors: Comply with ANSI Z21.24.
 - 2. Indoor, Movable Appliance Flexible Connectors: Comply with ANSI Z21.69.
 - 3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
 - 4. Operating Pressure Rating: 0.5 psig.
 - 5. End Fittings: Zinc-coated steel.
 - 6. Threaded Ends: Comply with ASME B1.20.1.
 - 7. Maximum Length: 72 inches.
- B. Quick Disconnect Devices: Comply with ANSI Z21.41.
 - 1. Copper-alloy convenience outlet and matching plug connector.
 - 2. Nitrile seals.
 - 3. Hand operated with automatic shutoff when disconnected.
 - 4. For indoor or outdoor applications.
 - 5. Adjustable, retractable restraining cable.
- C. 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 (DN 50) and smaller; flanged ends for NPS 2-1/2 (DN 65) and larger.
 - 3. Strainer Screen: 40-mesh startup strainer, and perforated stainless steel basket with 50 percent free area.
 - 4. CWP Rating: 125 psig.
- D. Weatherproof Vent Cap: Cast or malleable iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

2.03 JOINING MATERIALS

- A. Joint Compound: Suitable for natural gas.
- B. 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.
- C. Brazing Filler Metals: Alloy with melting point greater than 1000°F complying with AWS A5.8/A5.8M. Brazing alloys containing more than 0.05 percent phosphorus are prohibited.

2.04 MANUAL GAS SHUTOFF VALVES

- A. General Requirements for Metallic Valves, NPS 2 and Smaller: Comply with ASME B16.33.
 - 1. CWP Rating: 125 psig.
 - 2. Threaded Ends: Comply with ASME B1.20.1.

3. Dry seal Threads on Flare Ends: Comply with ASME B1.20.3.
 4. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 5. Listing: Listed and labeled by an NRTL acceptable to authorities having jurisdiction for valves 1 inch and smaller.
 6. Service Mark: Valves 1-1/4 inches to NPS 2 shall have initials "WOG" permanently marked on valve body.
- B. General Requirements for Metallic Valves, NPS 2-1/2 (DN 65) and Larger: Comply with ASME B16.38.
1. CWP Rating: 125 psig.
 2. Flanged Ends: Comply with ASME B16.5 for steel flanges.
 3. Tamperproof Feature: Locking feature for valves indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 4. Service Mark: Initials "WOG" shall be permanently marked on valve body.
- C. One-Piece, Bronze Ball Valve with Bronze Trim: MSS SP-110.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. BrassCraft Manufacturing Company; a Masco company.
 - b. Conbraco Industries, Inc.; Apollo Division
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Company
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 2. Body: Bronze, complying with ASTM B 584.
 3. Ball: Chrome plated brass.
 4. Stem: Bronze; blowout proof.
 5. Seats: Reinforced TFE; blowout proof.
 6. Packing: Separate pack nut with adjustable-stem packing threaded ends.
 7. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 8. CWP Rating: 600 psig.
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural gas service with "WOG" indicated on valve body.
 11. Ends: Threaded, flared, or socket as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 12. CWP Rating: 600 psig.
- D. Bronze Plug Valves: MSS SP-78.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Lee Brass Company
 - b. McDonald, A. Y. Mfg. Company
 2. Body: Bronze, complying with ASTM B 584.
 3. Plug: Bronze.
 4. Ends: Threaded, socket, or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 5. Operator: Square head or lug type with tamperproof feature where indicated.
 6. Pressure Class: 125 psig.
 7. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 8. Service: Suitable for natural gas service with "WOG" indicated on valve body.

- E. Cast Iron, Non-lubricated Plug Valves: MSS SP-78.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. McDonald, A. Y. Mfg. Company
 - b. Mueller Co.; Gas Products Division
 - c. Xomox Corporation; a Crane company.
 2. Body: Cast iron, complying with ASTM A 126, Class B.
 3. Plug: Bronze or nickel-plated cast iron.
 4. Seat: Coated with thermoplastic.
 5. Stem Seal: Compatible with natural gas.
 6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 7. Operator: Square head or lug type with tamperproof feature where indicated.
 8. Pressure Class: 125 psig.
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural gas service with "WOG" indicated on valve body.
- F. Cast Iron, Lubricated Plug Valves: MSS SP-78.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Flowserve.
 - b. Homestead Valve; a division of Olson Technologies, Inc.
 - c. McDonald, A. Y. Mfg. Company
 - d. Milliken Valve Company
 - e. Mueller Co.; Gas Products Division
 - f. R&M Energy Systems, A Unit of Robbins & Myers, Inc.
 2. Body: Cast iron, complying with ASTM A 126, Class B.
 3. Plug: Bronze or nickel-plated cast iron.
 4. Seat: Coated with thermoplastic.
 5. Stem Seal: Compatible with natural gas.
 6. Ends: Threaded or flanged as indicated in "Underground Manual Gas Shutoff Valve Schedule" and "Aboveground Manual Gas Shutoff Valve Schedule" articles.
 7. Operator: Square head or lug type with tamperproof feature where indicated.
 8. Pressure Class: 125 psig.
 9. Listing: Valves NPS 1 (DN 25) and smaller shall be listed and labeled by an NRTL acceptable to authorities having jurisdiction.
 10. Service: Suitable for natural gas service with "WOG" indicated on valve body.

2.05 MOTORIZED GAS VALVES

- A. Automatic Gas Valves: Comply with ANSI Z21.21.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. ASCO Power Technologies, LP; Division of Emerson
 - b. Dungs, Karl, Inc.
 - c. Eaton Corporation; Controls Division
 - d. Eclipse Combustion, Inc.
 - e. Honeywell International Inc.
 - f. Johnson Controls

2. Body: Brass or aluminum.
3. Seats and Disc: Nitrile rubber.
4. Springs and Valve Trim: Stainless steel.
5. Normally closed.
6. Visual position indicator.
7. Electrical operator for actuation by appliance automatic shutoff device.

B. Electrically Operated Valves: Comply with UL 429.

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. ASCO Power Technologies, LP; Division of Emerson.
 - b. Dungs, Karl, Inc.
 - c. Eclipse Combustion, Inc.
 - d. Goyen Valve Corp.; Tyco Environmental Systems.
 - e. Magnatrol Valve Corporation.
 - f. Parker Hannifin Corporation; Climate & Industrial Controls Group; Skinner Valve Division
 - g. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
2. Pilot operated.
3. Body: Brass or aluminum.
4. Seats and Disc: Nitrile rubber.
5. Springs and Valve Trim: Stainless steel.
6. 120-V ac, 60 Hz, Class B, continuous-duty molded coil, and replaceable.
7. NEMA ICS 6, Type 4, coil enclosure.
8. Normally closed.
9. Visual position indicator.

2.06 PRESSURE REGULATORS

A. General Requirements

1. Single stage and suitable for natural gas.
2. Steel jacket and corrosion-resistant components.
3. Elevation compensator.
4. End Connections: Threaded for regulators NPS 2 (DN 50) and smaller; flanged for regulators NPS 2-1/2 (DN 65) and larger.

B. Line Pressure Regulators: Comply with ANSI Z21.80.

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Actaris
 - b. American Meter Company
 - c. Eclipse Combustion, Inc.
 - d. Fisher Control Valves and Regulators; Division of Emerson Process Management
 - e. Invensys
 - f. Maxitrol Company
 - g. Richards Industries; Jordan Valve Division
2. Body and Diaphragm Case: Cast iron or die-cast aluminum.
3. Springs: Zinc plated steel; interchangeable.
4. Diaphragm Plate: Zinc plated steel.
5. Seat Disc: Nitrile rubber resistant to gas impurities, abrasion, and deformation at the valve port.
6. Orifice: Aluminum; interchangeable.
7. Seal Plug: Ultraviolet stabilized, mineral-filled nylon.

8. Single-port, self-contained regulator with orifice no larger than required at maximum pressure inlet, and no pressure sensing piping external to the regulator.
9. Pressure regulator shall maintain discharge pressure setting downstream, and not exceed 150 percent of design discharge pressure at shutoff.
10. Overpressure Protection Device: Factory mounted on pressure regulator.
11. Atmospheric Vent: Factory or field installed, stainless steel screen in opening if not connected to vent piping.
12. Maximum Inlet Pressure: 2 psig.

C. Appliance Pressure Regulators: Comply with ANSI Z21.18.

1. Manufacturers - subject to compliance with requirements, **provide products by one of the following:**
 - a. Canadian Meter Company Inc.
 - b. Eaton Corporation; Controls Division
 - c. Harper Wyman Company
 - d. Maxitrol Company
 - e. SCP, Inc.
2. Body and Diaphragm Case: Die-cast aluminum.
3. Springs: Zinc plated steel; interchangeable.
4. Diaphragm Plate: Zinc plated steel.
5. Seat Disc: Nitrile rubber.
6. Seal Plug: Ultraviolet stabilized, mineral filled nylon.
7. Factory Applied Finish: Minimum three-layer polyester and polyurethane paint finish.
8. Regulator may include vent limiting device, instead of vent connection, if approved by authorities having jurisdiction.
9. Maximum Inlet Pressure: 1 psig.

2.07 DIELECTRIC FITTINGS

A. Dielectric Unions

1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Hart Industries International, Inc.
 - d. McDonald, A. Y. Mfg. Company
 - e. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - f. Wilkins; Zurn Plumbing Products Group
2. Minimum Operating Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

B. Dielectric Flanges

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Capitol Manufacturing Company
 - b. Central Plastics Company
 - c. Watts Regulator Co.; Division of Watts Water Technologies, Inc.
 - d. Wilkins; Zurn Plumbing Products Group

2. Minimum Operating Pressure Rating: 150 psig.
3. Combination fitting of copper alloy and ferrous materials.
4. Insulating materials suitable for natural gas.
5. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

C. Dielectric Flange Kits

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico Inc.
 - c. Central Plastics Company
 - d. Pipeline Seal and Insulator, Inc.
2. Minimum Operating Pressure Rating: 150 psig.
3. Companion flange assembly for field assembly.
4. Include flanges, full-face or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
5. Insulating materials suitable for natural gas.
6. Combination fitting of copper alloy and ferrous materials with threaded, brazed-joint, plain, or welded end connections that match piping system materials.

2.08 SLEEVES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.
- B. Cast iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

2.09 MECHANICAL SLEEVE SEALS

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

2.10 ESCUTCHEONS

- A. General Requirements for Escutcheons: Manufactured wall and ceiling escutcheons and floor plates, with ID to fit around pipe or tube, and OD that completely covers opening.

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

2.11 GROUT

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

2.12 LABELING AND IDENTIFYING

- A. Detectable Warning Tape: Acid and alkali-resistant, PE film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches wide and 4 mils thick, continuously inscribed with a description of utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches deep; colored yellow.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine roughing-in for natural gas piping system to verify actual locations of piping connections before equipment installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.

- B. Inspect natural gas piping according to NFPA 54 and the International Fuel Gas Code to determine that natural gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 and the International Fuel Gas Code requirements for prevention of accidental ignition.

3.03 OUTDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural gas piping.
- B. Install underground, natural gas piping buried at least 36 inches below finished grade. Comply with requirements in Division 31 Section "Earth Moving" for excavating, trenching, and backfilling.
 - 1. If natural gas piping is installed less than 36 inches below finished grade, install it in containment conduit.
- C. Steel Piping with Protective Coating:
 - 1. Apply joint cover kits to pipe after joining to cover, seal, and protect joints.
 - 2. Repair damage to PE coating on pipe as recommended in writing by protective coating manufacturer.
 - 3. Replace pipe having damaged PE coating with new pipe.
- D. Install fittings for changes in direction and branch connections.
- E. Aboveground, Exterior Wall Pipe Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves smaller than 6 inches in diameter.
 - 2. Install cast iron "wall pipes" for sleeves 6 inches and larger in diameter.
- F. Mechanical Sleeve Seal Installation: Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble mechanical sleeve seals and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.
- G. Install pressure gauge upstream and downstream from each service regulator. Pressure gauges are specified in Division 23 Section 22 0519 "Meters and Gauges for HVAC Piping."

3.04 INDOOR PIPING INSTALLATION

- A. Comply with NFPA 54 and the International Fuel Gas Code for installation and purging of natural gas piping.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements are used to size pipe and calculate friction loss, expansion, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Arrange for pipe spaces, chases, slots, sleeves, and openings in building structure during progress of construction, to allow for mechanical installations.
- D. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
- E. 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.

- F. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- G. Locate valves for easy access.
- H. Install natural gas piping at uniform grade of 2 percent down toward drip and sediment traps.
- I. Install piping free of sags and bends.
- J. Install fittings for changes in direction and branch connections.
- K. Install escutcheons at penetrations of interior walls, ceilings, and floors.
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep pattern type.
 - b. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass type with polished chrome plated finish.
 - c. Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, stamped-steel type.
 - d. Piping at Ceiling Penetrations in Finished Spaces: One-piece or split-casting, cast brass type with polished chrome plated finish.
 - e. Piping at Ceiling Penetrations in Finished Spaces: One-piece, stamped-steel type or split-plate, stamped-steel type with concealed hinge and set screw.
 - f. Piping in Unfinished Service Spaces: One-piece, cast brass type with rough-brass finish.
 - g. Piping in Unfinished Service Spaces: One-piece, stamped-steel type with setscrew or spring clips.
 - h. Piping in Equipment Rooms: One-piece, cast brass type.
 - i. Piping in Equipment Rooms: One-piece, stamped-steel type with setscrew or spring clips.
 - j. Piping at Floor Penetrations in Equipment Rooms: One-piece, floor plate type.
- L. 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 in Division 07 Section "Penetration Firestopping."
- M. Verify final equipment locations for roughing-in.
- N. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- O. Drips and Sediment Traps: Install drips at points where condensate may collect, including service meter outlets. Locate where accessible to permit cleaning and emptying. Do not install where condensate is subject to freezing.
 - 1. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use nipple a minimum length of 3 pipe diameters, but not less than 3 inches long and same size as connected pipe. Install with space below bottom of drip to remove plug or cap.
- P. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- Q. Conceal pipe installations in walls, pipe spaces, utility spaces, above ceilings, below grade or floors, and in floor channels unless indicated to be exposed to view.
- R. Concealed Location Installations: Except as specified below, install concealed natural gas piping and piping installed under the building in containment conduit constructed of steel pipe with welded joints as described in Part 2. Install a vent pipe from containment conduit to outdoors and terminate with weatherproof vent cap.
 - 1. Above Accessible Ceilings: Natural gas piping, fittings, valves, and regulators may be installed in accessible spaces without containment conduit.

2. In Floors: Install natural gas piping with welded or brazed joints and protective coating in cast-in-place concrete floors. Cover piping to be cast in concrete slabs with minimum of 1-1/2 inches of concrete. Piping may not be in physical contact with other metallic structures such as reinforcing rods or electrically neutral conductors. Do not embed piping in concrete slabs containing quick-set additives or cinder aggregate.
 3. In Floor Channels: Install natural gas piping in floor channels. Channels must have cover and be open to space above cover for ventilation.
 4. In Walls or Partitions: Protect tubing installed inside partitions or hollow walls from physical damage using steel striker barriers at rigid supports.
 - a. Exception: Tubing passing through partitions or walls does not require striker barriers.
 5. Prohibited Locations:
 - a. Do not install natural gas piping in or through circulating air ducts, clothes or trash chutes, chimneys or gas vents (flues), ventilating ducts, or dumbwaiter or elevator shafts.
 - b. Do not install natural gas piping in solid walls or partitions.
- S. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
- T. Connect branch piping from top or side of horizontal piping.
- U. Install unions in pipes NPS 2 (DN 50) and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
- V. Do not use natural gas piping as grounding electrode.
- W. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
- X. Install pressure gauge upstream and downstream from each line regulator. Pressure gauges are specified in Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping."

3.05 VALVE INSTALLATION

- A. Install underground valves with valve boxes.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.

3.06 PIPING JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Threaded Joints:
 1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
 2. Cut threads full and clean using sharp dies.
 3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
 4. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

- D. Welded Joints:
 - 1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
 - 2. Bevel plain ends of steel pipe.
 - 3. Patch factory applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.
- F. Flanged Joints: Install gasket material, size, type, and thickness appropriate for natural gas service. Install gasket concentrically positioned.
- G. Flared Joints: Cut tubing with roll cutting tool. Flare tube end with tool to result in flare dimensions complying with SAE J513. Tighten finger tight, then use wrench. Do not overtighten.

3.07 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1 (DN 25) and Smaller: Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 2. NPS 1-1/4 (DN 32): Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/2 and NPS 2 (DN 40 and DN 50): Maximum span, 108 inches; minimum rod size, 3/8 inch.
 - 4. NPS 2-1/2 to NPS 3-1/2 (DN 65 to DN 90): Maximum span, 10 feet; minimum rod size, 1/2 inch.
 - 5. NPS 4 (DN 100) and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.
- C. Install hangers for horizontal, corrugated stainless steel tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 3/8 (DN 10): Maximum span, 48 inches; minimum rod size, 3/8 inch.
 - 2. NPS 1/2 (DN 15): Maximum span, 72 inches; minimum rod size, 3/8 inch.
 - 3. NPS 3/4 (DN 20) and larger: Maximum span, 96 inches; minimum rod size, 3/8 inch.

3.08 CONNECTIONS

- A. Connect to utility's gas main according to utility's procedures and requirements.
- B. Install natural gas piping electrically continuous, and bonded to gas appliance equipment grounding conductor of the circuit powering the appliance according to NFPA 70.
- C. Install piping adjacent to appliances to allow service and maintenance of appliances.
- D. Connect piping to appliances using manual gas shutoff valves and unions. Install valve within 72 inches of each gas-fired appliance and equipment. Install union between valve and appliances or equipment.
- E. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.09 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 22 Section 22 0553 "Identification for Plumbing Piping and Equipment" for piping and valve identification.
- B. Install detectable warning tape directly above gas piping, 12 inches below finished grade, except 6 inches below subgrade under pavements and slabs.

3.10 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural gas piping.
- B. Paint exposed, exterior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel gloss.
 - d. Color: Yellow.
- C. Paint exposed, interior metal piping, valves, service regulators, service meters and meter bars, earthquake valves, and piping specialties, except components, with factory applied paint or protective coating.
 - 1. Latex over Alkyd Primer System: MPI INT 5.1Q.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior latex matching topcoat.
 - c. Topcoat: Interior latex gloss.
 - d. Color: Yellow.
 - 2. Alkyd System: MPI INT 5.1E.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Interior alkyd matching topcoat.
 - c. Topcoat: Interior alkyd gloss.
 - d. Color: Yellow.
- D. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.11 CONCRETE BASES

- A. Concrete Bases: Anchor equipment to concrete base.
 - 1. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit.
 - 2. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch centers around the full perimeter of the base.
 - 3. Install epoxy coated anchor bolts for supported equipment that extend through concrete base, and anchor into structural concrete floor.
 - 4. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 5. Install anchor bolts to elevations required for proper attachment to supported equipment.

3.12 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Test, inspect, and purge natural gas according to NFPA 54 and the International Fuel Gas Code and authorities having jurisdiction.
- C. Natural gas piping will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.13 DEMONSTRATION

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

3.14 OUTDOOR PIPING SCHEDULE

- A. Underground natural gas piping shall be one of the following:
 - 1. Steel pipe with wrought-steel fittings and welded joints, or mechanical couplings. Coat pipe and fittings with protective coating for steel piping.
- B. Aboveground natural gas piping shall be the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints.
 - 2. Steel pipe with wrought-steel fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.

3.15 INDOOR PIPING SCHEDULE FOR SYSTEM PRESSURES LESS THAN 0.5 PSIG

- A. Aboveground piping shall be one of the following:
 - 1. Steel pipe with malleable-iron fittings and threaded joints. (2" and smaller)
 - 2. Steel pipe with wrought-steel fittings and welded joints. (2 1/2" and larger)
- B. Underground, below building, piping shall be **one of** the following:
 - 1. Steel pipe with malleable iron fittings and threaded joints.
 - 2. Steel pipe with wrought steel fittings and welded joints.
- C. Containment Conduit: Steel pipe with wrought-steel fittings and welded joints. Coat pipe and fittings with protective coating for steel piping.
- D. Containment Conduit Vent Piping: Steel pipe with malleable iron fittings and threaded or wrought steel fittings with welded joints. Coat underground pipe and fittings with protective coating for steel piping.

3.16 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 (DN 50) and smaller at service meter shall be one of the following:
 - 1. One-piece, bronze ball valve with bronze trim.
 - 2. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 (DN 65) and larger at service meter shall be one of the following:
 - 1. Bronze plug valve.
 - 2. Cast iron, non-lubricated plug valve.
- C. Distribution piping valves for pipe sizes NPS 2 (DN 50) and smaller shall be one of the following:
 - 1. One-piece, bronze ball valve with bronze trim.
 - 2. Bronze plug valve.
- D. Distribution piping valves for pipe sizes NPS 2-1/2 (DN 65) and larger shall be one of the following:
 - 1. Bronze plug valve.
 - 2. Cast iron, non-lubricated or lubricated plug valve.
- E. Valves in branch piping for single appliance shall be the following:
 - 1. One-piece, bronze ball valve with bronze trim.
 - 2. Bronze plug valve.

END OF SECTION 22 1616

SECTION 22 3400 - FUEL FIRED DOMESTIC WATER HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following fuel fired water heaters:
 - 1. Commercial, high efficiency, storage, gas water heaters.
 - 2. Compression tanks.
 - 3. Water heater accessories.

1.03 SUBMITTALS

- A. Product Data: For each type and size of water heater indicated. Include rated capacities, operating characteristics, furnished specialties, and accessories.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Product Certificates: For each type of commercial and instantaneous water heater, signed by product manufacturer.
- D. Source quality control test reports.
- E. Field quality control test reports.
- F. Operation and Maintenance Data: For water heaters to include in emergency, operation, and maintenance manuals.
- G. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of water heaters and are based on the specific system indicated. Refer to Division 01 Section "Product Requirements."
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

- D. ASME Compliance:
 - 1. Where ASME code construction is indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.
 - 2. Where ASME code construction is indicated, fabricate and label commercial, finned-tube water heaters to comply with ASME Boiler and Pressure Vessel Code: Section IV.
- E. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9" for all components that will be in contact with potable water.

1.05 COORDINATION

- A. Coordinate size and location of concrete bases with Architectural and Structural Drawings.

1.06 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of fuel fired water heaters that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures including storage tank and supports.
 - b. Faulty operation of controls.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal use.
 - 2. Warranty Period(s): From date of Substantial Completion:
 - a. Commercial, Gas Water Heaters:
 - 1) Storage Tank: Five years.
 - 2) Controls and Other Components: Three years.
 - b. Compression Tanks: One year(s).

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

2.02 COMMERCIAL, GAS WATER HEATER DWH-1

- A. The WATER HEATER shall be a LOCHINVAR SHIELD Model SWA200N having a maximum input rating of 200,000 Btu/Hr, a recovery capacity of 232 gallons per hour at a 100°F rise and shall be operated on Natural Gas. The WATER HEATER shall be capable of full modulation firing down to 20% of rated input with a 5:1 turndown ratio. Check local and state codes for allowance of non-ASME models over 200,000 Btu/hr input.
 - 1. The WATER HEATER shall consist of a direct fired Stainless Steel heat exchanger mounted on top of a glass lined storage tank in a fashion that will reduce the amount of scale build-up that is known to reduce efficiency. The WATER HEATER shall have no visible pipes that connect the heat exchanger to the storage tank. There shall be no banding material, bolts, gaskets or "O" rings in the construction of the heat exchanger header. The stainless steel combustion chamber shall be designed to drain condensation to the bottom of the heat

exchanger assembly. A built-in trap shall allow condensation to drain from the heat exchanger assembly. The WATER HEATER shall carry a three (3) year heat exchanger and tank warranty and a one (1) year parts warranty.

2. Specified "SNA" SHIELD WATER HEATERS shall bear the ASME "HLW" stamp and shall be National Board listed. The tank shall have a working pressure of 150 psi. The tank shall be glass lined and fired to 1600°F to ensure a molecular fusing of glass and steel. The tank shall be completely encased in high density insulation of sufficient thickness to meet the energy efficiency requirements of the latest edition of the ASHRAE 90.1 Standard. The tank shall be fitted with a brass drain valve.
3. The WATER HEATER shall be certified and listed by C.S.A. International under the latest edition of the harmonized ANSI Z21.10.3 test standard for the US and Canada. The WATER HEATER shall comply with the energy efficiency requirements of the latest edition of the ASHRAE 90.1 standard. The WATER HEATER shall be certified for indoor installation. The WATER HEATER's efficiency shall be verified through third party testing by AHRI and listed in the AHRI Certification Directory.
4. The WATER HEATER shall be constructed with a heavy gauge steel jacket assembly, primed and pre-painted on both sides. The combustion chamber shall be sealed and completely enclosed, independent of the outer jacket assembly, so that integrity of the outer jacket does not affect a proper seal. A burner/flame observation port shall be provided. The burner shall be a premix design and constructed of high temperature stainless steel with a woven metal fiber outer covering to provide modulating firing rates. The WATER HEATER shall be supplied with a gas valve designed with negative pressure regulation and be equipped with a variable speed blower system, to precisely control the fuel/air mixture to provide modulating firing rates for maximum efficiency. The WATER HEATER shall operate in a safe condition at a de-rated output with gas supply pressures as low as 4 inches of water column.
5. The WATER HEATER shall utilize a 24 VAC control circuit and components. The control system shall have an electronic display for setup, status and diagnostics. All electronic circuitry shall be easily accessed and serviceable from the front of the jacket. The WATER HEATER shall be equipped with; a circulating pump; high limit temperature control; ASME certified temperature and pressure relief valve; inlet & outlet water temperature sensors; flue temperature sensor; runtime contacts; alarm contacts; low water flow protection, contacts for louvers, security protection, adjustable pump delay, enable/disable contacts and built-in freeze protection. The control shall have optional capability to communicate via Modbus or BACnet protocol and capability for optional CON-X-US remote connectivity. The manufacturer shall verify proper operation of the burner, all controls and the heat exchanger by connection to water and venting for a factory operation test prior to shipping.
6. The WATER HEATER shall feature the SMART CONTROL platform with pump delay, freeze protection, pump exercise and Start-Up Wizard operating with an LCD display and soft key pad. The WATER HEATER shall be equipped with an eight-foot power cord. Supply voltage shall be 120 volt / 60 hertz / single phase.
7. The WATER HEATER shall be installed and vented with a (select one):
 - a. Direct Vent Vertical system with a vertical roof top termination of both the vent and combustion air. The flue shall be PVC, CPVC, Polypropylene or Stainless Steel sealed vent material terminating at the roof top with the manufacturers specified vent termination. A separate pipe shall supply combustion air directly to the WATER HEATER from the outside. The air inlet pipe may be PVC, CPVC, Polypropylene, ABS, Galvanized, Dryer Vent, or Stainless Steel sealed pipe. The air inlet must terminate on the roof top with the manufacturer's specified air inlet cap. The total combined air intake length shall not exceed 150 equivalent feet. The total combined exhaust venting length shall not exceed 150 equivalent feet. **Foam Core pipe is not an approved material for exhaust piping.**
8. The WATER HEATER shall be approved for 180°F operation. The WATER HEATER shall have an independent laboratory rating for Oxides of Nitrogen (NOx) of 20 ppm or less, corrected to 3% O₂. The WATER HEATER shall operate at altitudes up to 4,500 feet above sea level without additional parts or adjustments.
9. The Firing Control System shall be M9, Direct Spark Ignition with Electronic Supervision.
10. Provide condensate drain kit.
11. Model SWA200N manufactured by Lochinvar Corporation.

2.03 COMMERCIAL, HIGH EFFICIENCY, GAS WATER HEATERS: DWH-2

- A. Manufacturers
 - 1. Lochinvar Corporation
 - 2. Smith, A. O. Water Products Company
 - 3. Bradford White Corporation
- B. Description: Manufacturer's proprietary design to provide at least 95 percent combustion efficiency at optimum operating conditions. Following features and attributes may be modified or omitted if water heater otherwise complies with requirements for performance.
- C. Storage tank Construction: ASME code steel with 150-psig minimum working-pressure rating.
 - 1. Tappings: Factory fabricated of materials compatible with tank. Attach tappings to tank before testing.
 - a. NPS 2 and Smaller: Threaded ends according to ASME B1.20.1.
 - b. NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel and stainless steel flanges, and according to ASME B16.24 for copper and copper alloy flanges.
 - 2. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - 3. Lining: Glass complying with NSF 61 barrier materials for potable-water tank linings, including extending lining into and through tank fittings and outlets.
 - 4. Factory installed, Storage tank Appurtenances:
 - a. Anode Rod: Replaceable magnesium.
 - b. Dip Tube: Provide unless cold water inlet is near bottom of tank.
 - c. Drain Valve: Corrosion-resistant metal complying with ASSE 1005.
 - d. Insulation: Comply with ASHRAE/IESNA 90.1. Surround entire storage tank except connections and controls.
 - e. Jacket: Steel with enameled finish.
 - f. Combination Temperature and Pressure Relief Valves: ANSI Z21.22/CSA 4.4. Include one or more relief valves with total relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select one relief valve with sensing element that extends into storage tank.
 - 5. Burner or Heat Exchanger: Comply with UL 795 or approved testing agency requirements for high-efficiency water heaters and for natural gas fuel.
 - 6. Temperature Control: Adjustable thermostat.
 - 7. Safety Controls: Automatic, high temperature limit and low water cutoff devices or systems.
 - 8. Energy Management System Interface: Normally closed dry contacts for enabling and disabling water heater.
 - 9. Draft Hood: Draft diverter; complying with ANSI Z21.12.
 - 10. Capacity and Characteristics:
 - a. Capacity: Refer to water heater schedule on drawings.
 - b. Recovery: Refer to water heater schedule on drawings.
 - c. Temperature Setting: 140°F.
 - d. Fuel Gas Demand: Refer to water heater schedule on drawings.
 - e. Fuel Gas Input: Refer to water heater schedule on drawings.
 - f. Gas Pressure Required at Burner: Refer to water heater schedule on drawings.
 - g. Minimum Vent Diameter: Refer to drawings
 - h. Provide condensate drain kit
 - i. Model SWN130-050 manufactured by Lochinvar Corporation

2.04 EXPANSION TANKS (ET)

- A. Description: Steel, pressure rated tank constructed with welded joints and factory installed, butyl-rubber diaphragm. Include air pre-charge to minimum system operating pressure at tank.
 - 1. Manufacturers:
 - a. AMTROL Inc.
 - b. Armstrong Pumps, Inc.
 - c. Smith, A. O.; Aqua-Air Division
 - d. State Industries, Inc.
 - e. Watts Regulator Company
 - f. Wessels Company
 - 2. Construction:
 - a. Tappings: Factory fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1 pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air Charging Valve: Factory installed.
 - 3. Capacity and Characteristics:
 - a. Refer to drawings

2.05 WATER HEATER ACCESSORIES

- A. Gas Shutoff Valves: ANSI Z21.15/CGA 9.1, manually operated. Furnish for installation in piping.
- B. Gas Pressure Regulators: ANSI Z21.18, appliance type. Include pressure rating, capacity, and pressure differential required between gas supply and water heater.
- C. Gas Automatic Valves: ANSI Z21.21, appliance, electrically operated, on-off automatic valve.
- D. Combination Temperature and Pressure Relief Valves: Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating. Select each relief valve with sensing element that extends into storage tank.
 - 1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
 - 2. Oil Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
- E. Pressure Relief Valves: Include pressure setting less than working-pressure rating of water heater.
 - 1. Gas Water Heaters: ANSI Z21.22/CSA 4.4.
 - 2. Oil Fired Water Heaters: ASME rated and stamped and complying with ASME PTC 25.3.
- F. Piping Manifold Kits: Water heater manufacturer's factory fabricated inlet and outlet piping arrangement for multiple-unit installation. Include piping and valves for field assembly that is capable of isolating each water heater and of providing balanced flow through each water heater.
- G. Piping Type Heat Traps: Field fabricated piping arrangement according to ASHRAE/IESNA 90.1 or ASHRAE 90.2.

2.06 SOURCE QUALITY CONTROL

- A. Test and inspect water heater storage tanks, specified to be ASME-code construction, according to ASME Boiler and Pressure Vessel Code.
- B. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.
- C. Prepare test reports.

PART 3 - EXECUTION

3.01 WATER HEATER INSTALLATION

- A. Install commercial water heaters on concrete bases.
 - 1. Exception: Omit concrete bases for commercial water heaters if installation on stand, bracket, suspended platform, or direct on floor is indicated.
 - 2. Concrete base construction requirements are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- B. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- C. Install gas water heaters according to NFPA 54.
- D. Install gas shutoff valves on gas supplies to gas water heaters without shutoff valves.
- E. Install gas pressure regulators on gas supplies to gas water heaters without gas pressure regulators if gas pressure regulators are required to reduce gas pressure at burner.
- F. Install automatic gas valves on gas supplies to gas water heaters, if required for operation of safety control.
- G. Install combination temperature and pressure relief valves in water piping for water heaters without storage. Extend commercial water heater relief valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- H. Install water heater drain piping as indirect waste to spill by positive air gap into open drains or over floor drains. Install hose end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section 22 1119 "Domestic Water Piping Specialties" for hose end drain valves.
- I. Install thermometer on outlet piping of water heaters. Refer to Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping" for thermometers.
- J. Install pressure gauge(s) on inlet and outlet piping of commercial, fuel fired water heater piping. Refer to Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping" for pressure gauges.

- K. Assemble and install inlet and outlet piping manifold kits for multiple water heaters. Fabricate, modify, or arrange manifolds for balanced water flow through each water heater. Include shutoff valve and thermometer in each water heater inlet and outlet, and throttling valve in each water heater outlet. Refer to Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping" for general-duty valves and to Division 22 Section 22 0519 "Meters and Gauges for Plumbing Piping" for thermometers.
- L. Install piping type heat traps on inlet and outlet piping of water heater storage tanks without integral or fitting-type heat traps.
- M. Support off the floor expansion tanks in accordance with manufacturer's installation instructions. Expansion tanks shall not be supported by the piping that connects to it.
- N. Fill water heaters with water.
- O. Charge compression tanks with air.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
- C. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust field assembled components and equipment installation, including connections, and to assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Leak Test: After installation, test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, confirm proper operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace water heaters that do not pass tests and inspections and retest as specified above.

3.04 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain commercial water heaters. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 22 3400

SECTION 22 4000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following conventional plumbing fixtures and related components:
 - 1. Water closets (Including flushometers, toilet seats and fixture supports).
 - 2. Lavatories (Including faucets, fixture supports, thermostatic mixing valves, and protective shielding guards).
 - 3. Sinks (Including faucets, thermostatic mixing valves, garbage disposals, and protective shielding guards).
 - 4. Showers (Including faucets).
 - 5. Mop basins (Including faucets and accessories).
 - 6. Washer Filler Assemblies
 - 7. Emergency Safety Station
- B. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in this section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.
- C. Related Sections include the following:
 - 1. Division 10 Section "Toilet, Bath, and Laundry Accessories."
 - 2. Division 22 Section 22 1119 "Domestic Water Piping Specialties" for backflow preventers and specialty fixtures not included in this Section.
 - 3. Division 22 Section 22 4700 "Drinking Fountains and Water Coolers."

1.03 DEFINITIONS

- A. ABS: Acrylonitrile-butadiene-styrene plastic.
- B. Accessible Fixture: Plumbing fixture that can be approached, entered, and used by people with disabilities.
- C. Cast Polymer: Cast filled polymer plastic material. This material includes cultured-marble and solid-surface materials.
- D. Cultured Marble: Cast filled polymer plastic material with surface coating.
- E. Fitting: Device that controls the flow of water into or out of the plumbing fixture. Fittings specified in this Section include supplies and stops, faucets and spouts, shower heads and tub spouts, drains and tailpieces, and traps and waste pipes. Piping and general-duty valves are included where indicated.
- F. FRP: Fiberglass reinforced plastic.

- G. PMMA: Polymethyl methacrylate (acrylic) plastic.
- H. PVC: Polyvinyl chloride plastic.
- I. Solid Surface: Nonporous, homogeneous, cast polymer plastic material with heat, impact, scratch, and stain resistance qualities.
- J. Standard-Efficiency Flush Volume: 1.6 gallons per flush.
- K. High-Efficiency Flush Volume: 1.28 gallons or less per flush.
- L. Water Sense Fixture: Water closet and/or flushometer valve/tank certified by the EPA to meet the Water Sense performance criteria.

1.04 SUBMITTALS

- A. Product Data: For each type of plumbing fixture indicated. Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports. Indicate materials and finishes, dimensions, construction details, and flow control rates.
- B. Shop Drawings: Diagram power, signal, and control wiring.
- C. Operation and Maintenance Data: For plumbing fixtures to include in emergency, operation, and maintenance manuals.
- D. Warranty: Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer.
 - 1. Exception: If fixtures, faucets, or other components are not available from a single manufacturer, obtain similar products from other manufacturers specified for that category.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" for plumbing fixtures for people with disabilities.
- D. Regulatory Requirements: Comply with requirements in Public Law 102-486, "Energy Policy Act," about water flow and consumption rates for plumbing fixtures.
- E. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- F. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.

- G. Comply with the following applicable standards and other requirements specified for plumbing fixtures:
1. Enameled, Cast iron Fixtures: ASME A112.19.1M.
 2. Plastic Laundry Trays: ANSI Z124.6.
 3. Plastic Mop Service Basins: ANSI Z124.6.
 4. Plastic Shower Enclosures: ANSI Z124.2.
 5. Porcelain Enameled, Formed Steel Fixtures: ASME A112.19.4M.
 6. Slip Resistant Bathing Surfaces: ASTM F 462.
 7. Solid Surface Material Lavatories and Sinks: ANSI/ICPA SS-1.
 8. Stainless steel Commercial, Handwash Sinks: NSF 2 construction.
 9. Stainless steel Residential Sinks: ASME A112.19.3.
 10. Vitreous China Fixtures: ASME A112.19.2M.
 11. Water closet, Flush Valve, Tank Trim: ASME A112.19.5.
 12. Water closet, Flushometer Tank Trim: ASSE 1037.
 13. Whirlpool Bathtub Fittings: ASME A112.19.8M.
- H. Comply with the following applicable standards and other requirements specified for lavatory and sink faucets:
1. Backflow Protection Devices for Faucets with Side Spray: ASME A112.18.3M.
 2. Backflow Protection Devices for Faucets with Hose thread Outlet: ASME A112.18.3M.
 3. Diverter Valves for Faucets with Hose Spray: ASSE 1025.
 4. Faucets: ASME A112.18.1.
 5. Hose connection Vacuum Breakers: ASSE 1011.
 6. Hose coupling Threads: ASME B1.20.7.
 7. Integral, Atmospheric Vacuum Breakers: ASSE 1001.
 8. NSF Potable water Materials: NSF 61.
 9. Pipe Threads: ASME B1.20.1.
 10. Sensor Actuated Faucets and Electrical Devices: UL 1951.
 11. Supply Fittings: ASME A112.18.1.
 12. Brass Waste Fittings: ASME A112.18.2.
- I. Comply with the following applicable standards and other requirements specified for bathtub/shower faucets:
1. Backflow Protection Devices for Hand held Showers: ASME A112.18.3M.
 2. Combination, Pressure equalizing and Thermostatic Control Anti-Scald Faucets: ASSE 1016.
 3. Deck mounted Bath/Shower Transfer Valves: ASME 18.7.
 4. Faucets: ASME A112.18.1.
 5. Hand held Showers: ASSE 1014.
 6. High temperature limit Controls for Thermal Shock Preventing Devices: ASTM F 445.
 7. Hose coupling Threads: ASME B1.20.7.
 8. Manual control Anti-scald Faucets: ASTM F 444.
 9. Pipe Threads: ASME B1.20.1.
 10. Pressure equalizing control Anti-scald Faucets: ASTM F 444 and ASSE 1016.
 11. Sensor Actuated Faucets and Electrical Devices: UL 1951.
 12. Thermostatic Control Anti-Scald Faucets: ASTM F 444 and ASSE 1016.
- J. Comply with the following applicable standards and other requirements specified for miscellaneous fittings:
1. Atmospheric Vacuum Breakers: ASSE 1001.
 2. Brass and Copper Supplies: ASME A112.18.1.
 3. Dishwasher Air Gap Fittings: ASSE 1021.
 4. Manual Operation Flushometers: ASSE 1037.
 5. Plastic Tubular Fittings: ASTM F 409.
 6. Brass Waste Fittings: ASME A112.18.2.
 7. Sensor Operation Flushometers: ASSE 1037 and UL 1951.

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

1. Disposers: ASSE 1008 and UL 430.
2. Dishwasher Air Gap Fittings: ASSE 1021.
3. Flexible Water Connectors: ASME A112.18.6.
4. Floor Drains: ASME A112.6.3.
5. Grab Bars: ASTM F 446.
6. Hose coupling Threads: ASME B1.20.7.
7. Hot Water Dispensers: ASSE 1023 and UL 499.
8. Off Floor Fixture Supports: ASME A112.6.1M.
9. Pipe Threads: ASME B1.20.1.
10. Plastic Shower Receptors: ANSI Z124.2.
11. Plastic Toilet Seats: ANSI Z124.5.
12. Supply and Drain Protective Shielding Guards: ICC A117.1.

1.06 EXTRA MATERIALS

A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents. Revise subparagraphs below to suit Project.

1. Faucet Washers and O-Rings:
2. Faucet Cartridges and O-Rings: Equal to 5 percent of amount of each type and size installed.
3. Flushometer Valve, Repair Kits: Equal to 10 percent of amount of each type installed, but no fewer than 12 of each type.
4. Provide hinged-top wood or metal box, or individual metal boxes, with separate compartments for each type and size of extra materials listed above.
5. Toilet Seats: Equal to 5 percent of amount of each type installed.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Subject to compliance with requirements, provide products by the list of acceptable manufacturers listed below.

B. Acceptable Manufacturers - Vitreous China Fixtures

1. American Standard Company, Inc.
2. Kohler Company
3. Sloan Valve Company

C. Acceptable Manufacturers - Stainless Steel Sinks

1. Elkay Manufacturing Company
2. Just Manufacturing Company
3. Advanced Tabco.
4. John Boos

D. Acceptable Manufacturers - Fixture Trim

1. American Standard Company, Inc.
2. Chicago Faucet Company

- E. Acceptable Manufacturers - Flush Valves
 - 1. American Standard
 - 2. Sloan Valve Company

- F. Acceptable Manufacturers - Water Closet Seats
 - 1. Beneke, Sanderson Plumbing Products Inc.
 - 2. Bemis Manufacturing Company
 - 3. Centoco Manufacturing
 - 4. Church, Bemis Manufacturing Company
 - 5. Olsonite, Bemis Manufacturing Company

- G. Acceptable Manufacturers - Fixture Carriers
 - 1. Josam Company
 - 2. Smith, Jay R. Manufacturing Company
 - 3. Tyler Pipe; Wade Division
 - 4. Watts Drainage Products Inc.
 - 5. Zurn Plumbing Products Group

- H. Acceptable Manufacturers - ASSE 1070 Thermostatic Valves
 - 1. Powers; a Watts Industries Company
 - 2. Symmons Industries, Inc.

- I. Acceptable Manufacturers - Pressure Balanced Mixing Valves
 - 1. Symmons Industries, Inc.

- J. Acceptable Manufacturers - Mop Basins:
 - 1. American Standard Company, Inc.
 - 2. Fiat Products
 - 3. Mustee, E.L & Sons, Inc.
 - 4. Stern Williams Company, Inc.

- K. Acceptable Manufactures: Emergency Safety Station
 - 1. Guardian Safety Products
 - 2. Bradley Corporation
 - 3. Haws Corporation

- L. Acceptable Manufacturers - Washer Filler Assemblies:
 - 1. Guy Gray, IPS Corporation
 - 2. Symmons Industries, Inc.
 - 3. Watts Industries, Inc.

2.02 WATER CLOSETS

- A. Water Closet (WC-1) Wall hung, Flush Valve, Standard Height:
 - 1. Bowl: ANSI A112.19.2; wall hung siphon jet, vitreous china, closet bowl with elongated rim, 1-1/2-inch top inlet spud, Model 2257.101 "Afwall Millennium FloWise" manufactured by American Standard.

2. Flush Valve (1.6 gpf - Manual): ANSI A112.18.1; exposed chrome plated, diaphragm type with oscillating, manual non-hold open handle, escutcheon, integral screwdriver stop and vacuum breaker, 1.6 gallons per flush; Model 111-1.6 "Royal" manufactured by Sloan Valve Company.
3. Seat (Open): elongated Solid white plastic, open front, extended back, self-sustaining check hinges, stainless steel posts, without cover; Model 95SSCT manufactured by Olsonite.
4. Wall Mounted Carrier: ANSI A112.6.1; adjustable cast iron frame, integral drain hub and vent, lugs for floor and wall attachment, threaded fixture studs with nuts and washers; Series Z1203 through Z1204 manufactured by Zurn Plumbing Products Group.

2.03 LAVATORIES

A. Lavatory (L-1) Wall hung, ADA Height:

1. Basin: ANSI A112.19.2: vitreous china, wall hung lavatory, 20-inch x 18 inch minimum, 4-inch-high back, drilling on (4" centers), rectangular basin with splash lip, front overflow, mounted at ADA height; Model 0355.012 (4" centers), "Lucerne" manufactured by American Standard.
2. Trim (0.5 gpm - manual with lever handles on 4" centers): ANSI A112.18.1; two handle, chrome plated center set faucet with conventional spout, lever handles on 4-inch centers, grid drain assembly with 1-1/4-inch tailpiece, washer less ceramic disc valve cartridges, 0.5 gpm vandal proof, non-aerating spray, chrome plated loose key angle stop valves and escutcheons, chrome plated 17-gauge brass P-trap with cleanout plug and arm with escutcheon. Model 802-VE2805ABCP manufactured by Chicago Faucet Company.
3. Wall Mounted Carrier: ANSI A112.6.1; cast iron and steel frame with tubular legs, lugs for floor and wall attachment, threaded studs for fixture hanger, concealed arm supports, bearing plate and studs; Model Z1231 manufactured by Zurn Plumbing Products Group, Inc.
4. Thermostatic Mixing Valve: ASSE 1070 & 1017; brass body, brass and stainless-steel internal components, dual stainless-steel strainers and checks on inlet, temperature-response element, vandal resistant universal cap/temperature adjustment handle, lead free; Model 8210CK "Maxline" manufactured by Symmons.
5. Insulation Kit: Provide ADA conforming insulating wrap as manufactured by Truebro, Inc. or equivalent. Install p-traps as high as possible under the counter to lessen the visibility of the trap.

2.04 SINKS

A. Sink (S-1) Drop-In, Single Bowl, ADA Compliant:

1. Bowl: ANSI A112.19.3; single compartment, ADA compliant, countertop drop-in, 25-inch x 22-inch x 6-inch, inch outside dimensions, 18-gauge, type 304 nickel bearing stainless steel, self-rimming with undercoating, 3-1/2-inch outlet and stainless-steel grid drain, ledge back drilled for trim; Model LRAD 252260 manufactured by Elkay Manufacturing Company.
2. Trim (2.2 gpm - lever handles on 8" centers with standard aerator): ANSI A112.18.1; chrome plated brass supply with 7-1/2 inch high, 5-3/8 inch spread rigid/swing gooseneck spout, 2.2 gpm aerator, indexed lever handles on 8 inch centers, compression operating cartridges, chrome plated brass wheel handle angle stop valves with 3/8 inch flexible risers and escutcheons, chrome plated 17 gauge brass P-trap with cleanout plug and arm with escutcheon, lead free; Model 786-E3-369ABCP manufactured by Chicago Faucet Company.
3. Thermostatic Mixing Valve: ASSE 1070 & 1017; brass body, brass and stainless-steel internal components, dual stainless-steel strainers and checks on inlet, temperature-response element, vandal resistant universal cap/temperature adjustment handle, lead free; Model 8210CK "Maxline" manufactured by Symmons.
4. Garbage Disposer: Continuous feed, 1/3 horsepower, permanently lubricated, stainless steel sink flange with stopper, overload protector, manual reset; Model Badger 1 manufactured by In-Sink-Erator.
5. Insulation Kit: Provide ADA conforming insulating wrap as manufactured by Truebro, Inc. or equivalent. Install p-traps as high as possible under the counter to lessen the visibility of the trap.

B. Sink (S-2) Wall-Mounted, Stainless Steel Wall-Hung Multi-Station Sink:

1. Bowl: ANSI A112.19.3; single compartment, ADA compliant, wall-mounted stainless steel hand sink, 48" x 20" x 8" inch dimensions, 18-gauge, type 304 stainless steel polish, satin finish, 3-1/2" drain opening with 1-1/2" outlet connection., NSF certified, stainless steel grid drain, ledge back drilled for trim; Model J4820-J manufactured by Just Manufacturing.
2. Trim (2.2 gpm - lever handles on 4" centers with vacuum breaker and hose thread nozzle): ANSI A112.18.1; chrome plated brass supply with 2-3/8" rigid atmospheric vacuum breaker spout with 3/4-inch hose thread, 1/4 turn compression cartridges, integral checks, lead free, indexed lever handles on 3-inch – 8-3/8 inch centers, compression operating cartridges, chrome plated brass wheel handle angle stop valves with 3/8 inch flexible risers and escutcheons, chrome plated 17 gauge brass P-trap with cleanout plug and arm with escutcheon, lead free; Model 305-VBCP manufactured by Chicago Faucets.
3. Thermostatic Mixing Valve: ASSE 1070 & 1017; brass body, brass and stainless steel internal components, dual stainless steel strainers and checks on inlet, temperature-response element, vandal resistant universal cap/temperature adjustment handle, lead free; Model 8210CK "Maxline" manufactured by Symmons.
4. Insulation Kit: Provide ADA conforming insulating wrap as manufactured by Truebro, Inc. or equivalent. Install p-traps as high as possible under the counter to lessen the visibility of the trap.

2.05 SHOWERS

A. Shower (SHR-1), ADA:

1. Enclosure (3' x 3' shower stall): ANSI Z124.1 and Z124.2, ADA compliant barrier free transfer shower, gelcoat fiberglass, 38 x 38 x 78 inch high outside dimensions, 3/4 inch threshold, rear center drain, left, right or double return flange, collapsible water stop threshold, vertical and horizontal grab bars, soap dish, folding seat, curtain rod, shower curtain; Model MF3837BF34 manufactured by Clarion Bathware.
2. Trim (2.0 gpm - wall/hand shower head): ANSI A112.18.1; concealed shower supply, pressure balanced mixing valve with adjustable temperature limit stop, 2.0 gpm wall/hand shower head with in-line vacuum breaker and non-positive shutoff, flexible 5 feet of metal hose, wall connection and escutcheon, 24-inch slide bar for hand shower mounting, integral service stops; Model S9608-X-PLR-T724 "Origins" manufactured by Symmons Industries, Inc.

2.06 MOP BASINS

A. Mop Basin (MB-1):

1. Basin (Molded Stone): (24 x 24) x 10-inch-high white molded stone, floor mounted, with one-inch-wide shoulders, stainless steel strainer; Model MSB2424 manufactured by Fiat Products, Inc.
2. Trim: ANSI A112.18.1; exposed wall type supply lever handles, spout wall brace, vacuum breaker, hose end spout, eccentric adjustable inlets, integral screwdriver stops with covering caps and adjustable threaded wall flanges; Model 897-CRCF manufactured by Chicago Faucet Company. Provide 5 feet of 1/2 inch diameter plan end Reinforced Rubber Hose and Hose Bracket - Model 832-AA, Mop Hanger – Model 889-CC, Stainless Steel Bumper guard - Model E-88-AA, and stainless-steel Wall Guard – Model MSG2424 manufactured by Fiat Products, Inc.

2.07 WASHER FILLER ASSEMBLIES

A. Washer Filler Assemblies (WFA-1):

1. Plastic body, single lever, on-off control, with wall mounting box and cover, 1/2-inch copper tubing supplies with hw & cw water hammer arrestors, 3/4-inch hose thread outlets, 2-inch PVC drain connection, 2-inch x 36-inch-high standpipe drain, adjustable P-trap with cleanout and 2-inch vent piping; Model Eliminator manufactured by Oatley, Inc.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before plumbing fixture installation.
- B. Examine cabinets, counters, floors, and walls for suitable conditions where fixtures will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Assemble plumbing fixtures, trim, fittings, and other components according to manufacturers' written instructions.
- B. Install off-floor supports, affixed to building substrate, for wall-mounting fixtures.
 - 1. Use carrier supports with waste fitting and seal for back-outlet fixtures.
 - 2. Use carrier supports without waste fitting for fixtures with tubular waste piping.
 - 3. Use chair-type carrier supports with rectangular steel uprights for accessible fixtures.
- C. Install back-outlet, wall-mounting fixtures onto waste fitting seals and attach to supports.
- D. Install floor mounting fixtures on closet flanges or other attachments to piping or building substrate.
- E. Install wall mounting fixtures with tubular waste piping attached to supports.
- F. Install floor mounting, back-outlet water closets attached to building floor substrate and wall bracket and onto waste fitting seals.
- G. Install counter mounting fixtures in and attached to casework.
- H. Install fixtures level and plumb according to roughing-in drawings.
- I. Install water supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
 - 1. Exception: Use ball, if supply stops are not specified with fixture. Valves are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- J. Install trap and tubular waste piping on drain outlet of each fixture to be directly connected to sanitary drainage system.
- K. Install tubular waste piping on drain outlet of each fixture to be indirectly connected to drainage system.
- L. Install flushometer valves for accessible water closets and urinals with handle mounted on wide side of compartment. Install other actuators in locations that are easy for people with disabilities to reach.
- M. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

- N. Install water-supply flow-control fittings with specified flow rates in fixture supplies at stop valves.
- O. Install faucet flow-control fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.
- P. Install shower flow-control fittings with specified maximum flow rates in shower arms.
- Q. Install traps on fixture outlets.
 - 1. Exception: Omit trap on fixtures with integral traps.
 - 2. Exception: Omit trap on indirect wastes, unless otherwise indicated.
- R. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Escutcheons are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- S. Set service basins in leveling bed of cement grout. Grout is specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."
- T. Seal joints between fixtures and walls, floors, and countertops using sanitary-type, one-part, mildew-resistant silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

- A. Refer to architectural drawings for exact plumbing fixture locations, mounting heights and dimensions.
- B. Verify that installed plumbing fixtures are categories and types specified for locations where installed.
- C. Check that plumbing fixtures are complete with trim, faucets, fittings, and other specified components.
- D. Inspect installed plumbing fixtures for damage. Replace damaged fixtures and components.
- E. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

3.05 ADJUSTING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Operate and adjust controls. Replace damaged and malfunctioning units and controls.
- C. Adjust water pressure at faucets and flushometer valves to produce proper flow and stream.
- D. Replace washers and seals of leaking and dripping faucets and stops.
- E. Install fresh batteries in sensor-operated mechanisms.

3.06 CLEANING

- A. Clean fixtures, faucets, and other fittings with manufacturers' recommended cleaning methods and materials. Do the following:
 - 1. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts.
 - 2. Remove sediment and debris from drains.
- B. After completing installation of exposed, factory finished fixtures, faucets, and fittings, inspect exposed finishes and repair damaged finishes.

3.07 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of plumbing fixtures for temporary facilities unless approved in writing by Owner.

END OF SECTION 22 4000

SECTION 22 4700 - DRINKING FOUNTAINS AND WATER COOLERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following electric water coolers and drinking fountains and related components:
 - 1. Electric Water Coolers
 - 2. Fixture supports
- B. Products furnished for this project shall be "LEAD FREE" as required by Federal legislation passed on January 4, 2011. This entails the wetted surfaces of plumbing fixtures, equipment, valves, etc. described in this section to have a weighted-average lead content of no more than 0.25% when used in applications intended to convey or dispense water for human consumption through drinking or cooking.

1.03 DEFINITIONS

- A. Accessible Electric Water Coolers and Drinking Fountains: Fixture that can be approached and used by people with disabilities.
- B. Cast Polymer: Dense, cast filled polymer plastic.
- C. Fitting: Device that controls flow of water into or out of fixture.
- D. Water Cooler: Electrically powered fixture for generating and delivering cooled drinking water.

1.04 SUBMITTALS

- A. Product Data: For each fixture indicated. Include rated capacities, furnished specialties, and accessories.
- B. Operation and Maintenance Data: For fixtures to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities" and Public Law 101-336, "Americans with Disabilities Act"; for fixtures for people with disabilities.

- C. NSF Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- D. ARI Standard: Comply with ARI 1010, "Self-Contained, Mechanically Refrigerated Drinking-Water Coolers," for water coolers and with ARI's "Directory of Certified Drinking Water Coolers" for type and style classifications.
- E. ASHRAE Standard: Comply with ASHRAE 34, "Designation and Safety Classification of Refrigerants," for water coolers. Provide HFC 134a (tetrafluoroethane) refrigerant, unless otherwise indicated.

1.06 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Filter Cartridges: Equal to 50 percent of amount installed for each type and size indicated, but no fewer than 5 of each.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by the list of acceptable manufacturers listed below.
- B. Acceptable Manufacturers - Electric Water Coolers and Drinking Fountains
 - 1. Elkay
 - 2. Oasis
- C. Acceptable Manufacturers - Carriers
 - 1. Josam Company
 - 2. Smith, Jay R. Mfg. Company
 - 3. Tyler Pipe, Wade Division
 - 4. Zurn Plumbing Products Group

2.02 ELECTRIC WATER COOLERS

- A. Electric Water Cooler (EWC-1):
 - 1. (Double, Rectangular, Bottle Filler, Standard and ADA Heights)Fountains: ARI 1010; surface mounted, dual-height, rectangular electric water coolers with stainless steel tops, powder coated paint on steel cabinets, elevated anti-squirt bubblers with flexible guards, automatic stream regulators, front and side mechanical push pads, filtered, bottle filler with independent manual activation, chrome plated brass wheel handle angle stop valves with escutcheons, chrome plated 17 gauge brass P-traps with cleanout plugs and arm with escutcheons, mounting brackets, refrigerated with integral air cooled condensers; capacity of 8.0 gal/hour of 50°F water with inlet at 80°F and room temperature of 90°F, 1/4 HP compressor; Model PG8SBFSL "Bi-Level Versacooler II w/ Mechanical Bottle Filler" manufactured by Oasis International. Provide apron if electric water coolers are not installed in an alcove.

2.03 CARRIERS

- A. Description: ASME A112.6.1M, water cooler carriers. Include vertical, steel uprights with feet and tie rods and bearing plates with mounting studs matching fixture to be supported.
 - 1. Type I: Hanger type carrier with two vertical uprights.
 - 2. Type II: Bi-level, hanger type carrier with three vertical uprights.
 - 3. Supports for Accessible Fixtures: Include rectangular, vertical, steel uprights instead of steel pipe uprights.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine roughing-in for water and waste piping systems to verify actual locations of piping connections before fixture installation. Verify that sizes and locations of piping and types of supports match those indicated.
- B. Examine walls and floors for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATIONS

- A. Use carrier off-floor supports for wall-mounting fixtures, unless otherwise indicated.
- B. Use mounting frames for recessed water coolers, unless otherwise indicated.
- C. Use chrome plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.

3.03 INSTALLATION

- A. Install off-floor supports affixed to building substrate and attach wall mounting fixtures, unless otherwise indicated.
- B. Install mounting frames affixed to building construction and attach recessed water coolers to mounting frames, unless otherwise indicated.
- C. Install fixtures level and plumb. For fixtures indicated for children, install at height required by authorities having jurisdiction.
- D. Install water supply piping with shutoff valve on supply to each fixture to be connected to water distribution piping. Use ball, gate, or globe valve. Install valves in locations where they can be easily reached for operation. Valves are specified in Division 22 Section 22 0523 "General-Duty Valves for Plumbing Piping."
- E. Install trap and waste piping on drain outlet of each fixture to be connected to sanitary drainage system.
- F. Install pipe escutcheons at wall penetrations in exposed, finished locations. Use deep-pattern escutcheons where required to conceal protruding pipe fittings. Escutcheons are specified in Division 22 Section 22 0500 "Common Work Results for Plumbing."

- G. Seal joints between fixtures and walls and floors using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color. Sealants are specified in Division 07 Section "Joint Sealants."

3.04 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect fixtures with water supplies, stops, and risers, and with traps, soil, waste, and vent piping. Use size fittings required to match fixtures.
- C. Ground equipment according to Division 26 Section 26 0526 "Grounding and Bonding for Electrical Systems."
- D. Connect wiring according to Division 26 Section 26 0519 "Low Voltage Electrical Power Conductors and Cables."

3.05 FIELD QUALITY CONTROL

- A. Water Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties.
 - 1. Remove and replace malfunctioning units and retest as specified above.
 - 2. Report test results in writing.

3.06 ADJUSTING

- A. Adjust fixture flow regulators for proper flow and stream height.
- B. Adjust water cooler temperature settings.

3.07 CLEANING

- A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

END OF SECTION 22 4700

SECTION 23 0500 - COMMON WORK RESULTS FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Definitions
 - 2. Permits, Codes, and Inspections.
 - 3. Visiting Premises
 - 4. Delegated Design Services
 - 5. Sleeves.
 - 6. Escutcheons.
 - 7. Painting and finishing.
 - 8. Fire stopping.
 - 9. Roof curbs.
 - 10. Concrete bases.
 - 11. Supports and anchorages.
 - 12. Access doors and panels.

1.03 DEFINITIONS

- A. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct chases, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and tunnels.
- B. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.
- C. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- D. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and chases.
- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.04 SUBMITTALS

- A. Product data for the following:
 - 1. Escutcheons.
 - 2. Interference/Coordination drawings.
 - 3. Roof curbs.
 - 4. Access doors and panels.

1.05 PERMITS, CODES, AND INSPECTIONS

- A. Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules, and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. The HVAC installation shall comply fully with:
 - 1. All local, county and state laws, ordinances and regulations having jurisdiction and as applicable to the HVAC installations.
 - 2. All approved published instructions set forth by manufacturers of equipment furnished or installed on this project.
- C. The HVAC installation and all components shall be in compliance with all applicable codes and ordinances adopted by the local authority having jurisdiction. Unless noted otherwise in the applicable codes and ordinances adopted by the local authority having jurisdiction, requirements of the latest or state-adopted edition of the following Standards shall apply.
 - 1. American Society for Testing and Materials (ASTM)
 - 2. Americans with Disabilities Act (ADA)
 - 3. International Building Code (IBC)
 - 4. International Fire Code (IFC)
 - 5. International Energy Conservation Code (IECC)
 - 6. National Electric Code (NEC)
 - 7. National Fire Protection Association (NFPA)
 - 8. National Safety Code
 - 9. Occupational Safety and Health Act (OSHA)
 - 10. Sheet Metal & Air Conditioning Contractors National Association Standards (SMACNA)
 - 11. Underwriter's Laboratories, Inc. (UL)
- D. Submit certificates issued to authorized agencies which indicate the work conforms to the above requirements, as well as any additional certificates as may be required for the performance of this contract work.
- E. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from the municipality-approved inspection agency and deliver it to the Architect before final payment is made.

1.06 VISITING PREMISES

- A. All bidders are encouraged to visit the project site prior to submitting a bid proposal. The Contractor's is responsible for becoming familiar with the existing conditions of the project prior to submitting a bid proposal. Sufficient allowances shall be included in the bid proposal to perform work that may not be illustrated on the drawings, but due to existing conditions can be reasonably inferred as belonging to work required to complete this contract.
- B. By submission of a bid, the Contractor is attesting that responsible personnel are aware and familiar with all existing pertinent conditions.

- C. Contractor shall verify all measurements and dimensions at the site which may materially affect the contract price prior to submitting a bid proposal.

1.07 QUALITY ASSURANCE

- A. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

1.08 DRAWINGS AND SPECIFICATIONS

- A. The implied and stated intent of the drawings and specifications is to establish minimum acceptable quality standards for materials, equipment and workmanship, and to provide operable mechanical systems complete in every respect.
- B. Any apparatus, appliance, material or work not typically shown on drawings as standard industry practice but is mentioned in the specifications, or vice versa, shall be provided by the HVAC Trade without additional expense to the Owner.
- C. The drawings are diagrammatic, intending to show general arrangement and location of system components, and are not intended to be rigid in detail.
- D. Due to the small scale of the drawings, all offsets and fittings required for a complete installation may not be shown but shall be provided at no change in Contract price.
- E. The equipment schedules shown on the drawings list the manufacturer used as the basis of design in the preparation of the Bid Drawings.
 - 1. The equipment specifications list that manufacturer as well as other manufacturers the Engineer, Architect and/or Owner find acceptable from a performance and product quality perspective, but not as the basis of design, provided the requirements of the specifications are met.
 - 2. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they offer products which meet all of the specified requirements.
 - a. Manufacturers shall only offer proposals that meet the specified items.
 - b. Substitutions that in the engineer's opinion, do not meet the specified requirements due to variations in manufacturing or available options, will not be approved.
 - 3. Listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether they have a positive or negative monetary impact on the design shown on the Bid Drawings.
 - 4. In addition, listing these other manufacturers in no way implies that the Engineer or Architect has exhaustively researched the products available by these manufacturers to determine whether the dimensions of these products will have a negative impact on the space allotted for this equipment.
 - 5. If the Contractor or his Subcontractors decide to submit a product or manufacturer for approval that is listed as acceptable in the specifications but is different from the product or manufacturer scheduled on the drawings, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the plumbing system(s) and/or the fire protection system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, etc., between the scheduled item and the equipment item used.

6. If the Contractor or his Subcontractors decide to submit a product or manufacturer for approval that is not listed as acceptable in the specifications, and approval to use the substituted equipment is granted, it will be the responsibility of the Contractor or his Subcontractors to fully explore the product to ensure that it can be installed in the space allotted and shall pay any and all costs (including additional professional design fees) associated with the use of these products or manufacturers that impact the structure, the electrical system(s), the plumbing system(s) and/or the fire protection system(s) due to an increase in weight, electrical load, drain and vent requirements, connection sizes, or any other difference, between the scheduled item and the equipment item used.
7. Use of a product or manufacturer not scheduled on the Bid Drawings constitutes a representation that:
 - a. The HVAC Trade has investigated the proposed product and determined that the product can be installed within the space allotted.
 - b. The HVAC Trade will coordinate the installation of product used into the work
 - c. The HVAC Trade will be responsible for making all changes as may be required to make the work complete in all respects; waives all claims for additional costs under his responsibility, which may subsequently become apparent.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Deliver pipes and tubes with factory applied end caps. Maintain end caps through shipping, storage, and handling to prevent pipe end damage and to prevent entrance of dirt, debris, and moisture.
- B. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.
- C. Deliver ducts with shop-applied plastic covers over each opening of every duct. Prior to applying the plastic covers on each duct, vacuum all dirt and debris from its interior. Maintain the plastic covers through shipping and storage. Handle ducts to prevent damage to the ducts and to the plastic covers. If a ducts plastic cover(s) is damaged or comes loose, re-vacuum the interior of the duct and apply new plastic covers. The plastic cover shall be maintained over the openings of each duct until that duct is ready to be installed.

PART 2 - PRODUCTS

2.01 NAMEPLATE DATA

- A. Provide factory-installed, permanent operational data nameplate on each item of HVAC equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

2.02 SLEEVES

- A. Galvanized Steel Sheet (For Ductwork Only): 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- B. Steel Pipe: ASTM A 53, Type E, Grade B, Schedule 40, galvanized, plain ends.

2.03 ESCUTCHEONS

- A. Description: Manufactured wall and ceiling escutcheons and floor plates, with an ID to closely fit around pipe, tube, and insulation of insulated piping and an OD that completely covers opening.
- A. One-Piece, Deep-Pattern Type: Deep-drawn, box-shaped brass with polished chrome plated finish.
- B. One-Piece, Cast brass Type: With set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- C. Split-Casting, Cast brass Type: With concealed hinge and set screw.
 - 1. Finish: Polished chrome plated and rough brass.
- D. One-Piece, Stamped-Steel Type: With spring clips and chrome plated finish.
- E. Split-Plate, Stamped-Steel Type: With concealed hinge, set screw or spring clips, and chrome plated finish.
- F. One-Piece, Floor plate Type: Cast iron floor plate.
- G. Split-Casting, Floor plate Type: Cast brass with concealed hinge and set screw, and chrome plated finish.

2.04 GROUT

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

2.05 METAL SUPPORTS AND ANCHORAGES

- A. Structural design shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.
- B. Details of all structural steel shall be provided in shop drawing format. All structural steel shop drawings shall be stamped by the HVAC Trade's design Engineer prior to submittal.
- C. The design, materials, fabrication and erection shall conform to "Specifications for the Design, Fabrication and Erection of Structural Steel for Buildings" of the American Institute of Steel Construction, "Code of Standard Practice for Steel Buildings and Bridges", of the American Institute of Steel Construction, and also, when applicable, shall conform to the "Code for Welding Building Construction" of the American Welding Society.
- D. Steel angles, channels, and plate shall be in accord with ASTM A36.
- E. Bolts, including nuts and washers, used for fabricating steel members shall be in accord with ASTM A325.
- F. Steel members, including fasteners, exposed to weather shall be galvanized.
- G. Refer to Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment" for additional requirements for hanging and supporting HVAC piping, ductwork and equipment.

2.06 FIRESTOPPING

- A. Firestopping material shall be in accordance with ASTM E 814 or UL 1479. Refer to Division 07 for requirements.

2.07 ROOF CURBS

- A. All roof curbs shall be sloped to match the pitch of the roof to provide a level equipment installation.
- B. The HVAC trade shall furnish all roof mounted equipment items, such as gravity roof ventilators, roof exhaust fans, etc., with factory-built roof curbs. Roof curbs serving equipment items shall be furnished by their respective equipment manufacturers. Refer to equipment specifications in other Division 23 Sections for roof curb requirements that are indicated to be furnished by the particular equipment manufacturers.
- C. The HVAC trade shall furnish factory-built roof curbs at all duct openings.
 - 1. Factory built roof curbs shall be of box section design, 18-gauge galvanized steel with continuous welded corner seams, factory installed wood nailer and insulated with 1-1/2-inch, 3-pound density rigid fiberglass board.
 - 2. The base of each curb shall be manufactured to match the roof pitch while maintaining a level equipment installation or a vertical duct installation.
 - 3. Minimum installed height of curb shall be 24 inches above the finished surface of the roof. Coordinate the height of the roofing materials with the Architectural Drawings and with the Roofing trade.
 - 4. Roof curbs shall be similar to the Roof Products Systems (RPS) Type RC-4.

2.08 ACCESS DOORS AND PANELS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Bar-Co., Inc.
 - 2. J.L. Industries
 - 3. Karp Associates, Inc.
 - 4. Milcor Division, Inryco, Inc.
 - 5. Nystrom, Inc.
- B. Steel Access Doors and Frames: Factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded, with welds ground smooth and flush with adjacent surfaces.
 - 1. Door material - 16-gauge steel, having a factory-prime finish suitable for field painting except as follows:
 - a. For kitchens, toilet rooms, janitor's closet, or elsewhere as indicated, 16-gauge stainless steel having a No. 4 finish.
 - 2. Frame material - same material and finish as door, with the following features:
 - a. For installation in masonry, concrete, ceramic tile, or wood paneling: 1 inch-wide-exposed perimeter flange and adjustable metal masonry anchors.
 - b. For gypsum wallboard or plaster: Perforated flanges with wallboard bead.
 - c. For full-bed plaster applications: Galvanized expanded metal lath and exposed casing bead, welded to perimeter of frame.
- C. Flush Panel Doors: Furnish with concealed spring hinges or concealed continuous piano hinge.

- D. Fire rated Units: Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
 - 1. Fire Resistance Rating: Not less than 1½-hours.
- E. Locking Devices: Flush, screwdriver operated cam locks.
- F. Size: Doors and/or panels shall be of sufficient size for the intended function, but not less than 12 inches by 16 inches.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Before any HVAC construction work is performed and/or any equipment and materials are ordered, the HVAC Trade shall examine the project area(s) where HVAC work will be performed to verify actual locations, dimensions, and other conditions that may affect the installation of HVAC equipment, materials and associated work.

3.02 COORDINATION

- A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for HVAC installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for HVAC items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- D. Cooperation and Coordination with Other Trades:
 - 1. This HVAC trade must cooperate completely and coordinate work with the General Trade and other trades providing equipment under this division and other divisions of the specifications.
 - 2. Interference drawings shall be prepared as a combined effort of all trades. Each trade shall proceed with their own set of drawings on electronic backgrounds in AutoCAD format prepared by the HVAC trade. The HVAC trade shall start its drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
 - 3. After the HVAC trade has finished, it shall forward one print along with an electronic file to the Plumbing trade that, in turn, will show and coordinate the plumbing work on the combined plans with the other trades. After the Plumbing trade has finished, it shall forward one print along with an electronic file to the Electrical trade that, in turn, will show and coordinate the electrical work on the combined plans with the other trades. After the Electrical trade has finished, it shall forward one print along with an electronic file to the Fire Protection trade that, in turn, will show and coordinate the fire protection work on the combined plans with the other trades.
 - 4. Interference plans and elevations shall show in detail the location of the following items that require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the article contained in Part 3 of this Section entitled "Space Priority".
 - a. In addition, show mechanical and electrical work in equipment rooms.
 - b. On the interference drawings, show all electrical conduits which are 1-1/2" and larger.

5. Reproducible copies along with an electronic file of the finished interference drawings shall be submitted to the Architect for record and approval before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
6. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.

3.03 CUTTING AND PATCHING

- A. Cutting and patching shall be in accordance with the General Conditions and the applicable Section of Division 01, General Requirements.
- B. The HVAC trade shall seal all openings he has utilized in fire rated floors, ceilings or partitions after his work has been installed. The material used for sealing the openings shall have a fire-rating equal to or greater than the rating of the floor, ceiling or partition material.
- C. In new construction, where openings, chases, sleeves, inserts, anchors, etc., have not been provided by the General Trade, the HVAC trade shall be responsible for providing all cutting, patching, and finishing of new construction which is not specifically shown on the Architectural Drawings, but is required for the proper installation of HVAC equipment and materials as shown on the HVAC Drawings and specified in Division 23.
- D. Cutting, patching and finishing shall be performed by workmen skilled in this type of work. All patching shall be done utilizing materials of the same quality and texture as the adjacent undisturbed areas. All finishing shall match the undisturbed adjacent areas. Painting of the final finished areas, where general construction work occurs, will be the responsibility of the General Trade. Painting of the final finished areas, where no general construction work occurs, shall be the responsibility of the HVAC trade. The HVAC trade shall paint entire plane in which damage occurs whether the surface is a wall or a ceiling.
- E. No cutting shall be done which may affect the building structurally or architecturally without first consulting with the General Trade and then securing the approval of the Architect. Cutting shall be accomplished in such a manner as not to cause damage to the building or leave unsightly surfaces which cannot be concealed by plates, escutcheons or other construction. Where such unsightly conditions are caused, the HVAC trade shall be required, at his own expense, to repair the damaged areas. Note: all holes or openings in existing concrete or masonry shall be drilled, core bored or saw cut.
- F. Where an opening is cut into a block or brick wall for the purpose of ductwork or piping to pass through the wall, the HVAC trade shall be responsible for furnishing and installing a properly sized lintel to support the block or brick above the opening.
- G. Where present equipment or material is removed and unused openings remain in walls, floors, partitions, roof deck, etc., the HVAC trade shall properly patch all such openings.

3.04 SPECIAL CONDITIONS RELATED TO HVAC WORK

- A. During the course of construction, cap or otherwise seal off, in an approved manner, those portions of the piping or duct system in which work is not being performed, in order to prevent the entry of dirt or dust. Should the HVAC trade fail to cover open ends of ducts, he may be required to vacuum the entire duct system and remove sections of ductwork for inspection.
- B. The HVAC trade shall coordinate all utility shutdowns with the Owner to determine when the most advantageous time is for the Owner to accommodate the utility shutdown. The HVAC trade shall coordinate the utility shutdown a minimum of 7 days in advance.

- C. Install equipment along with control devices and all replaceable fittings with sufficient clearance for operation and maintenance functions.
- D. Do not install piping and ductwork in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the piping and/or ductwork serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install piping and ductwork adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- E. Exposed piping shall be run so as to allow maximum headroom consistent with proper pitch. Piping shall not interfere with any light, opening, door, window or equipment. Headroom in front of openings, doors and windows shall not be less than the top of the opening. Minimum clearance of 1 inch shall be maintained around all piping, valves and fittings.
- F. Lay out the work and establish all heights and grades required for installation.
- G. Provide safety guards for all pulleys, belt-drives and rotating equipment. Safety requirements of OSHA shall be met.

3.05 SPACE PRIORITY

- A. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
 - 1. Gravity flow piping systems.
 - 2. Vent piping systems.
 - 3. Ceiling recessed lighting fixtures.
 - 4. Concealed air terminal units, fans.
 - 5. Air duct systems.
 - 6. Sprinkler systems piping.
 - 7. Forced flow piping systems.
 - 8. Electrical conduit, wiring, control wiring.
- B. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
- C. Change in order of priority is permissible by mutual agreement of all affected trades.
- D. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
- E. The work of a particular trade shall not obstruct access for installation, operation, and maintenance of the Work, materials and equipment of another trade.

3.06 ESCUTCHEONS

- A. Install escutcheons where piping penetrates walls, ceilings, and floors according to the following:
 - 1. New Piping:
 - a. Piping with Fitting or Sleeve Protruding from Wall: One-piece, deep-pattern type.
 - b. Insulated Piping: One-piece, stamped-steel type with spring clips.

- c. Bare Piping at Wall and Floor Penetrations in Finished Spaces: One-piece, cast brass type with polished chrome plated finish.
- d. Bare Piping at Ceiling Penetrations in Finished Spaces: One-piece (for drywall type ceilings) or split-casting (for lay-in type ceilings), cast brass type with polished chrome plated finish.
- e. Bare Piping in Unfinished Service Spaces and Equipment Rooms: One-piece, cast brass type with polished rough-brass finish.
- f. Bare Piping at Floor Penetrations in Unfinished Service Spaces and Equipment Rooms: One-piece, floor plate type.

3.07 SLEEVES

- A. Sleeves are not required for core-drilled holes.
- B. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - a. Exception: Extend sleeves installed in floors of mechanical equipment areas or other wet areas **2 inches** above finished floor level. Extend cast iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Use the following sleeve materials:
 - a. Steel Pipe Sleeves: For pipes smaller than NPS 8 (DN 200).
 - 4. Seal annular space between sleeve and pipe or pipe insulation, using joint sealants appropriate for size, depth, and location of joint. Refer to Division 07 for material and installation requirements of joint sealants.
- C. Aboveground, Exterior wall Pipe Penetrations: Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
 - 1. Install steel pipe for sleeves.
- D. Aboveground, Interior wall Pipe Penetrations: Seal penetrations through all walls identified to have an STC rating. Refer to the Architectural Drawings to determine the walls where this requirement applies.
 - 1. Sealant shall be an acoustical type sealant; refer to Division 07 for requirements.
- E. Fire Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Refer to Division 07 for material and installation requirements of firestopping.

3.08 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install HVAC equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

- D. Install equipment to allow right of way for piping installed at required slope.
- E. Install all new, relocated, or owner furnished equipment in accord with the manufacturer's written installation instructions.

3.09 PAINTING

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

3.10 CONCRETE BASES

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

3.11 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Provide all materials, equipment, supplies and labor necessary to construct all miscellaneous steel required for supporting piping, ductwork and equipment for installation of the HVAC system. All miscellaneous steel, metal supports and anchorages required for supporting ductwork, piping and equipment is not shown on the Drawings, but shall be provided.
- B. All structural steel shall be designed to attach to the main building structure in such a manner as to not overstress this structure. Reinforcement of the building structure may be required in work areas located in existing buildings and in areas where the HVAC trade has relocated ductwork, piping, and equipment to areas other than is shown on the Drawings.
- C. Refer to Division 05 Section "Metal Fabrications" for structural steel.
- D. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor HVAC materials and equipment.
- E. Shop and Field Welding: Shop and field welding shall be in accordance with AWS D1.1.

3.12 GROUTING

- A. Mix and install grout for HVAC equipment base bearing surfaces, pump and other equipment base plates, and anchors.
- B. Clean surfaces that will come into contact with grout.
- C. Provide forms as required for placement of grout.
- D. Avoid air entrapment during placement of grout.
- E. Place grout, completely filling equipment bases.
- F. Place grout on concrete bases and provide smooth bearing surface for equipment.
- G. Place grout around anchors.
- H. Cure placed grout.

3.13 FINAL CLEANING

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES.

3.14 WARRANTIES

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES and as stated below.
- B. Refer to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- C. Compile and assemble the warranties specified in Division 23 into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.
- D. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- E. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner and Architect. Obtain similar warranties from subcontractors, manufacturers, suppliers and sub-trade specialists.
- F. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or that are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

3.15 FIRESTOPPING

- A. Firestopping is required in the following locations:
 - 1. Where exposed and concealed horizontal ducts penetrate fire rated walls and shaft walls, except where fire dampers are installed in ducts.
 - 2. Where exposed and concealed vertical ducts penetrate rated and non-rated floors, except where fire dampers are installed in ducts.
 - 3. Where exposed and concealed horizontal pipes penetrate fire rated walls and shaft walls.
 - 4. Where exposed and concealed vertical pipes penetrate rated and non-rated floors.
- B. Clean surfaces to be in contact with firestopping materials of dirt, grease, oil, loose materials, rust, or other substances that may affect proper fitting, adhesion, or the required fire resistance.
- C. Install materials in accordance with printed instructions of the UL Fire Resistance Directory and per manufacturer's published instructions.
- D. Place firestopping in annular space around fire dampers before installation of damper's anchoring flanges which are installed in accordance with fire damper manufacturer's recommendations.
- E. Where large openings are created in walls or floors to permit installation of ducts or other items, close unused portions of opening with firestopping material tested for the application.
- F. Fill annular space between duct and sleeve, with approved material. Depth of material shall be in accord with laboratory tests for 1, 2, or 3 hour rated assemblies.
- G. Damming material may be temporary non-fire approved, or permanent fire-approved. Where permanent fire-approved damming material is used, depth of firestopping material may be decreased in accord with manufacturer's recommendations. Temporary damming material shall be removed after installation of firestopping material.
- H. Seal all gaps or voids in cured foam with material to match the firestopping material.
- I. Trim excess cured foam from around all openings and leave smooth, flush surface.
- J. Position metal collar on duct penetrating floors or walls in air plenums and air shafts. Secure neck of collar to duct with screws.

3.16 INSTALLATION OF ROOF CURBS

- A. Prefabricated roof curbs shall be furnished and installed by the HVAC Trade. Counter flashing and leveling shims shall be provided by the General Trade.
- B. Rooftop curbs, for equipment or components that require service, shall be located to provide a minimum of 10'-0" clearance from the face of the equipment to adjacent roof edges.
- C. Cutting of roof deck will be performed by the HVAC Trade, in strict cooperation with the General Trade. The HVAC Trade shall coordinate the exact opening sizes with the entity designated to cut the roof deck to ensure roof deck is not over-cut. Verify the exact opening requirements with the unit manufacturer.
 - 1. All openings between the ducts and the roof deck, within the curb area, shall be caulked with Dow Corning 799 Silicone Metal Building Sealant by the HVAC Trade.

3.17 INSTALLATION OF ACCESS DOORS AND PANELS

A. Access Doors and Panels:

1. Where HVAC devices which require periodic maintenance, cleaning or adjustment will be concealed in shafts, chases, above drywall ceilings and in other inaccessible general construction work, the HVAC Trade shall furnish and install access doors and panels for all such devices. These HVAC devices include, but are not limited to, valves, traps, air vents, cleanouts, damper regulators, fire dampers, smoke dampers, controls and other devices,
2. The HVAC Trade in conjunction with the General Trade shall determine door and/or panel locations subject to the Architect's approval. Locate items to be made accessible through doors and/or panels so that the doors and/or panels may be installed with not less than 6 inches between an edge and the surface of any intersecting construction or opening.
3. Access doors and panels shall be installed in accordance with the manufacturers written recommendations and Division 08 of these Specifications.

3.18 DUCT MOUNTED SMOKE DETECTOR INSTALLATION

- #### **A.**
- Refer to Division 23 Section 23 0510 "Basic Electrical Requirements for HVAC Equipment" for duct-mounted smoke detector requirements.

3.19 TEMPORARY HEATING, COOLING, AND DEHUMIDIFICATION

- #### **A.**
- Provide specified temporary services in accordance with Division 01 Section "TEMPORARY FACILITIES AND CONTROLS".
- #### **B.**
- Provide temporary services to facilitate scheduled completion of the work for every entity authorized to do work at project site. Maintain interior conditions as required for each type of work to be performed.
- #### **C.**
- Refer to Division 01 for requirements.

3.20 PIPING VENTS

- #### **A.**
- For all gas-fired HVAC equipment installed indoors; the HVAC Trade shall extend vents from their vent connections to the exterior of the building. The vents shall be terminated a minimum of 10-feet from any building opening or air intake. Vents shall not be combined. The size of each vent shall be equal to or greater than the vent connection size of the equipment item it serves.

3.21 FINAL HVAC CONNECTIONS

- #### **A.**
- Provide rough-in and final connection of all HVAC services needed for equipment provided by the Owner or by other trades. Shop Drawings will be furnished by those providing the equipment. These Drawings shall be checked by the trade responsible for rough-in and final connections before submission to the Architect for approval. The work shall be done in accordance with the approved Shop Drawings.
- #### **B.**
- In general, connection and termination points are given in the Contract Documents. Where not given or where conflicts occur, refer the question to the Architect for a binding decision.

3.22 MAINTENANCE MANUALS

- A. Provide in accordance with Division 01 Section OPERATION AND MAINTENANCE DATA and as stated below.
- B. Include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Provide a cover sheet for each manual including the project name, Architect's name and contact information, Engineer's name and contact information, and Division 23 contractor's name and contact information.
 - 6. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
 - 7. Manufacturer's data of each piece of equipment including:
 - a. Installation instructions.
 - b. Drawings and Specifications.
 - c. Parts list, including recommended items to be stocked.
 - d. Complete wiring diagrams.
 - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
 - f. Test and inspection certificates.

3.23 RECORD DOCUMENTS

- A. Provide in accordance with Division 01 Section PROJECT RECORD DOCUMENTS and as stated below.
- B. Indicate installed conditions for the following:
 - 1. Ductwork.
 - 2. Duct Accessories
 - 3. Piping.
 - 4. Piping Accessories.
 - 5. Valves.
 - 6. HVAC Equipment.
 - 7. Automatic Temperature Control Panels, Control Devices, and Sensors.
 - 8. Approved substitutions, Contract Modifications, and actual equipment and materials installed.

3.24 DEMONSTRATION AND TRAINING

- A. Provide in accordance with Division 01 Section DEMONSTRATION AND TRAINING and as stated below.
- B. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.

C. The following is a list system that require Demonstration and Training, refer to the individual specification sections for additional training requirements:

1. Automatic Temperature Controls
2. HVAC Equipment.
3. Duct Accessories
4. Piping Accessories.
5. Valves.

END OF SECTION 23 0500

SECTION 23 0510 - BASIC ELECTRICAL REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes the following:
 - 1. Disconnect Switches
 - 2. Fuses
 - 3. Electrical Requirements - General
 - 4. Duct Mounted Smoke Detector Installation
 - 5. Piping and Ductwork Coordination

1.03 SUBMITTALS

- A. Product Data
 - 1. For each type of disconnect switch. Include dimensions and electrical characteristics, ratings, and finishes. Also include dimensioned plans, elevations, sections, and details. Include the following:
 - a. Wiring Diagrams: Power wiring.
 - 2. For each type of fuse. Include electrical characteristics and ratings.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain disconnect switches of a single type through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- C. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store disconnect switches and fuses indoors in clean, dry space with uniform temperature to prevent condensation. Protect disconnect switches and fuses from exposure to dirt, fumes, water, corrosive substances, and physical damage.

- B. If stored in areas subject to weather, cover disconnect switches and fuses to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside equipment; install electric heating of sufficient wattage to prevent condensation.

1.06 COORDINATION

- A. Coordinate layout and installation of disconnect switches with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of disconnect switches with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each disconnect switch with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.01 DISCONNECT SWITCHES

- A. Acceptable Manufacturers
 - 1. Square D
 - 2. Cutler Hammer
 - 3. General Electric
 - 4. Siemens
- B. Heavy Duty Safety Switches: Provide surface-mounted, heavy-duty type, sheet-steel enclosed safety switches of types, sizes and electrical characteristics indicated on the drawings.
- C. Provide switches with quick-make, quick-break type operation, with switchblades that are visible in the 'OFF' position with door open.
- D. Operating handle shall be an integral part of the enclosure base the operating position shall be easily recognizable and pad-lockable in OFF position.
- E. Current carrying parts shall be constructed of 98% conductivity copper, with silver-tungsten type switch contacts and positive pressure type reinforced fuse clips.
- F. Enclosures shall meet environmental conditions of installed location.
 - 1. Indoor Locations: NEMA 250, Type 1
 - 2. Outdoor Locations: NEMA 250, Type 3R.
 - 3. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 4. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 5. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.
- G. Provide motor and motor starter disconnects with horsepower ratings suitable to the loads.

- H. Fusible Switches: Heavy duty switches, with positive pressure type reinforced fuse clips and fuses of classes and current ratings indicated.
 - 1. Non-fused disconnect switches may be used provided that the equipment nameplate makes no reference to "maximum fuse size", "maximum overcurrent protection", "fuse size" or "MFS".
- I. Provide disconnect switches having the capability to have auxiliary contacts mounted as required.
- J. Disconnects shall be finished in manufacturer's standard gray finish unless otherwise noted on drawings.
- K. Disconnect switches specified as being an integral part of a piece of equipment shall come factory installed and wired.

2.02 FUSES

- A. Acceptable Manufacturers
 - 1. Bussman Division of Cooper Industries, Inc.
 - 2. Shawmut Division of Gould, Inc.
 - 3. Littelfuse, Inc.
- B. All fuses shall be Class RK1, time delay type.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and surfaces to receive disconnect switches for compliance with requirements, installation tolerances, and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 ELECTRICAL REQUIREMENTS - GENERAL

- A. While Electrical Trade is responsible for proper direction of rotation of all 3-phase equipment, it is the duty of the HVAC Trade to confirm that all 3-phase equipment is rotating in the proper direction during start-up of equipment and to inform the Electrical Trade of any equipment that is not rotating in the proper direction.
- B. In general, rigid conduit or tubing shall be used, but equipment that requires movement or that would transmit vibration to conduit shall be wired with flexible (liquid tight) steel conduit not exceeding 18" in length.
- C. All equipment shall be grounded with a green-covered ground wire run inside the conduit and connected to equipment frame on one end and to grounding system on the other end.
- D. All electrical work required in Division 23 shall conform to all applicable requirements of Division 26 of these Specifications, and shall comply with the latest edition of the National Electric Code.

- E. The HVAC Trade shall assign all low-voltage and line-voltage Electrical Control Work required under this Contract to the Automatic Temperature Control Subcontractor, who shall perform this work with qualified electricians employed by that Subcontractor.
- F. The HVAC Trade shall co-operate with the contractor for Electrical Work in making all necessary tests and in receiving, storing and setting all motor-driven equipment, electrical devices, and controls furnished and/or installed under these Contracts.
- G. Single phase equipment controls and wiring shall be as follows:
 - 1. HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as motor sentinel switches, PE switches, thermostats, etc.
 - 2. The Electrical Trade shall complete all power wiring and connections for single phase equipment, through the disconnect and/or the thermal cutouts and local control stations to the equipment as required.
 - 3. The HVAC Trade will furnish a THERMAL OVERLOAD SWITCH for all single-phase motors except where units are furnished with built-in Thermal Protection, in which case he will furnish a single pole switch.
- H. Three phase equipment controls and wiring shall be as follows:
 - 1. The HVAC Trade shall furnish all combination motors starters; refer to Division 23 Section 23 0511 "Enclosed Motor Controllers for HVAC Equipment" for requirements. The Electrical Trade shall install all combination motor starters.
 - 2. The HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as EP and PE switches, thermostats, etc.
 - 3. The ATC Subcontractor shall furnish and install all controls and control wiring from control devices to motor starters and contactors and between control devices.
 - 4. The Electrical Trade shall complete all electrical connections through the disconnect, starter and motor terminals of all three-phase equipment. He shall be responsible for all power wiring and connections.

3.03 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic control devices where applicable.
 - 1. Connect selector switches to bypass only manual control and automatic control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches in both hand and automatic positions for safety-type control devices such as low- and high-pressure cutouts, high temperature cutouts, and motor overload protectors.

3.04 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26.

3.05 DISCONNECT SWITCHES

- A. For each HVAC equipment item being furnished on the project the HVAC Trade shall:
 - 1. Review/coordinate with the equipment manufacturer to determine whether a disconnect switch will be furnished with it.
 - 2. Review the electrical drawings and/or coordinate with the Electrical Trade to determine whether the Electrical Trade will be providing a disconnect switch for the equipment item.
- B. A disconnect switch shall be provided for each HVAC equipment item that has a 1-phase or 3-phase power connection. The HVAC Trade shall provide a disconnect switch for an equipment item unless one of the following occur:
 - 1. The equipment manufacturer is required to furnish or provide a disconnect switch or a combination motor starter/disconnect for the equipment item.
 - 2. The electrical drawings require the Electrical Trade to provide a disconnect switch for the equipment item.
- C. Mount disconnect switch to the equipment item it serves. If a disconnect switch cannot be mounted to the equipment item it serves or the drawings indicate the disconnect switch to be mounted in a different location, mount switch in a location within 50 feet and within eyesight of the equipment item. Provide miscellaneous steel as required to mount the disconnect switch.
 - 1. Bolt disconnect switches to equipment casing or to wall, or mount on free-standing lightweight structural steel channels and bolted to floor, equipment rails or roof curb.
 - 2. Structural steel channels, angle iron and other miscellaneous steel are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."

3.06 FUSES

- A. Fuses: Fuses shall be provided for each HVAC equipment item having power connection and requiring fuses. If fuses are not furnished with the HVAC equipment item, then the HVAC Trade shall provide all the necessary fuses for proper operation of the equipment and the electrical circuit.
 - 1. Install fuses in each fusible switch. Comply with requirements in Division 26.

3.07 IDENTIFICATION

- A. Identify disconnect switches, components, and control wiring according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

3.08 DUCT MOUNTED SMOKE DETECTOR INSTALLATION

- A. All duct mounted smoke detectors will be furnished by the Electrical Contractor. The HVAC Trade shall install all duct mounted smoke detectors furnished by the Electrical Trade under this project.
- B. The Electrical Trade will provide all power wiring for duct mounted smoke detectors.
- C. The HVAC Trade shall provide all control wiring from the smoke detector(s) auxiliary contacts to its (their) associated system supply and/or return fan(s) motor starter(s) for the purpose of de-energizing the fan motor when smoke is detected within the duct system.

3.09 PIPING AND DUCTWORK COORDINATION

- A. The HVAC Trade shall not run ductwork or piping above switchboards or panelboards in accordance with the National Electric Code Article 384. Before ductwork or piping is installed coordinate the exact locations with the Electrical Trade. Failure to comply with this requirement shall be cause for the ductwork and piping to be removed and relocated at no additional cost to the Owner.

END OF SECTION 23 0510

SECTION 23 0511 - ENCLOSED MOTOR CONTROLLERS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Across-the-line, enclosed magnetic-type motor controllers.

1.03 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon controlled rectifier.

1.04 SUBMITTALS

- A. Product Data
 - 1. For each type of across-the-line, magnetic controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes. Also include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following
 - a. Each installed unit's type and details.
 - b. Nameplate legends.
 - c. Short circuit current rating of integrated unit.
 - d. Listed and labeled for series rating of overcurrent protective devices in combination controllers by an NRTL acceptable to authorities having jurisdiction.
 - e. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices in combination controllers.
 - f. Wiring Diagrams: Power, signal, and control wiring.

- B. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Routine maintenance requirements for enclosed controllers and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Source Limitations: Obtain enclosed controllers and disconnect switches of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency acceptable to authorities having jurisdiction, and marked for intended location and application.
- D. 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.
- E. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside equipment; install electric heating of sufficient wattage to prevent condensation.

1.07 COORDINATION

- A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- C. Coordinate features, accessories, and functions of each enclosed controller with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.08 PROJECT CONDITIONS

- A. Environmental Limitations - rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than -22°F and not exceeding 104°F.
 - 2. Altitude: Not exceeding 6,600 feet.

PART 2 - PRODUCTS

2.01 ACROSS-THE-LINE ENCLOSED MOTOR CONTROLLERS

A. Acceptable Manufacturers

1. Cerus
2. Eaton
3. General Electric
4. Square D
5. Furnas
6. Cutler-Hammer
7. Allen-Bradley

B. Combination Magnetic Controller: NEMA ICS 2, Class A, full voltage, non-reversing, across the line, unless otherwise indicated; and disconnect switch.

1. Control Circuit: 120-volt, single-phase power; obtained from an integral control power transformer with sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity. The control circuit transformer shall have dual primary fusing and a fuse in a hot secondary leg, and one normally open auxiliary contact.
2. Overload Relay: Ambient-compensated type with inverse-time-current characteristic and NEMA ICS 2, Class 20 tripping characteristic. Provide with heaters or sensors in each phase matched to nameplate full-load current of specific motor to which they connect and with appropriate adjustment for duty cycle.
3. Fusible Disconnecting Means: NEMA KS 1, heavy-duty, fusible switch with rejection-type fuse clips rated for fuses. Select and size fuses to provide Type 2 protection according to IEC 947-4-1, as certified by an NRTL.
4. Accessories: The following devices shall be factory installed in controller enclosure, unless otherwise indicated.
 - a. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - 1) Each combination magnetic controller that serves equipment specified or scheduled to be manually controlled shall be provided with a START-STOP push-button station.
 - 2) Each combination magnetic controller that serves equipment specified or scheduled to be automatically controlled shall be provided with a HAND-OFF-AUTO selector switch.
 - 3) Each combination magnetic controller shall be provided with red 'RUN' and green 'STOP' indicating lights.
 - b. Control Relays:
 - 1) Provide an auxiliary relay for control of associated equipment.
 - 2) Provide an adjustable time-delay relay to eliminate nuisance tripping when momentary loss of power occurs.
 - c. Phase Failure and under voltage relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable under voltage setting.

C. Enclosures

1. Description: Flush or surface mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 - a. Indoor Mechanical Equipment Room, Machine Lab and Welding Lab Locations: NEMA 250, Type 12.
 - b. Outdoor Locations: NEMA 250, Type 4X, stainless steel.
 - c. Wet Areas, such as Kitchen Areas, Washdown Areas, etc.: NEMA 250, Type 4X, stainless steel.

- D. Factory Finishes:
 - 1. Finish: Manufacturer's standard paint applied to factory assembled and tested enclosed controllers before shipping.
- E. Application - the HVAC Trade shall furnish properly-sized across-the-line, magnetic controller for all 3-phase motors provided under Division 23 to include the following:
 - 1. Supply fans and return/exhaust fans for air handling units installed indoors.
 - 2. Supply fans and return/exhaust fans for air handling units installed outdoors.
 - 3. Centrifugal pumps.
 - 4. Roof exhaust fans.
 - 5. In-line exhaust fans.
 - 6. Fan coil units.
 - 7. Unit heaters.
 - 8. Cabinet unit heaters.
- F. For enclosed magnetic controllers with external control voltages, furnish an auxiliary contact on the disconnect switch to disconnect the external voltage source when the disconnect switch is off.
- G. All safety devices shall be wired so that they stop the motor with the Hand-Off-Auto switch in the Hand as well as the Auto position. This will normally mean breaking the common wire from the Hand-Off-Auto switch to the starter's holding coil through the safety devices.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers for compliance with requirements, installation tolerances, and other conditions affecting performance.
 - 1. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 ENCLOSED CONTROLLER APPLICATIONS

- A. Select features of each enclosed controller to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; duty cycle of motor, controller, and load; and configuration of pilot device and control circuit affecting controller functions.
- B. Select horsepower rating of controllers to suit motor controlled.
- C. Furnish an enclosed controller for each HVAC equipment item provided on the project that will operate on 3-phase power to the Electrical Trade. The Electrical trade shall mount and wire each enclosed controller.
 - 1. Enclosed controllers are not required for the following:
 - a. HVAC equipment that is scheduled, noted, or indicated to be provided with a variable frequency motor controller.
 - b. HVAC equipment that is scheduled, noted, or indicated to operate on 1-phase power.
 - c. HVAC equipment that is furnished with an integral enclosed controller from the factory.

3.03 INSTALLATION

- A. Mount enclosed controllers as follows:
 - 1. Wall Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Section 26 0529 "Hangers and Supports for Electrical Systems."
- B. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- E. Install, connect, and fuse thermal-protector relays furnished with motor-driven equipment.
- F. Comply with NECA 1.
- G. While Electrical Trade is responsible for proper direction of rotation of all 3- phase equipment, it is the duty of the HVAC Trade to confirm that all 3-phase equipment is rotating in the proper direction during start-up of equipment and to inform the Electrical Trade of any equipment that is not rotating in the proper direction.
- H. Equipment delivered with enclosures that are inadequate for the installed location shall be equipped with special enclosures that suit the conditions of the installed location by the HVAC Contractor furnishing the equipment.
- I. Controls and wiring for enclosed motor controllers furnished on the project shall be as follows:
 - 1. The HVAC Trade shall furnish all enclosed motor controllers. The Electrical Trade shall install all enclosed motor controllers.
 - 2. The HVAC Trade shall retain the services of an ATC Subcontractor, who shall furnish and install all control devices, such as EP and PE switches, thermostats, etc.
 - 3. The ATC Subcontractor shall furnish and install all controls and control wiring from control devices to enclosed motor controllers and contactors and between control devices.
 - 4. The Electrical Trade shall complete all electrical connections through the disconnect, enclosed motor controller and motor terminals of all three-phase equipment. He shall be responsible for all power wiring and connections.

3.04 IDENTIFICATION

- A. Identify enclosed motor controllers according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

3.05 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed motor controller element, bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.

- B. Manufacturer's Field Service - engage a factory authorized service representative to perform the following:
 - 1. Inspect enclosed motor controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
 - 2. Assist in field testing of equipment including pretesting and adjusting of enclosed motor controllers.
 - 3. Report results in writing.
- C. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.06 ADJUSTING

- A. Set field adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.

3.07 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.
- B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.08 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain enclosed motor controllers. Refer to Division 01.

END OF SECTION 23 0511

SECTION 23 0512 - VARIABLE FREQUENCY MOTOR CONTROLLERS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This section includes separately enclosed, pre-assembled, combination variable frequency motor controllers (VFCs), rated 600 V and less, for speed control of three-phase, squirrel-cage induction motors.

1.03 DEFINITIONS

- A. BAS: Building automation system.
- B. CPT: Control power transformer.
- C. EMI: Electromagnetic interference.
- D. IGBT: Insulated gate bipolar transistor.
- E. LAN: Local area network.
- F. LED: Light emitting diode.
- G. MCP: Motor circuit protector.
- H. NC: Normally closed.
- I. NO: Normally open.
- J. OCPD: Overcurrent protective device.
- K. PCC: Point of common coupling.
- L. PID: Control action, proportional plus integral plus derivative.
- M. PWM: Pulse width modulated.
- N. RFI: Radio frequency interference.
- O. TDD: Total demand (harmonic current) distortion.

- P. THD (V): Total harmonic voltage demand.
- Q. VFC: Variable frequency motor controller.

1.04 SUBMITTALS

- A. Product Data: For each type and rating of VFC indicated. Include features, performance, electrical ratings, operating characteristics, shipping and operating weights, and furnished specialties and accessories. Also, include dimensioned plans, elevations, and sections; and conduit entry locations and sizes, mounting arrangements, and details, including required clearances and service space around equipment.
 - 1. Schematic and Connection Wiring Diagrams: For power, signal, and control wiring.
- B. Product Certificates: For each VFC, from manufacturer.
- C. Operation and Maintenance Data: For VFCs to include in operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
 - 1. Manufacturer's written instructions for testing, adjusting, and programming overload setting, timers, controls, and status and alarm points related to the VFC.

1.05 QUALITY ASSURANCE

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

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Comply with the requirements described in Division 01.

1.07 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation, capable of driving full load without derating, under the following conditions unless otherwise indicated:
 - 1. Ambient Temperature: Not less than 14°F and not exceeding 104°F.
 - 2. Ambient Storage Temperature: Not less than -4°F and not exceeding 140°F.
 - 3. Humidity: Less than 95 percent (non-condensing).
 - 4. Altitude: Not exceeding 3,300 feet.
- B. Drawings indicate maximum dimensions for VFCs, including clearances between VFCs, and adjacent surfaces and other items.

1.08 COORDINATION

- A. Coordinate features of motors, load characteristics, installed units, and accessory devices to be compatible with the following:
 - 1. Torque, speed, and horsepower requirements of the load.

2. Ratings and characteristics of supply circuit and required control sequence.
3. Ambient and environmental conditions of installation location.

1.09 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace VFCs that fail in materials or workmanship within specified warranty period.
 1. Warranty Period: Five (5) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURED VARIABLE FREQUENCY MOTOR CONTROLLERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 1. ABB
 2. Danfoss Inc.; Danfoss Drives Division
 3. Eaton
 4. Toshiba International Corporation
 5. Yaskawa Electric America, Inc; Drives Division
- B. Description: Enclosed variable frequency motor controllers shall be suitable for operation at the current, voltage, and horsepower of the motor being controlled as indicated in the schedules on the Drawings. Conform to requirements of NEMA ICS 3.1.
 1. Motors shall be inverter duty rated, per NEMA MG1 parts 30 and 31, for motor-drive compatibility.
- C. Ratings
 1. Input Voltage: VFCs must operate, without fault or failure, when voltage varies plus or minus 10% from rating.
 2. Input Frequency: VFCs must operate, without fault or failure, when frequency varies plus or minus 5% from rating.
 3. Displacement Power Factor: 0.98 over entire range of operating speed and load.
 4. Operating Ambient Temperature: VFCs must operate, without fault or failure, at ambient temperature conditions ranging from 14°F to 104°F. Above 104°F, the maximum output current shall be de-rated not more than 1% for every additional 1°C up to 50°C (122°F).
 5. Operating Ambient Humidity: VFCs must operate, without fault or failure, at ambient relative humidity conditions ranging from 5% to 95% non-condensing.
 6. Altitude: Up to 3,300-feet above sea level. At sites over 3300-feet above sea level, the maximum output current shall be de-rated not more than 1% for every additional 330-feet of elevation.
 7. Minimum Efficiency: 96% at half speed; 98% at full speed.
 8. Continuous Output Current, Variable Torque: 100% starting torque shall be available from 0.5 Hz. to 60 Hz.
 9. Short Term Overload Capacity, Variable Torque: 110% of rated FLA (Full Load Amps) for 60 seconds.
 10. Peak Overload Capacity, Variable Torque: 135% of rated FLA (Full Load Amps) instantaneously.
 11. Output Acceleration Time: Adjustable from 0 to 1800 seconds
 12. Output Deceleration Time: Adjustable from 0 to 1800 seconds
 13. The VFC must meet the requirements for Radio Frequency Interference (RFI) above 7 MHz as specified by FCC regulations, part 15, subpart J, Class A devices.
 14. VFCs must have a minimum short circuit rating of 65K amps RMS (100K amps RMS with a DC bus reactor) without additional input fusing.

15. Total Harmonic Distortion (THD) compliance: Given the information provided by the electric power single line diagram and distribution transformer data shown on the Bid Documents, the VFC manufacturer shall carry out an analysis of the system. The analysis reviews the potential for the proposed equipment, and any existing equipment, to meet IEEE 519 (tables 10.2 and 10.3) recommendations at the Point of Common Coupling (PCC). The result of the analysis shall determine if additional power quality improvement measures should be included in the proposal to meet the THD recommendations of IEEE 519. The PCC shall be at the primary side of the main distribution transformer.

D. Design

1. VFCs shall employ microprocessor-based inverter logic, isolated from all power circuits.
2. VFCs shall include surface mount technology with protective coating.
3. VFCs shall employ a PWM (Pulse Width Modulated) power electronic system, consisting of:
 - a. Input Section:
 - 1) VFC input power stage shall convert three-phase AC line power into a fixed DC voltage via a solid-state full wave diode rectifier, with MOV (Metal Oxide Varistor) surge protection.
 - b. Intermediate Section:
 - 1) DC bus as a supply to the VFC output Section shall maintain a fixed voltage with filtering and short circuit protection.
 - 2) DC bus shall be interfaced with the VFC diagnostic logic circuit, for continuous monitoring and protection of the power components.
 - 3) VFCs 40 HP and larger shall include a DC bus reactor to minimize reflected harmonics.
 - c. Output Section
 - 1) Insulated Gate Bipolar Transistors (IGBTs) shall convert DC bus voltage to variable frequency and voltage.
 - 2) The VFC shall employ PWM sine coded output technology to power the motor.
 - d. VFCs must be selected for operation at carrier frequencies at or above 500 Hz without derating to satisfy the conditions for current, voltage, and horsepower as indicated on the equipment schedule.
 - e. VFCs shall have an adjustable carrier frequency. The carrier frequency shall have a minimum of six settings to allow adjustment in the field.
 - f. Building Automation System (BAS) Interface: VFCs shall have embedded BAS protocols for network communications or be furnished with an interface device accessible via a RS-422/485 communication port to provide one **or more** of the following:
 - 1) A fully BACNet compatible VFC.
 - g. VFCs shall have a quick disconnect, removable control I/O terminal block to simplify control wiring procedures.
 - h. Analog Inputs: VFCs shall include two independent analog inputs as described below. Either input shall respond to a programmable bias and gain.
 - 1) One shall be 0-10 VDC.
 - 2) The other shall be programmable for either 0-10 VDC or 4-20 mA.
 - i. Digital Inputs: VFCs shall include a minimum of six multi-function digital input terminals, capable of being programmed to determine the function on a change of state. These terminals shall provide up to 30 functions, including, but not limited to:
 - 1) Remote/Local operation selection
 - 2) Detection of external fault condition
 - 3) Remote Reset
 - 4) Multi-step speed commands
 - 5) Run permissive
 - 6) Floating control

- j. Analog Outputs: VFCs shall include two 0-10 VDC or 4-20 mA analog outputs for monitoring or "speed tracking" the VFCS. The analog output signal will be proportional to output frequency, output current, output power, PI (Proportional & Integral control) feedback or DC bus voltage.
- k. VFCs shall provide terminals for remote input contact closure, to allow starting in the automatic mode.
- l. VFCs shall include a minimum three form "C" output relay contacts each capable of being programmed to determine conditions that must be met in order for them to change state. These output relay contacts shall be rated for at least 5A at 120 VAC and shall provide up to 18 functions, including, but not limited to:
 - 1) Speed agree detection.
 - 2) Low and high frequency detection.
 - 3) Missing frequency reference detection.
 - 4) Over torque/Under torque detection
 - 5) Drive Running
 - 6) Drive Faulted
- m. Power Loss Ride Through: VFCs shall include a power loss ride through of 2 seconds.
- n. VFCs shall have DC injection braking capability, to prevent fan "wind milling" at start or stop, adjustable, current limited.
- o. VFCs shall include diagnostic fault indication in selected language, last 10 faults storage and heatsink cooling fan operating hours.
- p. VFCs shall have a digital operator with program copy and storage functions to simplify set up of multiple drives. The digital operator shall be interchangeable for all drive ratings.
- q. User Control Panel (Keypad): VFCs shall include a front mounted, sealed keypad operator, with an English language (or one of 6 additional international languages) illuminated LCD display. The operator will provide complete programming, program copying, operating, monitoring, and diagnostic capability. Keys provided shall include industry standard commands for Hand, Off, and Auto functions. VFCs plain language display shall be viewed in an easy-to-read illuminated LCD with International language selectability and shall provide readouts of the following:
 - 1) Output frequency in hertz
 - 2) PI feedback in percent
 - 3) Output voltage in volts
 - 4) Output current in amps
 - 5) Output power in kilowatts
 - 6) D.C. bus voltage in volts
 - 7) Interface terminal status
 - 8) Heatsink temperature
 - 9) Fault conditions.
 - 10) The VFC unit shall include the following meters to estimate use of energy:
 - a) Elapsed Time Meter
 - b) Kilowatt Meter
 - c) Kilowatt Hour Meter
- r. PID Control: VFCs shall include PI control logic, to provide closed loop setpoint control capability, from a feedback signal, eliminating the need for closed loop output signals from a building automation system. The PI controller shall have a differential feedback capability for closed loop control of fans and pumps for pressure, flow or temperature regulation in response to dual feedback signals.
- s. Sleep Function: An energy saving sleep function shall be available in both open loop (follower mode) and closed loop (PI) control, providing significant energy savings while minimizing operating hours on driven equipment. When the sleep function senses a minimal deviation of a feedback signal from setpoint, or low demand in open loop control, the system shall react by stopping the driven equipment. Upon receiving an increase in speed command signal deviation, the drive and equipment shall resume normal operation.

- t. VFCs shall include the following motor control features:
- 1) 14 preset and 1 custom volts per hertz pattern. These shall include scalar and vector modes of motor control. Volts per hertz patterns shall also include linear and squared shapes.
 - 2) Energy optimization.
 - 3) IR compensation.
 - 4) Slip compensation
 - 5) Critical frequency rejection capability. A minimum of 3 selectable, adjustable dead bands shall be provided.
 - 6) Motor preheat function: VFCs shall have a motor preheat function to prevent moisture accumulation in an idle motor.
- u. VFCs shall include the following preprogrammed protection circuits:
- 1) Overcurrent.
 - 2) Short circuit.
 - 3) Overvoltage
 - 4) Under voltage
 - 5) Input phase loss
 - 6) Output device (IGBT) over temperature
 - 7) Current limit regulator adjustable from 30% to 200% of rated full load current of the VFC
 - 8) Electronic motor overload (UL 508C approved)
- v. VFCs shall include the following programmable fault functions for protection:
- 1) Electronic thermal overload protection for both the drive and motor. The electronic thermal motor overload shall be approved by UL.
 - 2) Loss of analog input signal protection, with a selectable response strategy including speed default to a percent of the most recent speed.
 - 3) Loss of panel
 - 4) External fault. VFCs shall include at least one external fault input, which shall be programmable for a normally open or normally closed contact. This terminal or terminals shall be used for connection of firestats, low temperature thermostats, high pressure limits or similar safety devices.
 - 5) Stall prevention
 - 6) Underload
 - 7) Motor phase loss
 - 8) Ground fault
- w. VFCs shall also include the following additional program functions:
- 1) Auto restart capability: 0 to 10 attempts with adjustable delay between attempts.
 - 2) Ability to close fault contact after the completion of all fault restart attempts.
 - 3) "S" curve soft start capability.
 - 4) Bi-directional "Speed search" capability, in order to start a rotating load.
 - 5) Heatsink over temperature speed fold back capability
 - 6) Terminal status indication.
 - 7) Program copy and storage in a removable digital operator.
 - 8) Motor pre-heat capability
 - 9) Input signal or serial communication loss detection and response strategy.
 - 10) Anti "wind-milling" function capability.
 - 11) Automatic energy saving function.
 - 12) Under torque/Over torque Detection.
 - 13) Preset speeds
- x. VFCs shall include factory settings for all parameters, and the capability for those settings to be reset.

- y. VFCs shall include user parameter initialization capability to re-establish project specific parameters
- z. The VFC shall include the capability to adjust the following functions, while the VFC is running:
 - 1) Speed command input.
 - 2) Acceleration adjustment from 0 to 1800 seconds.
 - 3) Deceleration adjustment from 0 to 1800 seconds.
 - 4) Select from 5 preset speeds.
 - 5) Analog monitor display.
 - 6) Removal of digital operator.

E. VFC Enclosures

- 1. NEMA 250, to comply with environmental conditions at installed location. All standard and additional features shall be included in a single enclosure with a UL certification label.
 - a. Dry and Clean Indoor Locations: NEMA 1 extended enclosure, to house additional equipment within the VFC enclosure for VFCs not requiring Bypass.

F. Additional Features

- 1. Input Disconnect: A VFC Input MCP circuit breaker/disconnect shall be provided.
- 2. Miscellaneous Accessories:
 - a. Miscellaneous control accessories such as relays, motor overloads and time delays shall be furnished integral with the VFC in order to provide proper operation and control of the VFC in accordance with the sequence of operation described in Division 23 Section 23 0993 "Sequence of Operation for HVAC Control."
 - b. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
 - 1) Each VFC that serves equipment specified or scheduled to be manually controlled shall be provided with a START-STOP push-button station.
 - 2) Each VFC that serves equipment specified or scheduled to be automatically controlled shall be provided with a HAND-OFF-AUTO selector switch.
 - 3) Each VFC shall be provided with red 'RUN' and green 'STOP' indicating lights.
- 3. Engraved Cabinet Nameplate: An engraved cabinet nameplate shall be provided for each VFC.
- 4. Three-Contactor Manual Bypass: The bypass shall be provided for each fan indicated to be provided with a VFC. The VFC and bypass components shall be mounted inside a common NEMA rated enclosure, fully pre-wired, and ready for installation as a single UL listed device. Refer to the "Enclosure" paragraph above for the enclosure required for each particular installation. The bypass shall include the following:
 - a. Input, output, and bypass contactors, to disconnect power to the VFC, when the motor is running in the bypass mode.
 - b. 120 VAC control transformer, with fused primary.
 - c. Magnetic overload relay, to protect the motor while operating in the bypass mode.
 - d. Circuit breaker/disconnect switch, with a pad-lockable through-the-door handle mechanism.
 - e. Control and safety circuit terminal strip.
 - f. Drive/Bypass selector switch, Hand/Off/Auto selector switch, Normal/Test selector switch
 - g. Switch selectable auto transfer to bypass and remote transfer functions.
 - h. Pilot lights (22 mm LEDs) for "Control Power ", "Drive Fault", "Drive Run", "Bypass Run", and "OL/Safety Fault".
 - i. Normal/Test selector switch, shall allow testing and adjustment of the VFC, while the motor is running in the bypass mode.
 - j. Hand/Off/Auto selector switch shall provide the following operation:
 - 1) Hand Position - The drive is given a start command; operation is via the local speed input (digital operator or speed pot.). If in bypass mode, the motor is running.
 - 2) Off Position - The start command is removed, all speed inputs are ignored, power is still applied to the drive. If in bypass mode, the motor is stopped.

- 3) Auto Position - The drive is enabled to receive a start command and speed input from a building automation system. If in bypass mode, the motor start/stop is controlled by the building automation system
- k. Annunciation contacts for drive run, drive fault, bypass run and motor OL/safety fault.
- l. Damper control circuit with end of travel feedback capability.
- m. VFC operator/keypad selection, LCD or LED types.
- n. H/O/A control panel selection, Touch pad or rotary switch types.
- 5. Line Reactors: 3% Line reactors shall be provided on the input side of the drive for harmonic suppression.
- 6. RFI (Radio Frequency Interference) Filters: RFI filters shall be provided to further attenuate possible VFC generated noise.
- 7. Analog Output: An additional analog output (4-20 mA) shall be provided to make available two analog current outputs.
- 8. Analog Meter: An analog meter shall be provided in addition to the digital keypad monitoring capabilities.
- 9. PC Software Cable: A PC software and cable shall be provided for parameter upload/download/graphing.

2.02 SOURCE QUALITY CONTROL

- A. In-circuit testing of all printed circuit boards shall be conducted, to insure the proper mounting and correct value of all components.
- B. All printed circuit boards shall be burned in for 96 hours, at 185°F.
- C. Final printed circuit board assemblies shall be functionally tested, via computerized test equipment. All tests and acceptance criteria shall be preprogrammed. All test results shall be stored as detailed quality assurance data.
- D. All fully assembled controls shall be functionally tested, with fully loaded induction motors. The combined test data shall then be analyzed, to insure adherence to quality assurance specifications.
- E. Inspect and production test, under load, each completed VFC assembly.

PART 3 - EXECUTION

3.01 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.
- 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. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 HARMONIC ANALYSIS STUDY

- A. Perform a harmonic analysis study to identify the effects of nonlinear loads and their associated harmonic contributions on the voltages and currents throughout the electrical system. Analyze possible operating scenarios, including recommendations for VFC input filtering to limit TDD and THD (V) at each VFC to specified levels.

- B. Prepare a harmonic analysis study and report complying with IEEE 399 and NETA Acceptance Testing Specification.

3.03 INSTALLATION

- A. Coordinate layout and installation of VFCs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Wall mounting Controllers: Install VFCs on walls with tops at uniform height and with disconnect operating handles not higher than 79 inches above finished floor unless otherwise indicated. Bolt units to wall or mount on lightweight structural steel channels bolted to wall. For controllers not mounted on walls, provide freestanding racks complying with Division 26.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in control circuits if not factory installed. Comply with requirements in Division 26.
- E. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.
- F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.
- G. Comply with NECA 1.

3.04 IDENTIFICATION

- A. Identify VFCs, components, and control wiring. Comply with requirements for identification specified in Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."
 - 1. Identify field installed conductors, interconnecting wiring, and components.
 - 2. Label each VFC with engraved nameplate.
 - 3. Label each enclosure mounted control and pilot device.

3.05 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices and facility's building automation system. Comply with requirements in Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic control devices where applicable. Refer to Division 23 Section 23 0993 "Sequence of Operation for HVAC Control" for requirements.

3.06 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

- B. 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.
- C. 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 Architect and Engineer before starting the motor(s).
 - 5. Test each motor for proper phase rotation.
 - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 8. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- D. VFCs will be considered defective if they do not pass tests and inspections.
- E. 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.

3.07 STARTUP SERVICE

- A. Engage a factory authorized service representative to perform startup service.
 - 1. Complete installation and startup check according to manufacturer's written instructions.

3.08 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. Set the taps on reduced voltage autotransformer controllers.
- D. Set field adjustable pressure switches.

3.09 DEMONSTRATION

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

END OF SECTION 23 0512

SECTION 23 0513 - COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes general requirements for single-phase and polyphase, general-purpose, horizontal, small and medium, squirrel cage induction motors for use on ac power systems up to 600 V and installed at equipment manufacturer's factory or shipped separately by equipment manufacturer for field installation.

1.03 COORDINATION

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

PART 2 - PRODUCTS

2.01 GENERAL MOTOR REQUIREMENTS

- A. Comply with requirements in this Section except when stricter requirements are specified in HVAC equipment schedules or Sections.
- B. Comply with NEMA MG 1 unless otherwise indicated.
- C. Efficiency: NEMA Premium efficiency, as defined in NEMA MG 1.
 - 1. Electric motors shall comply with the requirements of the Energy Policy Act of 1992.
 - 2. Motors that are single-speed, polyphase, 1-500 horsepower, 2, 4, and 6 pole, squirrel cage induction type, NEMA Design A or B, continuous rated shall be NEMA Premium efficiency electric motors.
 - a. NEMA Premium efficiency electric motors must meet or exceed the nominal energy efficiency levels presented below.
 - 1) The NEMA Premium efficiency levels are contained in NEMA Standards Publication MG 1-2006, in Tables 12-12 and 12-13, respectively.

2.02 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 104°F and at altitude of 3300 feet above sea level.
- B. Capacity and Torque Characteristics: Sufficient to start, accelerate, and operate connected loads at designated speeds, at installed altitude and environment, with indicated operating sequence, and without exceeding nameplate ratings or considering service factor.

2.03 POLYPHASE MOTORS

- A. Description: NEMA MG 1, Design B, medium induction motor.
- B. Service Factor: 1.15.
- C. Rotor: Random-wound, squirrel cage.
- D. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading.
- E. Temperature Rise: Match insulation requirements.
- F. Insulation: Class F.
- G. Code Letter Designation:
 - 1. Motors 15 HP and Larger: NEMA starting Code F or Code G.
 - 2. Motors Smaller than 15 HP: Manufacturer's standard starting characteristic.
- H. Enclosure Material: Cast iron for motor frame sizes 324T and larger; rolled steel for motor frame sizes smaller than 324T.

2.04 POLYPHASE MOTORS WITH ADDITIONAL REQUIREMENTS

- A. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features of motors shall be coordinated with the variable frequency controller manufacturer. Each motor shall be compatible with the variable frequency controller driving it.
 - 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.
 - 5. Shaft Grounding Ring: Provide for all motors 5 hp and greater.
 - a. General: Protects motor bearings from Electrical Discharge Machining (EDM), by discharging shaft currents to ground, via motor frame.
 - b. Type: Circumferential, with aluminum frame, and frictionless, conductive microfiber shaft brushes
 - c. Mounting Location: Drive end or non-drive end of motor; Internal to the motor frame; Installed by motor manufacturer
 - d. Maintenance Required: None
 - e. Service Life: Designed to last for service life of motor
 - f. RPM Limitation: None
 - g. Manufacturer: Aegis SGR, or approved equal

2.05 SINGLE PHASE MOTORS

- A. Motors larger than 1/20 HP shall be one of the following, to suit starting torque and requirements of specific motor application:
 - 1. Permanent-split capacitor.
 - 2. Split phase.
 - 3. Capacitor start, inductor run.
 - 4. Capacitor start, capacitor run.
- B. Multispeed Motors: Variable-torque, permanent-split-capacitor type.
- C. Bearings: Pre-lubricated, antifriction ball bearings or sleeve bearings suitable for radial and thrust loading.
- D. Motors 1/20 HP and Smaller: Shaded-pole type.
- E. Thermal Protection: Internal protection to automatically open power supply circuit to motor when winding temperature exceeds a safe value calibrated to temperature rating of motor insulation. Thermal-protection device shall automatically reset when motor temperature returns to normal range.
- F. Electronic Commutation (EC) Motors: Each EC motor shall be specifically designed for its particular application. EC motors shall be permanently lubricated, shall have heavy-duty ball bearings to match the load, and shall be prewired to the specific voltage and phase. EC motors shall have internal motor circuitry to convert AC power supplied to DC power in order to properly operate the motor. EC motors shall be capable of having their speed controlled down to 20% of full speed (80% turndown). EC motor speed shall be controlled by either a potentiometer dial mounted on the motor or by a 0-10 VDC signal. Each EC motor shall have a minimum efficiency of 85% at all speeds.

PART 3 - EXECUTION (Not Applicable)

END OF SECTION 23 0513

SECTION 23 0529 - HANGERS AND SUPPORTS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes the following hangers and supports for HVAC system piping and equipment:
 - 1. Steel pipe hangers and supports.
 - 2. Metal framing systems.
 - 3. Fastener systems.
 - 4. Equipment supports.

1.03 DEFINITIONS

- A. MSS: Manufacturers Standardization Society for The Valve and Fittings Industry Inc.
- B. Terminology: As defined in MSS SP-90, "Guidelines on Terminology for Pipe Hangers and Supports."

1.04 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water. Design of pipe supports shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components. Design of equipment supports shall be provided through the HVAC trade by a civil or structural Engineer who is registered in the Commonwealth of Pennsylvania.

1.05 SUBMITTALS

- A. Product data for the following:
 - 1. Steel pipe hangers and supports.
 - 2. Thermal hanger shield inserts.
 - 3. Powder actuated fastener systems.
 - 4. Trapeze pipe hangers. Include Product Data for components.
 - 5. Metal framing systems. Include Product Data for components.
 - 6. Equipment supports.

1.06 QUALITY ASSURANCE

- A. Welding - qualify procedures and personnel according to the following:
 - 1. AWS D1.1, "Structural Welding Code--Steel."
 - 2. AWS D1.2, "Structural Welding Code--Aluminum."
 - 3. AWS D1.3, "Structural Welding Code--Sheet Steel."
 - 4. AWS D1.4, "Structural Welding Code--Reinforcing Steel."
 - 5. ASME Boiler and Pressure Vessel Code: Section IX.

PART 2 - PRODUCTS

2.01 STEEL PIPE HANGERS AND SUPPORTS

- A. Description: MSS SP-58, Types 1 through 58, factory fabricated components. Refer to Part 3 "Hanger and Support Applications" article for where to use specific hanger and support types.
- B. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. AAA Technology & Specialties Co., Inc.
 - 2. B-Line Systems, Inc.; a division of Cooper Industries.
 - 3. ERICO/Michigan Hanger Company
 - 4. Globe Pipe Hanger Products, Inc.
 - 5. Grinnell Corporation
 - 6. GS Metals Corporation
 - 7. National Pipe Hanger Corporation
 - 8. PHD Manufacturing, Inc.
- C. Galvanized, Metallic Coatings: Pre-galvanized or hot dipped.
- D. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.02 TRAPEZE PIPE HANGERS

- A. Description: MSS SP-69, Type 59, shop or field fabricated pipe support assembly made from structural steel shapes with MSS SP-58 hanger rods, nuts, saddles, and U-bolts.

2.03 METAL FRAMING SYSTEMS

- A. Description: MFMA-3, shop- or field fabricated pipe support assembly made of steel channels and other components.
- B. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. B-Line Systems, Inc.; a division of Cooper Industries
 - 2. ERICO/Michigan Hanger Company; ERISTRUT Division
 - 3. GS Metals Corporation
 - 4. Power-Strut Division; Tyco International, Ltd.
 - 5. Thomas & Betts Corporation
 - 6. Tolco Inc.
 - 7. Unistrut Corp.; Tyco International, Ltd.

- C. Coatings
 - 1. General Areas: Manufacturer's standard finish, unless bare metal surfaces are indicated.

2.04 EQUIPMENT SUPPORTS

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

2.05 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- B. Grout: ASTM C 1107, factory mixed and packaged, dry, hydraulic cement, non-shrink and nonmetallic grout, suitable for interior and exterior applications.
 - 1. Properties: Non-staining, noncorrosive, and nongaseous.
 - 2. Design Mix: 5000-psi, 28-day compressive strength.

PART 3 - EXECUTION

3.01 HANGER AND SUPPORT APPLICATIONS

- A. Specific hanger and support requirements are specified in Sections specifying piping systems and equipment.
- B. Comply with MSS SP-69 for pipe hanger selections and applications that are not specified in piping system Sections.
- C. Use hangers and supports with galvanized, metallic coatings for piping and equipment that will not have field applied finish.
- D. Use nonmetallic coatings on attachments for electrolytic protection where attachments are in direct contact with copper tubing.
- E. Horizontal Piping Hangers and Supports - unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Adjustable, Steel Clevis Hangers (MSS Type 1): For suspension of non-insulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 - 2. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
- F. Vertical Piping Clamps - unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Extension Pipe or Riser Clamps (MSS Type 8): For support of pipe risers, NPS 3/4 to NPS 20.
 - 2. Carbon- or Alloy-Steel Riser Clamps (MSS Type 42): For support of pipe risers, NPS 3/4 to NPS 20, if longer ends are required for riser clamps.
- G. Hanger-Rod Attachments - unless otherwise indicated and except as specified in piping system Sections, install the following types:
 - 1. Steel Turnbuckles (MSS Type 13): For adjustment up to 6 inches for heavy loads.

- H. Building Attachments - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Steel or Malleable Concrete Inserts (MSS Type 18): For upper attachment to suspend pipe hangers from concrete ceiling.
 2. Top-Beam C-Clamps (MSS Type 19): For use under roof installations with bar-joist construction to attach to top flange of structural shape.
 3. C-Clamps (MSS Type 23): For structural shapes.
 4. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - b. Medium (MSS Type 32): 1500 lb.
 - c. Heavy (MSS Type 33): 3000 lb.
- I. Saddles and Shields - unless otherwise indicated and except as specified in piping system Sections, install the following types:
1. Protection Shields (MSS Type 40): Of length recommended in writing by manufacturer to prevent crushing insulation.
 2. Thermal hanger Shield Inserts: For supporting insulated pipe.
- J. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- K. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- L. Use powder actuated fasteners or mechanical expansion anchors instead of building attachments where required in concrete construction.

3.02 HANGER AND SUPPORT INSTALLATION

- A. Steel Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Install hangers, supports, clamps, and attachments as required to properly support piping from building structure.
1. Suspend hangers from building structural members and concrete floor slabs as follows:
 - a. Install hangers plumb and free from contact with objects within ceiling plenum that are not part of supporting structural system. Splay hangers only where required to miss obstructions and offset resulting horizontal forces by bracing, countersplaying, or other equally effective means.
 - b. Where width of ducts and other construction within ceiling plenum produces hanger spacings that interfere with location of hangers at spacings required to support standard suspension system members, install supplemental suspension members and hangers in form of trapezes or equivalent devices. Size supplemental suspension members and hangers to support loads within performance limits established by referenced standards.
 - c. Secure hangers either directly to structural steel or to inserts, eye screws, or other devices that are secure and appropriate for substrate, and in a manner that will not cause them to deteriorate or otherwise fail due to age, corrosion, or elevated temperatures.
 - d. Anchors must be installed in "rib" portion of metal deck/concrete slab (thickest portion of slab).
 - e. Do not attach hangers to steel deck tabs.
 - f. Do not attach hangers to steel roof deck. Provide supplemental framing between structural members where spacing of members exceeds required spacing of hangers.

- B. Trapeze Pipe Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Arrange for grouping of parallel runs of horizontal piping and support together on field fabricated trapeze pipe hangers.
1. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified above for individual pipe hangers.
 2. Field fabricate from ASTM A 36/A 36M, steel shapes selected for loads being supported. Weld steel according to AWS D1.1.
- C. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field assembled metal framing systems.
- D. Thermal hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
1. Install powder actuated fasteners for use in lightweight concrete or concrete slabs less than 4 inches thick in concrete after concrete is placed and completely cured. Use operators that are licensed by powder actuated tool manufacturer. Install fasteners according to powder actuated tool manufacturer's operating manual.
 2. Install mechanical-expansion anchors in concrete after concrete is placed and completely cured. Install fasteners according to manufacturer's written instructions.
- F. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- G. Equipment Support Installation: Fabricate from welded structural steel shapes.
- H. Install hangers and supports to allow controlled thermal movement of piping systems, to permit freedom of movement between pipe anchors, and to facilitate action of expansion joints, expansion loops, expansion bends, and similar units.
- I. Install lateral bracing with pipe hangers and supports to prevent swaying.
- J. Install building attachments within concrete slabs or attach to structural steel. Install additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2½ and larger and at changes in direction of piping. Install concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- K. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- L. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.9 (for building services piping) are not exceeded.
- M. Insulated Piping - comply with the following:
1. Attach clamps and spacers to piping.
 2. Insulation shall pass through pipe hangers and pipe clamps uninterrupted.
 3. Do not exceed pipe stress limits according to ASME B31.1 for power piping and ASME B31.9 for building services piping.
 4. Install MSS SP-58, Type 40, protective shields on cold piping with vapor barrier. Shields shall span an arc of 180 degrees.
 - a. Option: Thermal hanger shield inserts may be used. Include steel weight-distribution plate for pipe NPS 4 and larger if pipe is installed on rollers.

5. Shield Dimensions for Pipe - not less than the following:
 - a. NPS 1/4 to NPS 3-1/2: 12 inches long and 0.048 inch thick.
6. Pipes NPS 8 and Larger: Include wood inserts.
7. Insert Material: Length at least as long as protective shield.
8. Thermal hanger Shields: Install with insulation same thickness as piping insulation.

3.03 EQUIPMENT SUPPORTS

- A. Fabricate structural steel stands to suspend equipment from structure overhead or to support equipment above floor.
- B. Grouting: Place grout under supports for equipment and make smooth bearing surface.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.04 METAL FABRICATIONS

- A. Cut, drill, and fit miscellaneous metal fabrications for trapeze pipe hangers and equipment supports.
- B. Fit exposed connections together to form hairline joints. Field weld connections that cannot be shop welded because of shipping size limitations.
- C. Field Welding: Comply with AWS D1.1 procedures for shielded metal arc welding, appearance and quality of welds, and methods used in correcting welding work, and with the following:
 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 2. Obtain fusion without undercut or overlap.
 3. Remove welding flux immediately.
 4. Finish welds at exposed connections so no roughness shows after finishing and contours of welded surfaces match adjacent contours.

3.05 ADJUSTING

- A. Hanger Adjustments: Adjust hangers to distribute loads equally on attachments and to achieve indicated slope of pipe.
- B. Trim excess length of continuous-thread hanger and support rods to 1½-inches. Coordinate with ceiling height and trim

3.06 PAINTING

- A. Touch Up: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 23 0529

SECTION 23 0548.13 - VIBRATION CONTROLS FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Isolation pads.
 - 2. Restrained spring isolators.
 - 3. Spring hangers.

1.03 DEFINITIONS

- A. IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.04 SUBMITTALS

- A. Product Data: Include rated load, rated deflection, and overload capacity for each vibration isolation device. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of isolation device component used.

PART 2 - PRODUCTS

2.01 VIBRATION ISOLATORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Amber/Booth Company, Inc.
 - 2. Kinetics Noise Control
 - 3. Mason Industries
 - 4. Vibration Eliminator Co., Inc.
 - 5. Vibration Isolation
 - 6. Vibration Mountings & Controls, Inc.
- B. Pads: Arranged in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized steel baseplates, and factory cut to sizes that match requirements of supported equipment.
 - 1. Resilient Material: Oil- and water-resistant neoprene or rubber.

- C. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with limit-stop restraint.
 - 1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to 1/4-inch thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 - 2. Restraint: Limit stop restraint as required for equipment to resist wind forces.
 - 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
- D. Spring Hangers: Combination coil-spring and elastomeric-insert hanger with spring and insert in compression.
 - 1. Frame: Steel, fabricated for connection to threaded hanger rods and to allow for a maximum of 30 degrees of angular hanger-rod misalignment without binding or reducing isolation efficiency.
 - 2. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 - 3. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 - 4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 - 5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 - 6. Elastomeric Element: Molded, oil-resistant rubber or neoprene. Steel-washer-reinforced cup to support spring and bushing projecting through bottom of frame.
 - 7. Self-centering hanger rod cap to ensure concentricity between hanger rod and support spring coil.

2.02 FACTORY FINISHES

- A. Finish: Manufacturer's standard prime coat finish ready for field painting.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and wind-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 VIBRATION CONTROL DEVICE INSTALLATION

- A. Comply with requirements in Division 07 Section "Roof Accessories" for installation of roof curbs, equipment supports, and roof penetrations.
- B. Install bushing assemblies for anchor bolts for floor-mounted equipment, arranged to provide resilient media between anchor bolt and mounting hole in concrete base.
- C. Install bushing assemblies for mounting bolts for wall mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

- D. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.
- E. Drilled-in Anchors:
 - 1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid pre-stressed tendons, electrical and telecommunications conduit, and gas lines.
 - 2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
 - 3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
 - 4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
 - 5. Set anchors to manufacturer's recommended torque, using a torque wrench.
 - 6. Install zinc-coated steel anchors for interior and stainless steel anchors for exterior applications.

3.03 ADJUSTING

- A. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- B. Adjust active height of spring isolators.
- C. Adjust restraints to permit free movement of equipment within normal mode of operation.

3.04 VIBRATION CONTROLS SCHEDULE

- A. Vibration Isolators
 - 1. Pads - provide vibration isolation pads for the following:
 - a. Each condensing unit having a capacity of 3-tons or less.
 - 2. Restrained Spring Isolators - provide restrained spring isolators for the following:
 - a. Each pad mounted air handling unit.
 - b. Each condensing unit having a capacity of 3½-tons or greater.
 - 3. Spring Hangers - provide spring hangers for the following:
 - a. Each in-line supply, return or exhaust fan.
 - b. Each suspended cabinet unit heater.

END OF SECTION 23 0548.13

SECTION 23 0553 - IDENTIFICATION FOR HVAC PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes:
 - 1. Equipment labels
 - 2. Duct labels
 - 3. Pipe labels

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Valve Schedules: For each piping system to include in maintenance manuals.

1.04 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

2.01 EQUIPMENT LABELS

- A. Metal Labels for Equipment: Provide metal labels containing equipment performance data if not furnished and attached to the equipment item at the factory.
 - 1. Material and Thickness: Aluminum, 0.032-inch or anodized aluminum, 0.032-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 - 3. Minimum Letter Size: 1/4 inch.
 - 4. Fasteners: Stainless steel rivets or self-tapping screws.
 - 5. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 - 6. Label Content: Include equipment's performance data including capacity and electrical data.

- B. Plastic Labels for Equipment: Provide plastic label for each HVAC equipment item.
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°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: 1/2 inch for viewing distances up to 72 inches.
 7. Fasteners: Stainless steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 9. Label Content: Include equipment's drawing designation or unique equipment number.

2.02 DUCT LABELS

- A. Plastic Labels for Ducts and Duct Access Doors: Provide a plastic label for each duct access door and provide a label intermittently on each duct to identify the duct.
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°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: 1/2 inch for viewing distances up to 72 inches.
 7. Fasteners: Stainless steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
 9. Label Content: Include identification of device located behind duct access door using same designations as used on Drawings, duct size, and an arrow indicating flow direction.
 - a. 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.
 - b. Lettering Size: At least 1/2 inch high.

2.03 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/or pipe insulation, 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.

PART 3 - EXECUTION

3.01 PREPARATION

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

3.02 EQUIPMENT LABEL INSTALLATION

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

3.03 DUCT LABEL INSTALLATION

- A. Install or permanently fasten labels on the exterior of each duct access door that serves a fire damper, smoke damper, or combination fire/smoke damper.
- B. Label shall read "Fire Damper" or Fire/Smoke Damper" or "Smoke Damper" as applicable.
- C. Locate equipment labels where accessible and visible.

3.04 PIPE LABEL INSTALLATION

- A. Stenciled Pipe Label Option: Stenciled labels may be provided in lieu of pre-tensioned type pipe labels, at Installer's option. Install stenciled pipe labels with painted, color-coded bands on each piping system in accordance with the color schedule described herein. The stenciled pipe labels shall include identification of piping service using same designations or abbreviations as used on Drawings, pipe size, and an arrow indicating flow direction; and, shall be the minimum size indicated for the self-adhesive type pipe labels.
 - 1. Identification Paint: Use for contrasting background.
 - 2. Stencil Paint: Use for pipe marking.
- 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 25 feet along each run.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
- C. Pipe Label Color Schedule
 - 1. Coil Condensate Drain Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.

2. Refrigerant Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.

END OF SECTION 23 0553

SECTION 23 0593 - TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes
 - 1. Balancing Air Systems:
 - a. Constant volume air systems.
 - b. Variable air volume systems.

1.03 DEFINITIONS

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

1.04 SUBMITTALS

- A. Certified TAB reports.
- B. 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.

1.05 QUALITY ASSURANCE

- A. TAB Contractor Qualifications: Engage a TAB entity certified by NEBB, AABC, or TABB.
 - 1. TAB Field Supervisor: Employee of the TAB contractor and certified by NEBB, AABC, or TABB.
 - 2. TAB Technician: Employee of the TAB contractor and who is certified by NEBB, AABC, or TABB as a TAB technician.
- B. TAB Conference: Meet with Architect, Owner, Construction Manager, and Commissioning Agent on approval of the TAB strategies and procedures plan to develop a mutual understanding of the details. Require the participation of the TAB field supervisor and technicians. Provide fourteen (14) days advance notice of scheduled meeting time and location.
 - 1. Agenda Items:
 - a. The Contract Documents examination report.
 - b. The TAB plan.
 - c. Coordination and cooperation of trades and subcontractors.
 - d. Coordination of documentation and communication flow.
- C. 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.
- D. TAB Report Forms: Use standard TAB contractor's forms published by AABC or NEBB.
- E. Instrumentation Type, Quantity, Accuracy, and Calibration: As described in ASHRAE 111, Section 5, "Instrumentation."

1.06 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.

1.07 COORDINATION

- A. Notice: Provide seven (7) days advance notice to the Contractor and Owner prior to commencement of TAB work. Include scheduled test dates and times. Provide seven (7) days advance notice to any changes in the scheduled dates and times.
- B. Perform TAB after leakage and pressure tests on air distribution systems have been satisfactorily completed.
- C. Coordinate with ATC Contractor to balance VAV box and AHU damper positions. Pay particular attention to AHU minimum outside air damper position as listed in Division 23 Section 23 0993 "Sequence of Operations for HVAC Control."

1.08 TAB SPECIALISTS

- A. Subject to compliance with requirements, engage one of the following independent TAB contractors to provide the TAB work:
 - 1. Kahoe Air Balance Company
 - 2. Northstar Environmental, Ltd.
 - 3. WAE Balancing, Inc.

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 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. Notify contractor, Architect and Engineer immediately upon discovery of any deficiencies.
- B. Examine systems for installed balancing devices, such as test ports, gauge cocks, thermometer wells, flow control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are accessible. Notify contractor immediately upon discovery of any balancing devices not present that will prevent balancing of the system.
- C. Examine the approved submittals for HVAC systems and equipment.
- D. Examine ceiling plenums used for supply, return, or relief air to verify that they meet the leakage class of connected ducts as specified in Division 23 Section 23 3113 "Metal Ducts" and are properly separated from adjacent areas. Verify that penetrations in plenum walls are sealed and fire-stopped if required.
- E. Verify that transfer ducts or penetrations in plenum walls exist to enable air flow through plenum as indicated or required.
- F. Examine equipment performance data including fan and pump curves.
- G. Obtain and examine start-up test reports to verify that start-up testing, cleaning, and adjusting of HVAC equipment and systems have been performed prior to the commencement of TAB work.
- 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 suspended equipment, such as variable air volume boxes, in-line fans, etc., and verify that they are accessible and their controls are connected and functioning.
- J. Examine operating safety interlocks and controls on HVAC equipment.
- K. Report deficiencies discovered before and during performance of TAB procedures to the contractor, Architect and Engineer.

3.02 PREPARATION

- A. Complete system-readiness checks. Verify the following:
 - 1. Permanent electrical power wiring is complete.
 - 2. Automatic temperature-control systems are operational.
 - 3. Equipment and duct access doors are securely closed.
 - 4. Balancing, smoke, and fire dampers are open.
 - 5. Ceilings are installed in critical areas where air pattern adjustments are required and access to balancing devices is provided.
 - 6. Windows and doors can be closed so indicated conditions for system operations can be met.

3.03 GENERAL PROCEDURES FOR TESTING, ADJUSTING AND BALANCING

- A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance," NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems," or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing," and the requirements contained in this Section.
- B. Cut insulation, ducts, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures.
 - 1. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts.
 - 2. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to Division 23 Section 23 0713 "Duct Insulation".
- C. Mark equipment and balancing devices, including damper control positions, 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.

3.04 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 233113 "Metal Ducts."

3.05 PROCEDURES FOR CONSTANT VOLUME AIR SYSTEMS

- A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.
 - 1. Measure total airflow at outlet of supply fans or inlet of exhaust fans using Pitot-tube traverse measurements.
 - 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, and other air handling and treating equipment.
 - a. Report the cleanliness status of filters at the time static pressures are measured.
 - 4. For each fan on the project, make adjustment of fan speed higher or lower than scheduled speed in order to achieve design airflow rates. 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.
 - a. For each belt driven fan, provide one complete belt and sheave change in order to balance the fan to the design airflow rate.
 - b. 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 at terminal outlets and inlets without making adjustments and calculate the total airflow for that zone.
 - a. Measure terminal outlets using a direct reading hood or outlet manufacturer's written instructions and calculating factors.
 - 2. Adjust volume dampers until the proper airflow rate for that zone is achieved.
 - 3. Re-measure each sub-main and branch duct after all have been adjusted. Continue to adjust submain and branch ducts to indicated airflows within specified tolerances.
- C. Adjust air outlets and inlets for each space to indicated airflows within specified tolerances of indicated values. Make adjustments using branch volume dampers rather than extractors and the dampers at air terminals.
 - 1. Adjust each outlet in same room or space to within specified tolerances of indicated quantities without generating noise levels above the limitations prescribed by the Contract Documents.
 - 2. Adjust patterns of adjustable outlets for proper distribution without drafts.

3.06 PROCEDURES FOR VARIABLE AIR VOLUME SYSTEMS

- A. Compensating for Diversity: When the total airflow of all terminal units is more than the indicated airflow of the fan, place a selected number of terminal units at a minimum set-point airflow with the remainder at maximum-airflow condition until the total airflow of the terminal units equals the indicated airflow of the fan. Select the reduced airflow terminal units so they are distributed evenly among the branch ducts.
- B. Pressure Independent, Variable air volume Systems - after the fan systems have been adjusted, adjust the variable air volume systems as follows:
 - 1. Set outdoor air dampers at minimum, and set return and exhaust air dampers at a position that simulates full-cooling load.
 - 2. Select the terminal unit that is most critical to the supply fan airflow and static pressure. Measure static pressure. Adjust system static pressure so the entering static pressure for the critical terminal unit is not less than the sum of the terminal unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal unit discharge system losses.
 - 3. Measure total system airflow. Adjust to within indicated airflow.
 - 4. Set terminal units at maximum airflow and adjust controller or regulator to deliver the designed maximum airflow. Use terminal unit manufacturer's written instructions to make this adjustment. When total airflow is correct, balance the air outlets downstream from terminal units the same as described for constant volume air systems.
 - 5. Set terminal units at minimum airflow and adjust controller or regulator to deliver the designed minimum airflow. Check air outlets for a proportional reduction in airflow the same as described for constant volume air systems.
 - a. If air outlets are out of balance at minimum airflow, report the condition but leave outlets balanced for maximum airflow.
 - 6. Re-measure the return airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.
 - a. Adjust the fan and balance the return air ducts and inlets the same as described for constant volume air systems.
 - 7. Measure static pressure at the most critical terminal unit and adjust the static pressure controller at the main supply air sensing station to ensure that adequate static pressure is maintained at the most critical unit.
 - 8. Record final fan performance data.

3.07 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.

3.08 PROCEDURES FOR CONDENSING UNITS

- A. Verify proper rotation of fans.
- B. Record compressor data.

3.09 TOLERANCES

- A. Set HVAC system's air flow rates within the following tolerances:
 - 1. Supply, Return, Relief and Exhaust Fans and Equipment with Fans: Zero to plus 5 percent of scheduled design flow.
 - 2. Air Outlets and Inlets: Plus, or minus 10 percent of design flow indicated.

3.10 FINAL REPORT

- A. General: Prepare a certified written report; tabulate and divide the report into separate sections for tested systems and balanced systems.
 - 1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
 - 2. Include a list of instruments used for procedures, along with proof of calibration.
 - 3. Not all components listed below apply to this project. Provide data for each existing component, or component furnished to the jobsite as applicable.
- B. Final Report Contents - in addition to certified field report data, include the following:
 - 1. Field test reports (start-up reports) prepared by system and equipment installers.
 - 2. Other information relative to equipment performance such as fan curves and pump curves; 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.
 - 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 fan 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. Variable frequency drive settings for variable air volume systems.
- e. Settings for supply air, static pressure controller.
- f. Other system operating conditions that affect performance.

D. Air handling unit Test Reports - 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.

2. Fan data - for each fan, include the following:

- a. Fan sheave make, size in inches and bore.
- b. Center-to-center dimensions of sheave, and amount of adjustments in inches.
- c. Number, make, and size of belts.
- d. Number, type, and size of filters.

3. Motor data - for each motor, include the following:

- 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. Motor sheave make, size in inches and bore.
- f. Center-to-center dimensions of fan and motor sheaves, and amount of adjustments in inches.

4. Gas fired Heat Exchanger Data - for each gas-fired heat exchanger in rooftop units, include the following:

- a. Location.
- b. Make and type.
- c. Fuel type.
- d. Output capacity in Btu/h.
- e. Ignition type.
- f. Burner control types.
- g. Burner motor volts, phase, hertz, rpm and horsepower.

5. Unit Test Data (Indicated and Actual Values):

- a. Total air flow rate in cfm.
- b. Outdoor airflow in cfm.
- c. Return airflow in cfm.
- d. Total system static pressure in inches wg.
- e. Fan rpm for each fan.
- f. Voltage at each connection.
- g. Amperage for each phase.
- h. Unit discharge static pressure in inches wg.

- i. Unit inlet static pressure in inches wg.
 - j. Filter static pressure differential in inches wg for each filter bank.
 - k. Outdoor air damper position.
 - l. Return air damper position.
 - m. Relief-air damper position.
 - n. Variable frequency drive speed (for each fan).
 - 6. Gas fired Heat Exchanger Test Data (Indicated and Actual Values):
 - a. Air static pressure differential in inches wg.
- E. Terminal Equipment Unit (With Fan) Test Reports: For cabinet unit heaters and unit heaters, 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.
 - 2. Motor data include the following:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - 3. Coil data - for each coil, include the following:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Number of rows.
 - e. Rated voltage and amperage of each phase.
 - f. Capacity in KW.
 - 4. Unit Test Data (Indicated and Actual Values):
 - a. Total air flow rate in cfm.
 - b. Fan rpm.
 - c. Voltage at each connection.
 - d. Amperage for each phase.
 - 5. Electric Coil Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Air velocity in fpm.
 - c. Voltage at each connection.
 - d. Amperage for each phase.
- F. Terminal Equipment Unit (Without Fan) Test Reports - for convectors, and radiant ceiling panels, include the following:
- 1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Make and model number.

G. Apparatus Coil Test Reports - for VAV terminal boxes with reheat coils, include the following:

1. Coil Data:
 - a. System identification.
 - b. Location.
 - c. Coil type.
 - d. Make and model number.
 - e. Face area in sq. ft.
 - f. Rated voltage and amperage of each phase.
 - g. Capacity in KW.
 - h. Voltage at each connection.
 - i. Amperage for each phase.

H. Fan Test Reports - for all fans external to air handling units, rooftop units and terminal equipment such as exhaust fans, in-line supply and return fans, and wall mounted supply fans, include the following:

1. Fan Data:
 - a. System identification.
 - b. Location.
 - c. Make and type.
 - d. Model number and size.
 - e. Manufacturer's serial number.
 - f. Arrangement and class.
 - g. Sheave make, size in inches and bore.
 - h. Center-to-center dimensions of sheave, and amount of adjustments in inches.
2. Motor Data:
 - a. Motor make, and frame type and size.
 - b. Horsepower and rpm.
 - c. Volts, phase, and hertz.
 - d. Full-load amperage and service factor.
 - e. Sheave make, size in inches and bore.
 - f. Center-to-center dimensions of sheave, and amount of adjustments in inches.
 - g. Number, make, and size of belts.
3. Test Data (Indicated and Actual Values):
 - a. Total airflow rate in cfm.
 - b. Total system static pressure in inches wg.
 - c. Fan rpm.
 - d. Voltage at each connection.
 - e. Amperage for each phase.
 - f. Discharge static pressure in inches wg.
 - g. Suction static pressure in inches wg.

I. Round, and Rectangular Duct Traverse Reports: For main supply and return ducts for each system, 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 degree F.
 - d. Duct static pressure in inches wg.
 - e. Duct size in inches.
 - f. Duct area in square feet

- 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.
- k. Barometric pressure in psig.

J. Air Terminal Device Reports - for each diffuser, register and grille, include the following:

- 1. Unit Data:
 - a. System and air handling unit identification.
 - b. Location and zone.
 - c. Apparatus used for test.
 - d. Area served.
 - e. Make.
 - f. Number from system diagram.
 - g. Type and model number.
 - h. Size.
 - i. Effective area in square feet.
 - j. Design air flow rate in cfm.
- 2. Test Data (Indicated and Actual Values):
 - a. Air flow rate in cfm.
 - b. Air velocity in fpm.
 - c. Preliminary air flow rate in cfm.
 - d. Preliminary velocity in fpm.
 - e. Final air flow rate in cfm.
 - f. Final velocity in fpm.

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.

3.11 INSPECTIONS

A. Owner Inspection

- 1. After testing and balancing work is complete and accurately documented in the final report, the TAB subcontractor shall request that a final inspection be made by the Owner or his representative.
- 2. The TAB subcontractor shall conduct the inspection in the presence of the Owner or his representative.
- 3. The Owner or his representative will randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 15 percent of the total measurements recorded.
- 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.

- B. TAB Work will be considered defective if it does not pass the Owner inspection. If the 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 Owner inspection.
 - 2. If the second Owner inspection also fails, Owner may request the HVAC Trade to contract the services of another TAB subcontractor to complete TAB Work according to the Contract Documents or the Owner may contract the services of another TAB subcontractor to complete TAB Work according to the Contract Documents and deduct the cost of the services from the HVAC contractor's final payment.
- C. Prepare test and inspection reports.

3.12 ADDITIONAL TESTS

- A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.
- B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION 23 0593

SECTION 23 0713 - DUCT INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes
 - 1. Insulation Materials:
 - a. Mineral fiber.
 - 2. Adhesives.
 - 3. Mastics.
 - 4. Lagging adhesives.
 - 5. Sealants.
 - 6. Factory applied jackets.
 - 7. Field applied fabric reinforcing mesh.
 - 8. Field applied cloths.
 - 9. Field applied jackets.
 - 10. Tapes.
 - 11. Securements.
 - 12. Corner angles.

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

- A. Fire test response Characteristics: Insulation and related materials shall have fire test response characteristics indicated below as tested in accordance with ASTM E 84.
 - 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.
- B. Underwriters Laboratories (UL):
 - 1. UL 181 - Standards for Factory Made Air Ducts and Air Connectors.
 - 2. UL 723 - Standard Test Method for Surface Burning Characteristics of Building Materials.

1.05 COORDINATION

- A. 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.

PART 2 - PRODUCTS

2.01 INSULATION MATERIALS

- A. Comply with requirements in Part 3 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. Mineral fiber Blanket Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type III with factory applied FSK jacket. Factory applied jacket requirements are specified in "Factory applied Jackets" article.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. CertainTeed Corp.; Duct Wrap.
 - b. Johns Manville; Microlite.
 - c. Knauf Insulation; Duct Wrap.
 - d. Manson Insulation Inc.; Alley Wrap.
 - e. Owens Corning; All-Service Duct Wrap.
- F. Mineral fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 612, Type IA or Type IB. For duct and plenum applications, provide insulation with factory applied FSK jacket. Factory applied jacket requirements are specified in "Factory applied Jackets" article.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. CertainTeed Corp.; Commercial Board
 - b. Fibrex Insulations Inc.; FBX
 - c. Knauf Insulation; Insulation Board
 - d. Johns Manville; 800 Series Spin-Glas.
 - e. Manson Insulation Inc.; AK Board
 - f. Owens Corning; Fiberglas 700 Series

2.02 ADHESIVES

- A. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated, unless otherwise indicated.
- B. Mineral fiber adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-82.

- b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.
- C. FSK Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-82.
 - b. Foster Products Corporation, H. B. Fuller Company; 85-20.
 - c. ITW TACC, Division of Illinois Tool Works; S-90/80.
 - d. Marathon Industries, Inc.; 225.
 - e. Mon-Eco Industries, Inc.; 22-25.

2.03 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20° to plus 180°F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.

2.04 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-76-8.
 - b. Foster Products Corporation, H. B. Fuller Company; 95-44.
 - c. Marathon Industries, Inc.; 405.
 - d. Mon-Eco Industries, Inc.; 44-05.
 - e. Vimasco Corporation; 750.
 - 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°F.
 - 5. Color: Aluminum.

2.05 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.

2.06 FIELD APPLIED JACKETS

- A. Field applied jackets shall comply with ASTM C 921, Type I, for ducts operating at below ambient temperatures]and Type II, for ducts operating at above ambient temperatures.

2.07 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 the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0827.
 - b. Compac Corp.; 110 and 111.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 491 AWF FSK.
 - d. Venture Tape; 1525 CW, 1528 CW, and 1528 CW/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.

2.08 SECUREMENTS

- A. Insulation Pins and Hangers
 - 1. Capacitor Discharge Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor discharge welding, minimum 0.106-inch diameter shank, length, to suit depth of insulation indicated.
 - a. Products - subject to compliance with requirements, provide the following:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; CD.
 - 3) Midwest Fasteners, Inc.; CD.
 - 4) Nelson Stud Welding; TPA, TPC, and TPS.
 - 2. Cupped-Head, Capacitor Discharge Weld Pins: Copper- or zinc-coated steel pin, fully annealed for capacitor discharge welding, minimum 0.106-inch diameter shank diameter shank, length to suit depth of insulation indicated with integral 1-1/2-inch galvanized carbon steel washer.
 - a. Products - subject to compliance with requirements, provide the following:
 - 1) AGM Industries, Inc.; CWP-1.
 - 2) GEMCO; Cupped Head Weld Pin.
 - 3) Midwest Fasteners, Inc.; Cupped Head.
 - 4) Nelson Stud Welding; CHP.

- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.
 - 1. Manufacturers - subject to compliance with requirements, provide the following:
 - a. C & F Wire
 - b. Childers Products
 - c. PABCO Metals Corporation
 - d. RPR Products, Inc.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment 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.

3.02 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless steel surfaces, use demineralized water.

3.03 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, forms, vapor barriers or retarders, jackets, and thicknesses required for each duct system as specified in the 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, and other projections with vapor barrier mastic.
- 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. Install insulation with longitudinal seams at bottom of duct. 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 as recommended by insulation material manufacturer 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.
- O. For above ambient services, do not install insulation to the following:
 - 1. Vibration control devices.
 - 2. Testing agency labels and stamps.
 - 3. Nameplates and data plates.

3.04 PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. For applications requiring only indoor insulation, terminate insulation above roof surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof flashing with flashing sealant.
- B. Insulation Installation at 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. 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. Comply with requirements in Division 07 for fire-stopping and fire-resistive joint sealers.

D. Insulation Installation at Floor Penetrations:

1. Duct: Install insulation continuously through floor penetrations that are not fire rated. 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."

3.05 MINERAL FIBER INSULATION INSTALLATION

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

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, place pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over compress insulation during installation.
 - e. Impale insulation over pins and attach speed washers.
 - f. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 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°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 2 times the insulation thickness but not less than 3 inches.
5. Overlap unfaced blankets a minimum of 2 inches on longitudinal seams and end joints. At end joints, secure with steel bands spaced a maximum of 18 inches o.c.
6. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
7. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

B. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 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 duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
 - b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
 - c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - d. Do not over compress insulation during installation.
 - e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.
4. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from 1 edge and 1 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°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 2 times the insulation thickness but not less than 3 inches.
5. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.
6. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.

3.06 FIELD APPLIED JACKET INSTALLATION

- A. Where FSK jackets are indicated, install as follows:
 1. Draw jacket material smooth and tight.
 2. Install lap or joint strips with same material as jacket.
 3. Secure jacket to insulation with manufacturer's recommended adhesive.
 4. Install jacket with 1-1/2-inch laps at longitudinal seams and 3-inch-wide joint strips at end joints.
 5. Seal openings, punctures, and breaks in vapor retarder jackets and exposed insulation with vapor barrier mastic.

3.07 INSULATION SCHEDULE FOR DUCTS AND PLENUMS INSTALLED INDOORS

- A. Supply Air Ducts
 1. Concealed; round and transition duct insulation shall be the following:
 - a. Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
 2. Concealed; rectangular; duct insulation shall be the following:
 - a. Ductwork shall be internally insulated. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.

3. Exposed, round and transition, duct insulation shall be the following:
 - a. Ductwork shall be the double wall insulated type. Refer to Division 23 Section 23 3113 "Metal Ducts" for double wall duct requirements.
 4. Exposed; rectangular; supply air duct insulation shall be the following:
 - a. Ducts located in Mechanical Equipment Rooms:
 - 1) Ductwork shall be internally insulated. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.
 - b. Ducts located in all spaces, except Mechanical Equipment Rooms:
 - 1) Ductwork shall be internally insulated. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.
- B. Outdoor Air Ducts
1. Concealed or exposed; rectangular; outdoor air duct and plenum insulation shall be the following:
 - a. Mineral fiber Board: 2 inches thick and 3.0-lb/cu. ft. nominal density.
- C. Combustion Air Ducts
1. Concealed or exposed; rectangular; outdoor air duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
- D. Return Air Ducts
1. Concealed or exposed, rectangular, duct insulation shall be the following:
 - a. Ductwork shall be internally insulated for a distance of 50 feet upstream of the air handling unit or rooftop air handling unit. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.
- E. Exhaust Air Ducts - General Purpose
1. Concealed; rectangular; duct and plenum insulation, installed between the exhaust air louver or exhaust air gravity roof hood and a point 24-inches upstream of the automatic air damper, shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.
 2. Exposed; rectangular; duct and plenum insulation, installed between the exhaust air louver or exhaust air gravity roof hood and a point 24-inches upstream of the automatic air damper, shall be the following:
 - a. Mineral fiber Board: 2 inches thick and 3.0-lb/cu. ft. nominal density.
- F. Relief Air Ducts
1. Concealed; rectangular; duct and plenum insulation, installed between the relief air louver or relief air gravity roof hood and a point 24-inches upstream of the automatic-air damper, shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.
 2. Exposed; rectangular; duct and plenum insulation, installed between the relief air louver or relief air gravity roof hood and a point 24-inches upstream of the automatic-air damper, shall be the following:
 - a. Mineral fiber Blanket: 1-1/2 inches thick and 1.5-lb/cu. ft. nominal density.
 - 1) Provide a field applied jacket. Jacket shall be capable of being field painted. Refer to "Field applied Jacket Schedule for Ducts Installed Indoors" article in this section for requirements.
 - b. Mineral fiber Board: 2 inches thick and 3.0-lb/cu. ft. nominal density.

G. Transfer Air Ducts

1. Concealed or exposed, rectangular, duct insulation shall be the following:
 - a. Ductwork shall be internally insulated. Refer to Division 23 Section 23 3113 "Metal Ducts" for duct liner requirements.

H. Combustion Air Ducts

1. Concealed or exposed; round or rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.
 - 1) Provide a field applied jacket. Jacket shall be capable of being field painted. Refer to "Field applied Jacket Schedule for Ducts Installed Indoors" article in this section for requirements.

3.08 INSULATION SCHEDULE FOR DUCTS AND PLENUMS INSTALLED IN ATTIC SPACES

A. Supply air, duct insulation shall be the following:

1. Round, flat-oval and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. minimum nominal density.

B. Return air duct insulation shall be the following:

1. Round, flat-oval and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. minimum nominal density.

C. Exhaust air duct insulation shall be the following:

1. Round, flat-oval and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. minimum nominal density.

D. Relief air duct insulation shall be the following:

1. Round, flat-oval and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. minimum nominal density.

E. Outdoor air duct insulation shall be the following:

1. Round, flat-oval and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber blanket: 2 inches thick and 1.50 lb./cu. feet minimum nominal density.

F. Combustion Air Ducts:

1. Round and rectangular; duct and plenum insulation shall be the following:
 - a. Mineral fiber Blanket: 2 inches thick and 1.50-lb/cu. ft. nominal density.

END OF SECTION 23 0713

SECTION 23 0719 - HVAC PIPING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes
 - 1. Insulation Materials:
 - a. Flexible elastomeric.
 - 2. Adhesives.
 - 3. Mastics.
 - 4. Lagging adhesives.
 - 5. Sealants.
 - 6. Factory applied jackets.
 - 7. Field applied jackets.
 - 8. Tapes.
 - 9. Securements.

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

- A. Fire Test Response Characteristics: Insulation and related materials shall have fire-test-response characteristics indicated below as tested in accordance with ASTM E 84.
 - 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.

1.05 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping installer for piping insulation application. Before preparing piping Shop Drawings, establish and maintain clearance requirements for installation of insulation and field applied jackets and finishes and for space required for maintenance.

- C. Coordinate installation and testing of heat tracing.

1.06 SCHEDULING

- A. Schedule insulation application after pressure testing systems. 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

2.01 INSULATION MATERIALS

- A. Comply with requirements in Part 3 schedule articles for where insulating materials shall be applied.
- B. Products shall not contain asbestos, lead, mercury, or mercury compounds.
- C. Foam insulation materials shall not use CFC or HCFC blowing agents in the manufacturing process.
- D. Flexible Elastomeric: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. Armacell LLC; AP Armaflex.
 - c. RBX Corporation; Insul-Sheet 1800 and Insul-Tube 180.

2.02 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. Flexible Elastomeric Adhesive: Comply with MIL-A-24179A, Type II, Class I.
 - 1. Products - subject to compliance with requirements, provide 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.
- C. PVC Jacket Adhesive: Compatible with PVC jacket.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Dow Chemical Company (The); 739, Dow Silicone.
 - b. Johns-Manville; Zeston Perma-Weld, CEEL-TITE Solvent Welding Adhesive.
 - c. P.I.C. Plastics, Inc.; Welding Adhesive.
 - d. Speedline Corporation; Speedline Vinyl Adhesive.

2.03 MASTICS

- A. Materials shall be compatible with insulation materials, jackets, and substrates; comply with MIL-C-19565C, Type II.
- B. Vapor Barrier Mastic: Water based; suitable for indoor and outdoor use on below ambient services.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; CP-35.
 - b. Foster Products Corporation, H. B. Fuller Company; 30-90.
 - c. ITW TACC, Division of Illinois Tool Works; CB-50.
 - d. Marathon Industries, Inc.; 590.
 - e. Mon-Eco Industries, Inc.; 55-40.
 - f. Vimasco Corporation; 749.
 - 2. Water Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 3. Service Temperature Range: Minus 20° to plus 180°F.
 - 4. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 5. Color: White.

2.04 FACTORY APPLIED JACKETS

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

2.05 FIELD APPLIED JACKETS

- A. Field applied jackets shall comply with ASTM C 921, Type I, for pipes operating at below ambient temperatures and Type II, for pipes operating at above ambient temperatures.
- B. Metal Jacket:
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products, Division of ITW; Metal Jacketing Systems.
 - b. PABCO Metals Corporation; Surefit.
 - c. RPR Products, Inc.; Insul-Mate.
 - 2. Aluminum Jacket: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Factory cut and rolled to size; or, sheet and roll stock ready for shop or field sizing.
 - b. Finish and thickness are indicated in field applied jacket schedules.
 - c. Moisture Barrier for Outdoor Applications: 2.5-mil thick Polysurlyn.
 - d. Factory Fabricated Fitting Covers:
 - 1) Same material, finish, and thickness as jacket.
 - 2) Preformed 2-piece or gore, 45- and 90-degree, short and long-radius elbows.
 - 3) Tee covers.
 - 4) Flange and union covers.
 - 5) End caps.
 - 6) Beveled collars.
 - 7) Valve covers.
 - 8) Field fabricate fitting covers only if factory fabricated fitting covers are not available.

2.06 TAPES

- A. Aluminum Foil Tape: Vapor retarder tape with acrylic adhesive.
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Avery Dennison Corporation, Specialty Tapes Division; Fasson 0800.
 - b. Compac Corp.; 120.
 - c. Ideal Tape Co., Inc., an American Biltrite Company; 488 AWF.
 - d. Venture Tape; 3520 CW.
 - 2. Width: 2 inches.
 - 3. Thickness: 3.7 mils.
 - 4. Adhesion: 100 ounces force/inch in width.
 - 5. Elongation: 5 percent.
 - 6. Tensile Strength: 34 lbf/inch in width.

2.07 SECUREMENTS

- A. Bands
 - 1. Products - subject to compliance with requirements, provide the following:
 - a. Childers Products; Bands.
 - b. PABCO Metals Corporation; Bands.
 - c. RPR Products, Inc.; Bands.
 - 2. Aluminum: ASTM B 209 (ASTM B 209M), Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.
- B. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- C. Wire: 0.062-inch soft-annealed, stainless steel.
 - 1. Manufacturers - subject to compliance with requirements, provide the following:
 - a. C & F Wire
 - b. Childers Products
 - c. PABCO Metals Corporation
 - d. RPR Products, Inc.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions for compliance with requirements for installation and other conditions affecting performance of insulation application.
 - 1. Verify that systems and equipment 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.

3.02 PREPARATION

- A. Surface Preparation: Clean and dry surfaces to receive insulation. Remove materials that will adversely affect insulation application.
- B. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 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 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. Insulation installed on piping systems shall pass through pipe hangers and pipe clamps uninterrupted.
- E. Install insulation with longitudinal seams at top and bottom of horizontal runs.
- F. Install multiple layers of insulation with longitudinal and end seams staggered.
- G. Do not weld brackets, clips, or other attachment devices to piping, fittings, and specialties.
- H. Keep insulation materials dry during application and finishing.
- I. Install insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by insulation material manufacturer.
- J. Install insulation with least number of joints practical.
- K. 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.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- M. Install insulation with factory applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch-wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c.
 - a. For below ambient services, apply vapor-barrier mastic over staples.
 4. Cover joints and seams with tape as recommended by insulation material manufacturer 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.
- N. Cut insulation in a manner to avoid compressing insulation more than 75 percent of its nominal thickness.
- O. Finish installation with systems at operating conditions. Repair joint separations and cracking due to thermal movement.
- P. Repair damaged insulation facings by applying same facing material over damaged areas. Extend patches at least 4 inches beyond damaged areas. Adhere, staple, and seal patches similar to butt joints.
- Q. For above ambient services, do not install insulation to the following:
1. Vibration control devices.
 2. Cleanouts.

3.04 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 for fire-stopping 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 for fire-stopping and fire-resistive joint sealers.

3.05 GENERAL PIPE INSULATION INSTALLATION

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

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

1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity, unless otherwise indicated.
2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. 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 gauges, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.

3.06 FLEXIBLE ELASTOMERIC INSULATION INSTALLATION

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

B. Insulation Installation on Pipe Flanges:

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

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

3.07 FINISHES

- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.
- 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.

3.08 INSULATION SCHEDULE FOR PIPING INSTALLED INDOORS

- A. Condensate and Equipment Drain Water below 60°F:
 - 1. All Pipe Sizes: Flexible Elastomeric, 3/4 inch thick.
- B. Refrigerant Hot Gas Piping:
 - 1. ACR Pipe Sizes smaller than 1-1/2": Flexible Elastomeric, 1-inch thick.
 - 2. ACR Pipe Sizes 1-5/8" and larger: Flexible Elastomeric, 1½-inches thick.
- C. Refrigerant Suction and Liquid Piping:
 - 1. ACR Pipe Sizes smaller than 1-1/2": Flexible Elastomeric, 1/2-inch thick.
 - 2. ACR Pipe Sizes 1-5/8" and larger: Flexible Elastomeric, 1-inches thick.

3.09 INSULATION SCHEDULE FOR PIPING INSTALLED OUTDOORS, ABOVE GROUND

- A. Refrigerant Suction, Liquid and Hot Gas Piping:
 - 1. ACR Pipe Sizes smaller than 2": Flexible Elastomeric, 1-inch thick.
 - 2. ACR Pipe Sizes 2" and larger: Flexible Elastomeric, 1½-inches thick.

3.10 FIELD APPLIED JACKET SCHEDULE FOR PIPES INSTALLED INDOORS

- A. Install jacket over insulation material. For insulation with factory applied jacket, install the field applied jacket over the factory applied jacket.
- B. Piping, Exposed and Concealed, Fittings Only:
 - 1. PVC 30 mils thick.

3.11 FIELD APPLIED JACKET SCHEDULE FOR PIPES INSTALLED OUTDOORS

- A. Install jacket over insulation material. For insulation with factory applied jacket, install the field applied jacket over the factory applied jacket.
- B. Piping:
 - 1. Aluminum, Smooth: 0.016 inch thick.
- C. Provide waterproof sealant over jacketing.

END OF SECTION 23 0719

SECTION 23 0801 - COMMISSIONING OF HVAC

PART 1 - GENERAL

1.01 DESCRIPTION

- A. The HVAC Contractor will procure the services of independent Commissioning Consultant; other terms are Commissioning Provider, Commissioning Agent, and Commissioning Authority. The Commissioning Consultant shall be an independent and knowledgeable third party, contracted to verify that the HVAC systems, service water heating systems, lighting control systems, and other systems where indicated below, operate as illustrated, described or specified in the contract documents. The Commissioning Consultant will inform the Construction Manager, Engineer and the Architect of the results of the commissioning and provide suggestions, as necessary, to correct deficiencies in observed performance or installation.
- B. Commissioning is the process to verify to The HVAC Contractor that systems, equipment, mechanical, electrical, controls and special systems function together properly to meet performance requirements and design intent, and as described in the Contract Documents. The HVAC Contractor shall be responsible for participation in the commissioning process as outlined below and in references and attachments throughout the Contract Documents. The HVAC Contractor shall furnish labor and materials sufficient to meet all requirements of building commissioning under this contract.
- C. Various sections in the Division 00, 01, 22, 23 and 26 Specifications as well as specifications in other sections outline the specific commissioning responsibilities of each Contractor and corresponding subcontractors for the respective division and obligate the HVAC Contractor to coordinate and manage the commissioning responsibility of those subcontractors.

1.02 REQUIREMENTS INCLUDED

- A. Duties of Contractor.
- B. Duties of Commissioning Consultant.
- C. Commissioning Field Notebook.
- D. Acceptance Procedures.
- E. Performance Period.

1.03 RELATED SECTIONS

- A. All Division 1 Sections and General Requirements
- B. All Division 22 Sections
- C. All Division 23 Sections
- D. All Division 26 Sections

1.04 TERMS

- A. Acceptable Performance: A component or system being able to meet specified design parameters under actual load including satisfactory documented completion of all functional performance tests, control system trending and resolution of outstanding issues.
- B. Basis of Design: The Contract Documents shall constitute the Basis of Design.
- C. Commissioning Plan: The HVAC Contractor's Commissioning Consultant prepares The Commissioning Plan. *The Commissioning plan is a document that outlines the organization, schedule, allocation of resources, and documentation requirements of the Commissioning Process (ASHRAE Guideline 0-2013).* In addition, the Plan defines the scope and format of the commissioning process and the responsibilities of all involved parties. The commissioning team reviews the Commissioning Plan to inform the intent and scope of the commissioning process, to ensure inclusion in the construction project scope/schedule and to facilitate and expedite the commissioning process. The Commissioning Plan is to be distributed by the Commissioning Consultant during the first third of the construction timeframe.
- D. Functional Performance Testing: Is a full range of checkouts and tests carried out to determine if all components, sub-systems, systems and interfaces between systems function in accordance with the Contract Documents and meets the design intent. In this context, "function" includes all modes and sequences of control operation, all interlocks and conditional control responses and all specified responses to abnormal emergency conditions. The Commissioning Consultant will prepare the functional performance tests.
- E. Commissioning (Also Commissioning Process) is a *quality-focused process enhancing the delivery of a project. The process focusses upon verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements. (ASHRAE Guideline 0-2013).* Process to demonstrate The HVAC Contractor that building equipment controls and systems function together properly to meet design intent and performance requirements shown in a composite manner in the Contract Documents.
- F. Resolution Log: The purpose of this document is to provide a method for tracking and resolution of deficiencies discovered during the commissioning process. This list also includes the current disposition of issues and the date of final resolution as confirmed by the Commissioning Consultant. Deficiencies are issues where products, execution or performance does not satisfy the Specifications and/or the design intent. The Commissioning consultant creates and manages the Resolution Log.
- G. Pre-functional Construction Checklists: Commissioning Consultant prepares Checklist for equipment of systems and assemblies. See paragraph 1. A. Checklist shall be for the systems or equipment involved in the commissioning process to verify installation and start-up of equipment is complete and verify that systems are ready for functional testing. These documents require signature by the Contractor prior to continuing with the commissioning process, and are required as a pre-condition of beginning the Functional Performance Testing.
- H. Testing and balancing (TAB) process. A complete pencil copy of TAB reports, on a system-by-system basis, is required prior to the start of any final functional performance test.

1.05 DUTIES OF CONTRACTOR

- A. Provide copies of all approved shop drawings, manufacturer's literature, maintenance information or other information as may be needed for systems and assemblies to the Commissioning Consultant.
- B. Collect the information requested by Commissioning Consultant for development of a complete Commissioning Plan, Commissioning Field Notebook, and Functional Performance Tests and provide to the Commissioning Consultant. The HVAC Contractor shall review the Commissioning Plan, Commissioning Field Notebook, and Functional

performance Test and confirm in writing to the Construction Manager, Architect and Commissioning Consultant any known areas of conflict or areas requiring clarifications.

- C. Collect all proposed equipment start-up and Pre-Functional Construction Checklists documentation and place into the Commissioning Field Notebook. The HVAC Contractor will provide the Commissioning Consultant with the completed commissioning field notebook.
- D. Provide the Contractor's schedule to the commissioning Consultant for review and comment. Plan for and incorporate commissioning activities into the construction schedule. Provide a sufficient detailed level of scheduling, activity, detail to properly coordinate and schedule the trades. Provide a detailed Commissioning Schedule Fragnet to the project schedule, updated monthly.
- E. Provide Commissioning Consultant with submittals for all systems and assemblies for review and comments. Include submittals of controls system and wiring diagrams and narrative sequences of operation, in time for use in preparing the Functional Test Procedures. The Commissioning Consultant review comments of pertinent submittals is coordinated through the Construction Manager, Engineer and the Architect.
- F. Provide a fully operational system per Specifications, started, verified, debugged, calibrated, balanced, tested and under automatic control.
- G. Provide qualified personnel to participate in the commissioning tests, including seasonal testing.
- H. Cooperate with the Commissioning Consultant's personnel.
- I. Provide access to site for the Commissioning Consultant for review, verification and testing activities.
- J. Provide updates to all project documentation to reflect all supplemental instructions, addenda or other revisions to the project construction documents. Updates and architect's supplemental instructions must be posted to the master set of documentation for review and reference by all Contractors and for the Commissioning Consultant's use.
- K. Provide adequate time and resources to perform functional testing of systems and assemblies in contract. These times and activities shall be reflected in the Commissioning Fragnet schedule, updated monthly.
- L. Coordinate participation of all pertinent subcontractors including mechanical, electrical, controls and Testing and Balancing TAB subcontractors in the commissioning process.
- M. Participate in any efforts to finalize sequences of operations with Engineer, Architect and Commissioning Consultant.
- N. Verify that coordination, installation, quality control and final testing have been completed such that installed systems and equipment comply with construction documents.
- O. Review the Commissioning Plan, Project Reports and test results and submit comments to the Commissioning Authority.
- P. In a timely manner, address issues identified during construction that may affect the commissioning process or final system performance.
- Q. Perform equipment start-up and testing of mechanical and electrical equipment and systems and document as required with start-up reports and completion of Pre-functional Construction Checklists. These checklists include installation documentation, start-up documentation, controls point-to-point documentation and calibration documentation, verification that controls sequence of operations meets design intent and TAB final documentation. Reports will be stored in the Contractor's field trailer, as a part of the Commissioning Field Notebook. Contractor will coordinate efforts to complete the pre-functional documentation.

- R. Provide preliminary TAB report, indicating all actual field values recorded to the Commissioning Consultant through the Construction Manager, and the Architect, prior to initiation of functional testing. These reports shall be incorporated in the commissioning field notebook. Provide these "pencil copy" TAB data on a system-by-system basis, as systems have been finally and completely balanced.
- S. Pre-test all systems prior to scheduling the final Functional Performance Test for the record. Operate equipment and systems as required in preparation of final functional performance testing. This includes, but is not limited to; manipulating the appropriate controls systems to execute the Functional Test Procedures.
- T. The HVAC Contractor shall issue a written Notice of Readiness for each system; include verification of system completion, TAB completion and controls. Provide the Commissioning Consultant a copy of the Notice of Readiness upon completion of all systems work, start-up and Pre-functional Construction Checklists requirements by trade contractors including but not limited to plumbing and electrical contractors.
- U. Participate in the fine-tuning or troubleshooting of system performance, if of these measures becomes necessary.
- V. Review operating and maintenance data for verification, organization, distribution and conformance to requirement of the Contract Documents.
- W. Submit complete operation and maintenance information and as-built drawings to the Construction Manager, and the Architect, for compliance review of the requirement of the Contract Documents. Incorporate changes and recommendations provided by the commissioning Consultant into the documentation.
- X. Provide all proprietary test equipment required to test all the systems and equipment in this project. The **HVAC** Contractor shall provide all necessary tools, lifts, ladders, access, PPE and other equipment required for the Commissioning Consultant to witness Functional Performance Testing.
- Y. The Commissioning Field Notebook will be stored in the HVAC Contractors field trailer and will be managed by the HVAC Contractor. The HVAC Contractor shall confirm in writing to the Commissioning Consultant that systems are complete, functional and the appropriate subcontractors have completed the specified tasks and signed off all pre function documentation.
 - 1. Use of an electronic, internet enabled data storage and sharing site is permitted, provided all applicable stakeholders agree to its use, in writing.

1.06 DUTIES OF COMMISSIONING CONSULTANT

- A. Develop the Commissioning Plan.
- B. Review the Commissioning Field Notebook with appropriate documentation provided from HVAC Contractor. Provide supplemental documentation as necessary to ensure that all aspects of start-up and testing have been complete and documented prior to functional testing.
- C. Develop Functional Test Procedures from Contract Documents and final equipment submittals including narrative sequences of operation, control diagrams and software code for execution with the assistance of HVAC Contractor staff as required.
- D. Review the Contractor's submittals relative to the systems and assemblies. Provide comments on the submittals during the same timeframe as the architect / engineer's review. Architect / Engineer have final decision on incorporating comments by the Commissioning Consultant. Architect formally incorporates the response to the HVAC Contractor.

- E. Observe the start-up activities and initial testing of selected equipment and systems as required and review Contractor's start-up documentation.
- F. Observe or review documentation of validation activities including: Proper test and balance activities, rotating equipment drive alignment, vibration testing, acoustical testing, electrical testing and functional tests for normal and off-normal operating sequences.
- G. Review submittal of all required pre-functional and start-up documentation provided by the HVAC Contractor for completeness and reasonableness. This includes installation documentation, start-up documentation, point-to-point checklists and preliminary TAB report, prior to initiation of functional testing.
- H. Assist with scheduling, direct and witness complete functional testing as defined in the Commissioning Plan and Functional Test Procedures. All testing to be performed and verified by the HVAC, Plumbing or Electrical Contractors as applicable and documented by the Commissioning Consultant.
- I. Witness and verify satisfactory completion of equipment and system tests and inter-systems functional performance tests.
- J. Conduct commissioning meetings, and distribute minutes of those meetings to all attendees.
- K. Provide functional tests or other project reports in a timely manner.
- L. Document inconsistencies or deficiencies in system operations and system compliance. System deficiencies shall be forwarded to the Construction Manager, Engineer, Architect and documented in the Resolution Log.
- M. Coordinate via the Architect participation of owner's personnel with equipment, component and systems performance verification and participation in required training.
- N. When commissioning has been successfully completed, recommend acceptance to the Construction Manager, Engineer, and the Architect, and provide suggestions for those systems not performing as expected.
- O. Complete, certify and submit a Preliminary Commissioning Report that is organized into mechanical, service water heating and lighting controls for independent review. The Report shall include a 2018 International Energy Conservation Code, Section C408.2.4 Preliminary Commissioning Report compliant "Commissioning Compliance Checklist", and shall identify:
 - 1. Itemization of deficiencies found during testing that have not been corrected at the time of report preparation.
 - 2. Tests deferred because of climatic conditions.
 - 3. Climatic conditions required for performance of the deferred tests.
 - 4. Results of functional performance tests.
 - 5. Functional performance test procedures used during the commissioning process, including measurable criteria for test acceptance.
- P. After all functional tests are successfully completed and all outstanding issues resolved, the Commissioning Consultant will provide the owner HVAC Contractor engineer and architect with a Final Commissioning Report of all commissioning activities that occurred during the project.
- Q. The Final Commissioning Report shall include:
 - 1. Results of functional performance tests.
 - 2. Disposition of deficiencies found during testing, including details of corrective measures used or proposed.
 - 3. Functional performance test procedures used during the commissioning process including measurable criteria for test acceptance, provided herein for repeatability.

Exception: Deferred tests that cannot be performed at the time of report preparation due to climatic conditions.

- R. Provide technically qualified personnel when scheduled.
- S. The Commissioning Consultant will formally communicate with the HVAC Contractor via approved project channels. It is expected, however, that informal communication and coordination will be conducted directly with the subcontractors; records of all contacts will be sent to the Architect through the normal channels.
- T. The Commissioning Consultant is not authorized to release, revoke, alter or expand requirements of Contract Documents, to approve or accept any portion of the work or to perform any duties of the Contractor.

1.07 COMMISSIONING PLAN

- A. The Commissioning Plan is a tool through which the commissioning process is described and incorporates the Construction Manager, Architect, Engineer Trade Contractor(s) and Commissioning Authority roles relative to the commissioning process. Commissioning team members are all contractors, subcontractors and design professionals whose participation is of benefit in the delivery of a fully functioning building to the owner. The plan shall describe the communication, authority and responsibility of commissioning team members. The Commissioning Plan will include the following:
 - 1. The purpose of commissioning.
 - 2. Detail the commissioning process.
 - 3. Commissioning team members' responsibilities.
 - 4. Provide a guideline for acceptance of each piece of equipment or system.
 - 5. Systems to be commissioned.

1.08 COMMISSIONING FIELD NOTEBOOK

- A. The Commissioning Field Notebook is assembled by the HVAC Contractor and reviewed by the Commissioning Consultant to identify and track all pertinent commissioning documentation. The HVAC Contractor will maintain and manage completion of this Notebook. The Notebook provides a central location for the Commissioning Consultant to identify and organize all pertinent information and will include the following format:
 - 1. Summary describing Notebook contents and use.
 - 2. Commissioning Plan for contractor field reference.
 - 3. Listing of all specification documentation requirements listed by specification section, with construction completion sign offs for appropriate parties. These types of documents include piping pressure testing, flushing reports, factory start-up reports and any field-testing relative to the project.
 - 4. Copy of final approved submittal / shop drawings for each major piece of equipment involved in commissioning, as well as systems such as controls.
 - 5. Tabs for each specification section with copies of completed, signed off pre-functional checklists and final Functional Performance Tests.
 - 6. Commissioning project reports, resolution logs schedule information or any other documentation provided by the Commissioning Consultant.
 - 7. Provide a .pdf copy of entire completed Commissioning Field Notebook to Commissioning Consultant at conclusion of project for use in developing final Commissioning Report, prepared by the Commissioning Consultant.
- B. Internet enabled data sharing applications will be considered for use on this project as the Field Notebook provided the HVAC Contractor or Commissioning Consultant bear the cost for such application, and all stakeholders agree to its use.

1.09 SYSTEMS TO BE COMMISSIONED

- A. Systems and Equipment to Be Functionally Tested: The system features are to be functionally tested and other building features will be evaluated for installation quality during construction. The functional performance testing will include the following systems and equipment.
1. Mechanical Systems:
 - a. Air handling units
 - b. Packaged compressor and condensing units
 - c. Make-up air heater
 - d. Gas-fired radiant heaters
 - e. Gas-fired radiant heater vacuum pump
 - f. Fans
 - g. Air terminal units with reheat coils
 - h. Unit heaters (all types)
 - i. Electric ceiling radiant heaters
 - j. Condensate pumps (electric & pressure powered)
 - k. Building automation system
 - l. Gas instruments and controls
 - m. Service water heating equipment
 2. Electrical Systems:
 - a. Occupant Sensor Lighting Controls
 - b. Time-Switch Lighting Controls
 - c. Emergency Generator

1.10 COMMISSIONING ACTIVITIES

- A. The Commissioning Fragnet Schedule: This schedule defines the milestones and conditions that must be achieved before system testing and other commissioning activities can commence. The schedule also includes the expected duration of the various tasks so that the commissioning process can be incorporated into the overall construction schedule.
- B. Commissioning Field Notebook: The HVAC Contractor is required to create, develop and maintain the Commissioning Field Notebook. The HVAC Contractor shall identify and track all pertinent commissioning documentation required during the installation start-up and checkout phases in the Commissioning Field Notebook. The Commissioning Notebook will be kept by the HVAC Contractor on site and will be made available to all subcontractors for their use. The Notebook provides a central location for the subcontractors and Commissioning Consultant to identify, copy, and organize all pertinent information.
- C. Preparation for Testing: To prepare for the system performance testing, the Commissioning Consultant will examine the design and Construction Documents, and develop detailed Functional Test Procedures and data forms. The Contractor must verify that the systems they install comply with the Construction Documents and are fully functional. Commissioning is not intended to be a testing or inspection function that replaces any of the Contractors' obligations for testing and proof of performance. Functional testing will only begin when the contractor confirms to the Commissioning Consultant in writing that all systems intended to be commissioned are readied for functional testing, the TAB process is complete for both air and water balancing, and the controls are completed and all control loops properly tuned.

- D. Functional Testing: Functional testing is performed by experienced and qualified technicians of the Contractor(s), responsible for installation as facilitated by the Commissioning Consultant and may be observed by other members of the commissioning team including the Owner. Functional testing will verify proper sequencing, operation and performance of installed equipment and systems under realistic operating conditions. The functional testing will follow with written Functional Test Procedures with test results documented for permanent record.
- E. Documentation: In addition to the Functional Test Procedures, written documentation will be maintained for all other commissioning activities. Project communication reports shall be issued by the Commissioning Authority to the Contractor and key members of the commissioning team to document apparent deficiencies identified during examination of design and construction documents, daily activities on-site, construction deficiencies and successful or unsuccessful functional test results. At the end of the commissioning process, all documentation will be assembled and summarized in the Final Commissioning Report.
- F. Deficiency Resolution: When an Issues Log, Resolution Log or Field Report is issued to address an identified deficiency, the Contractor shall forward the reports to the appropriate parties to initiate corrective action in an expeditious manner. The designer is relied on for supplemental instructions or design modifications and issuance of final design details and the Contractors are relied on for implementation of that design. Change orders must be issued through proper contract channels.

1.11 FUNCTIONAL TEST PROCEDURES

- A. The Functional Test Procedures include, but are not limited to, the following:
 - 1. Verification that all HVAC and service water heating equipment is installed in a serviceable manner for maintenance.
 - 2. Verification of all equipment's ability to perform to the design intent.
 - 3. Verification of the performance of sub-systems consisting of combinations of equipment (e.g., refrigeration cycle, pumps and interconnecting piping).
 - 4. Verification of the performance of the automatic controls in all seasonal modes.
 - 5. Verification of the performance of the HVAC system as a whole.

PART 2 - PRODUCTS (NOT USED)

PART 3 - EXECUTION

3.01 GENERAL

- A. Operating equipment and systems shall be tested in presence of the Commissioning Consultant to demonstrate compliance with specified requirements.
 - 1. Notify the owner, architect, **and** construction manager in writing, fourteen (14) days prior to tests, twenty-one (21) days prior if a utility shutdown is required, scheduled under requirements of this Section.
 - 2. The Functional Performance Testing shall be completed by the Contractor as a requirement of Substantial Completion. The acceptance of Functional Performance Test by the Owner, Construction Manager, and Architect is a requirement of Final Completion.
- B. All elements of systems shall be tested to demonstrate that total systems satisfy all requirements of these Specifications. Testing shall be accomplished on hierarchical basis. Test each piece of equipment for proper operation, followed by each sub-system, followed by entire system, followed by interaction with other major systems.

- C. Proprietary test equipment required by the manufacturer, whether specified or not, shall be provided by the manufacturer of the equipment through the installing contractor. Manufacturer shall provide the test equipment, demonstrate its use, and assist the Commissioning Consultant in the commissioning process.
- D. Acceptance Documentation: A copy of the functional performance tests results shall be necessary acceptance documentation along with other specified requirements. Documentation must be signed and dated.

3.02 ACCEPTANCE PROCEDURES

- A. Prior to functional performance testing of each system, the Commissioning Consultant shall observe and verify that the physical installation of components and systems being tested is substantially installed in accordance with the Contract Documents.
- B. Contractor's Tests:
 - 1. System shall be checked for proper installation, shall be adjusted and calibrated to verify that it is ready to function as specified.
 - 2. All system elements shall be checked to verify that they have been installed properly and that all connections have been made correctly.
 - 3. All discrete elements and sub-systems shall be adjusted and checked for proper operation.
 - 4. Start-up and operational tests shall be complete, signed and submitted for review by Commissioning Consultant within five (5) days of each activity, prior to starting functional performance testing.
- C. The functional performance testing process shall be accomplished for all equipment, sub-systems, systems and system interfaces. The order of functional performance testing shall be reflected in the Commissioning Fragnet Schedule. All must be tested for acceptances and there shall be a separate checklist for each to ensure documentation specific to each is complete.
- D. Each system shall be operated through all modes of system operation (e.g., occupied, unoccupied, warm-up, cool-down, etc., as applicable) including every individual interlock and conditional control logic, all control sequences, both full-load and part-load conditions and simulation of all abnormal conditions for which there is a specified system or controls response. The warm-up and cool-down test shall be a performance test, as applicable.
- E. Temporary upsets of systems, such as distribution fault, control loss, set-point change, equilibrium upset and component failure, shall be imposed at different operation loads to determine system stability and recovery time.
- F. When the functional performance of all individual systems has been proven, the interface or coordinated responses between systems shall be checked. The systems involved may be within the overall HVAC work or they may involve other systems, such as emergency systems for life safety.
- G. Corrective Measures: If acceptable performance cannot be achieved, the cause of the deficiency will be identified. If it is determined, that the deficiency was caused by the system or component not being installed per the manufacturer's recommendations or Contract Documents, the necessary corrective measures shall be carried out by the installing Contractor. Every check or test for which acceptable performance was not achieved shall be repeated after the necessary corrective measures have been completed. This re-testing process should be repeated until acceptable performance is achieved. The Contractor will be allowed one retest after initial testing of the equipment. If the retest fails, the Contractor shall be financially responsible, at standard rates, to reimburse the Commissioning Consultant for the additional time taken to achieve acceptable performance.

3.03 SCHEDULE

- A. The following schedule reflects the probable expected sequence and duration for the various tasks, so that the commissioning process can be integrated with the general construction schedule and refined over the course of the project. Actual sequencing and durations shall be by the General Contractor and Sub-Contractors, coordinated with the Commissioning Consultant.

- B. Note: Attention to these scheduling needs is important to prevent conflicts that have been problematic within the commissioning process:

Milestone	Duration	Successor	Predecessor
Commissioning Kick off Mtg.	1 day	All contractors on board including Controls and TAB	Before major MEP installation
Review equipment submittals	2 weeks	After receipt of submittals	Before ordering or installation
Develop Pre-functional Construction Check-lists	2 weeks	After equipment submittal review and after receipt of O&M literature	Before MEP installation
Walk contractors through Pre-functional Construction Checklists	1 day	After development of Pre-Functional Checklist documentation	Before MEP installation
Write Functional Tests	3 to 5 weeks	After controls submittal review	3 weeks prior to functional testing
Submit Functional Tests for review by COTR and Contractors	1 week	After development of Functional Tests	Before Functional testing
Complete Pre-functional Construction Check-lists (contractor task)	On Going	During installation, startup and test, adjust and balance	Before TAB Backcheck and functional testing
Site Observations (CxA)	on-going	After majority of MEP installation	Before TAB Backcheck and functional testing
Test, Adjust and Balance (Contractor task)	See CPM schedule	After Start-up and Pre-functional Construction checks. All walls, windows, doors, ceilings must be installed.	Before TAB Backcheck
Test, Adjust and Balance Backcheck (10%)	1 week	After Start-up and receipt of completed Pre-functional Construction Check-lists from contractors	Before functional testing
Functional Testing	2 months	After TAB Backcheck and receipt of completed Pre-functional Construction Checklist have been completed by contractors	Before Government occupancy
Issues Resolution	1 week	After Functional Testing	Before Government occupancy
Final Commissioning Documentation Submittal	2 weeks	After resolution of issues log	2 weeks after resolution of issues log

COMMISSIONING COMPLIANCE CHECKLIST

Project Information: _____ Project Name: _____

Project Address: _____

Commissioning Authority: _____

Commissioning Plan (Section C408.2.1)

- ☐ Commissioning Plan was used during construction and includes all items required by Section C408.2.1
- ☐ Systems Adjusting and Balancing has been completed.
- ☐ HVAC Equipment Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: _____
- ☐ HVAC Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: _____
- ☐ Economizer Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: _____
- ☐ Lighting Controls Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: _____
- ☐ Service Water Heating System Functional Testing has been executed. If applicable, deferred and follow-up testing is scheduled to be provided on: _____
- ☐ Manual, record documents and training have been completed or scheduled
- ☐ Preliminary Commissioning Report submitted to owner and includes all items required by Section C408.2.4

I hereby certify that the commissioning provider has provided me with evidence of mechanical, service water heating and lighting systems commissioning in accordance with the 2018 IECC.

Signature of Building Owner or Owner's Representative _____ Date _____

END OF SECTION 23 0801

SECTION 23 0900 - AUTOMATIC TEMPERATURE CONTROL FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes control equipment for all HVAC systems and components, including control components for terminal heating and cooling units not supplied with factory-wired controls.
- B. All labor, material, equipment and software not specifically referred to herein or on the Drawings, but which can reasonably be inferred as required to provide a complete, fully functional control system to meet the functional intent of this specification, shall be provided without additional cost to the Owner.
- C. The BAS Contractor shall be responsible for integrating new HVAC equipment manufacturer supplied HVAC unit controls into a unified system in order to provide flexibility for expansion, maintenance, and service of the system. Further, the BAS contractor shall furnish and install any additional control components and wiring needed to render HVAC equipment installed under this contract operable in accord with the sequence of operations specified in Section 23 0993 SEQUENCE OF OPERATIONS FOR HVAC CONTROL.
 - 1. It is the responsibility of the BAS Contractor during the bid period, to examine all Division 23 sections for relevant information related to factory supplied controls necessary to ensure their bid proposal includes all scope to required meet the intent of this Section, and Section 230993 SEQUENCE OF OPERATIONS FOR HVAC CONTROL.
 - 2. Coordinate and resolve incompatibility issues that arise between control products provided under this Section and those provided under other Sections or Divisions of the Contract Document Specifications.
 - 3. The BAS Contractor shall be responsible for integration of control products provided by multiple suppliers regardless of where integration is described within the contract documents.
 - 4. Map all available points available from factory supplied control system interfaces.
- D. The Owner shall be the named license holder of all software associated with any and all incremental work on the project(s).
- E. The system shall be provided completely by the BAS Contractor with the exception of any factory-supplied HVAC unit controls and any factory supplied dampers that are integral to equipment.
- F. After completion of the installation, the BAS Contractor shall, in cooperation with the Commissioning Authority, completely adjust all control equipment provided under this contract, place the system in operation, subject to the engineer's approval, and instruct the operating personnel in the operation of the control system.
- G. The BAS supplier shall satisfactorily complete the entire control system so that it is functional and operating to the satisfaction of the Architect. Systems and their controls and their sequencing must be demonstrated and operated to the satisfaction of the Architect.

1.03 WORK INCLUDED

A. Automatic Temperature Control (ATC) Subcontractor shall:

1. Furnish and install a new building automation system (BAS), UL listed, incorporating direct digital control (DDC) for energy management, equipment monitoring and control, and operator interface.
 - a. Operator interface shall be provided via web-based access.
 - b. Electronic actuation shall be employed.
 - c. Provide a complete graphics package that includes all automatic temperature control system points and allows for easy adjustment.
 - d. Provide an operator's workstation in the upper-level mechanical equipment room, or, where directed by the owner.
2. Provide a complete DDC temperature control system as specified herein.
3. Provide all power wiring, control wiring, and conduit for all DDC panels, application specific controllers, programmable controllers and DDC temperature control devices, except as detailed within. Provide all electrical work associated with the BAS control system and as called for on the Drawings including:
 - a. Providing all line voltage and low voltage power wiring and conduit in accordance with all local codes, the National Electric Code (latest edition), and Division 26.
 - 1) Power circuits shall be run from normal/emergency power panel(s).
 - b. Providing all line voltage and low voltage control wiring, concealed in conduit or exposed as plenum-rated cable, in accordance with local codes, the National Electric Code (latest edition), and Division 26.
 - 1) Power circuits shall be run from normal/emergency power panel(s).
 - 2) All low voltage electrical control wiring throughout the building shall be as described in Part 3 of this Section.
 - c. Incorporating and providing surge transient protection in design of system to protect electrical components in all DDC Controllers, Application Specific Controllers, and operator interface devices.
 - d. Provide all cabling, terminations, and patch panels associated with equipment requiring IP connections to the District's IT network. All work must be coordinated with South Fayette Director of Technology, Rob Warfield.
4. The ATC Subcontractor shall hardwire from each duct mounted smoke detector to its associated supply and/or return fan. Fan shutdown via software is not acceptable. Provide all wiring and conduit required.
 - a. Control circuit shall de-energize fans in the 'Hand', as well as the 'Auto', position.
 - b. DDC system shall monitor all duct detectors.
5. Furnish all automatic air dampers, including actuators. Provide all power wiring, conduit and controls for automatic air dampers installed.
6. Furnish and install all airflow monitoring devices.
7. Provide a field technician to coordinate work with the Testing and Balancing technicians.
8. Provide a field technician to work with the Commissioning Authority (CxA) during functional testing.
9. For all exhaust fans, provide all interlock power/control wiring and conduit between the fan and its motorized damper.
10. Program initial occupied/unoccupied schedules and weekday/weekend/holiday time schedules for each HVAC equipment item and system. Coordinate with the Owner to determine the schedule parameters to be input.
11. Program initial trends for each HVAC equipment item and system. Coordinate with the Owner and CxA to determine the points to be trended on each system and the duration of the trends, along with any other required parameters associated with each particular trend.
12. Perform functional performance testing for all controls installed.

- B. The HVAC Trade shall:
1. Install all automatic air (outdoor air, return air, exhaust air, ventilation air) control dampers furnished by the ATC Subcontractor.
 2. Install all openings for all airflow monitoring devices, flow switches and alarms furnished by the ATC Subcontractor.
 3. Install all control devices, alarms and monitoring devices for all air and water systems required by the Drawings and the Specifications that is not installed by the ATC Subcontractor.
 4. Mount/install all duct mounted smoke detectors furnished by the Electrical Contractor.
 5. Provide all required access doors.
- C. The Electrical Trade will:
1. Furnish all duct or unit mounted smoke detectors, and provide power wiring and fire alarm control wiring to these smoke detectors. Detectors shall be provided with alarm contacts for use by the DDC system.
 2. Provide a minimum of two (2) 120-volt, 20-amp breakers in each normal/emergency power panel for use by the ATC Subcontractor.

1.04 DEFINITIONS

- A. DDC: Direct digital control.
- B. I/O: Input/output.
- C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. MS/TP: Master slave/token passing.
- E. Open system: A building automation system (BAS) that naturally facilitates and permits the owner to engage the services of a future vendor different than that which provided the BAS installed under this contract, to service, expand, and modify the BAS without requiring the services of, or future payment to, the controls vendor who initially provided the system
- F. PC: Personal computer.
- G. PID: Proportional plus integral plus derivative.
- H. RTD: Resistance temperature detector.

1.05 SYSTEM DESCRIPTION

- A. The Building Automation System (BAS, or equivalently, ATC, BMS, DDC, HCS) shall be entirely electronic utilizing microprocessor based direct digital equipment controllers and electric or pneumatic valve and damper actuators. System shall be complete in all respects including microprocessor, graphical user interface software, sensors, actuators, and other software in order to provide the functions described.

- B. The BAS shall be a peer-to-peer networked, stand-alone, distributed control system that is an *open system*, as defined in article Definitions above.
 - 1. To ensure that an open system is provided, this Direct Digital Control System shall include, but not be limited to having, the following features:
 - a. Utilize a Tridium Niagara 4 software platform.
 - b. Utilize only commonplace forms of ANSI/ASHRAE Standard 135-2012 BACnet technology communication protocols as further specified herein, and without the use of any proprietary gateways or routers.
 - c. Utilize only BTL listed controllers as further specified herein.
 - d. Provide a perpetual software license for all software furnished to the Owner.
 - e. Provide native format copies of all software tools, configuration files, control programs, etc. to the Owner.
- C. The intent of this specification is to provide a peer-to-peer networked, stand-alone, distributed control system with the capability to integrate the ANSI/ASHRAE Standard 135-2012 BACnet technology communication protocols in one open, interoperable system. To ensure future interoperability with *open systems* by multiple manufacturers and suppliers, the Direct Digital Control System installed under this contract shall communicate utilizing BACnet open protocol as described herein. Proprietary gateways or routers used to communicate between Tier 1 controllers and/or building controllers, workstations, or web servers and Tier 2 controllers are unacceptable for the open system requirements.
- D. Access to the control system, either locally in the building, or remotely, shall be accomplished through a BAS webserver, using standard web browsers, via the internet and/or local area network.
- E. The proposed system shall be backwards compatible so as to eliminate system obsolescence and provide seamless integration of future systems and software installed on future projects.

1.06 SYSTEM PERFORMANCE

- A. Comply with the following performance requirements:
 - 1. Graphic Display: Display graphic with minimum 20 dynamic points with current data within 10 seconds.
 - 2. Graphic Refresh: Update graphic with minimum 20 dynamic points with current data within 8 seconds.
 - 3. Object Command: Reaction time of less than two seconds between operator command of a binary object and device reaction.
 - 4. Object Scan: Transmit change of state and change of analog values to control units or workstation within six seconds.
 - 5. Alarm Response Time: Annunciate alarm at workstation within 45 seconds. Multiple workstations must receive alarms within five seconds of each other.
 - 6. Program Execution Frequency: Run capability of applications as often as five seconds, but selected consistent with mechanical process under control.
 - 7. Performance: Programmable controllers shall execute DDC PID control loops, and scan and update process values and outputs at least once per second.
 - 8. Reporting Accuracy and Stability of Control: Report values and maintain measured variables within tolerances as follows:
 - a. Space Temperature: Plus, or minus 1°F.
 - b. Ducted Air Temperature: Plus, or minus 1°F.
 - c. Outside Air Temperature: Plus, or minus 2°F.
 - d. Dew Point Temperature: Plus, or minus 3°F.
 - e. Temperature Differential: Plus, or minus 0.25°F.

- f. Relative Humidity: Plus, or minus 5 percent.
- g. Airflow (Pressurized Spaces): Plus, or minus 3 percent of full scale.
- h. Airflow (Measuring Stations): Plus, or minus 5 percent of full scale.
- i. Airflow (Terminal): Plus, or minus 10 percent of full scale.
- j. Air Pressure (Space): Plus, or minus 0.01-inch wg.
- k. Air Pressure (Ducts): Plus, or minus 0.1-inch wg.
- l. Carbon Dioxide: Plus, or minus 50 ppm.
- m. Electrical: Plus, or minus 5 percent of reading.

1.07 SEQUENCE OF OPERATION

- A. Refer to Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls" for required operating sequences for each HVAC system, equipment item and component.

1.08 GENERAL PRODUCT DESCRIPTION

- A. The building automation system shall consist of the following:
 - 1. Stand-alone Application Specific Programmable DDC Controllers (PRCs).
 - 2. DDC Network Panel.
- B. The system shall be modular in nature and shall permit expansion of both capacity and functionality through the addition of sensors, actuators, Application Specific Controllers and operator devices.
- C. System architectural design shall eliminate dependence upon any single device for alarm reporting and control execution. Each DDC Controller shall operate independently by performing its own specified control, alarm management, operator I/O and data collection. The failure of any single component or network connection shall not interrupt the execution of control strategies at other operational devices.
- D. The DDC system hardware and software installed for this project must maintain compatibility with systems developed in the future. It is a requirement that the ATC Subcontractor support this "Forward and Backward Compatibility" claim with written company literature and local references of facilities where the company's former DDC system ties into their current DDC system.

1.09 QUALITY ASSURANCE

- A. DDC System Manufacturer Qualifications:
 - 1. Nationally recognized manufacturer of DDC systems and products.
 - 2. DDC systems with similar requirements to those indicated for a continuous period of five years within time of bid.
 - 3. DDC systems and products that have been successfully tested and in use on at least five past projects.
 - 4. Having complete published catalog literature, installation, operation, and maintenance manuals for all products intended for use.
 - 5. Having full-time in-house employees for the following:
 - a. Product research and development.
 - b. Product and application engineering.
 - c. Product manufacturing, testing, and quality control.
 - d. Technical support for DDC system installation training, commissioning, and troubleshooting of installations.
 - e. Owner operator training.

B. DDC System Provider Qualifications:

1. Authorized representative of, and trained by, DDC system manufacturer.
2. Each BAS Company offering a Bid Proposal shall have a full-service office within 100 miles of the project site.
 - a. Each **Full-Service** office shall be staffed with applications engineers, software engineers, and field technicians; that maintains a parts inventory, and that has testing and diagnostic equipment to support the work.
3. Each BAS Company offering a Bid Proposal shall have previously completed a minimum of 3, fully installed, BACnet systems similar to the system required for this project that includes a Tridium Niagara platform.
 - a. The projects shall have been new system installations (not merely extensions or integrations of existing Tridium based systems) and have been completed within the last 5 years.
 - b. Representative projects shall have been web-based, native, and installed by the BAS contractor's local office proposing to perform the work.
4. Each BAS Company offering a Bid Proposal shall have in their direct employment, no less than 2 technicians who have passed the Niagara N4 Certification Class who will perform programming and installation of the operator interface for this project. Evidence of these certifications shall be submitted to the Architect / Engineer upon request.
5. Staffing resources of competent and experienced full-time employees that are assigned to execute work according to schedule.
6. Service and maintenance staff assigned to support Project during warranty period.
7. Product parts inventory to support on-going DDC system operation for a period of not less than 5 years after Substantial Completion.
8. DDC system manufacturer's backing to take over execution of Work if necessary to comply with requirements indicated. Include Project-specific written letter, signed by manufacturer's corporate officer, if requested.

C. Control Product Manufacturer Qualifications: A company experienced in manufacturing building automation systems similar to those indicated for this Project and with a record of successful in- service performance.

1. The manufacturer shall offer software tool and development training to the public on a regular, ongoing basis.

D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

E. BACnet: The system shall comply with the native BACnet architecture and web browser access described in this specification. All Tier 1 and 2 controllers shall be approved by BACnet Testing Laboratories (BTL Listed).

F. Engineering Review Meeting: After the Engineer has reviewed and returned the first submission of the Primary Submittal, an in-person meeting shall be held between the Engineer and the BAS provider on a mutually agreeable day and time to review the comments and clarify any project requirements. The BAS provider shall allocate no less than four (4) hours of meeting time plus travel time and expenses. The meeting location will be mutually agreed upon and announced.

1. It is the responsibility of the BAS provider to contact the Engineer and propose days and times for the meeting after review of the Engineer's comments on the Primary Submittal.

G. Point Naming Conventions

1. All point text naming conventions shall be consistent in their use and application with the Owner's existing points on the BAS.

2. If the building Owner has no preferred point naming conventions, all point text naming conventions shall be consistent in their use and application throughout the controls system, and shall utilize formats created under Project Haystack (<https://project-haystack.org/>) where applicable. The BAS provider may develop their own conventions for points and equipment types not yet covered under Project Haystack, however they shall be as consistent with Project Haystack as possible. Submit proposed naming arrangements for approval prior to data entry.
- H. Materials and equipment shall be the catalogued products of the manufacturer. The ATC Subcontractor personnel shall have been regularly engaged in production and installation of automatic temperature control systems for a minimum of 5 years. The control system shall be the manufacturer's latest standard design that complies with the specification requirements.
- I. Install system using competent workers who are regularly employed and fully trained by the ATC Subcontractor in the installation of temperature control equipment. The ATC shall provide adequate staff to engineer, supervise, program and commission the control system in a timely manner. In addition, ATC shall maintain fully equipped service trucks to provide full warranty service available 24 hours a day, 7 days a week with a minimum 4-hour response time.
- J. Single source responsibility of supplier shall be the complete installation and proper operation of the BAS and control system and shall include debugging and proper calibration of each component in the entire system.
- K. Electronic equipment shall conform to the requirements all government regulations.

1.10 BIDDING

- A. The BAS shall contain Tridium Niagara software and hardware, and shall be provided by one of the providers listed below in article 2.1 ACCEPTABLE MANUFACTURERS. All bidders must substantiate conformance with article QUALITY ASSURANCE with their bid proposal whether listed as an acceptable manufacturer or not.
- B. Include with your bid proposal, the following Submittal documents:
 1. Bid Compliance Report
 2. System Description
 3. Qualification Data

1.11 SUBMITTALS

- A. Multiple Submissions:
 1. Multiple submissions will be required to execute work. Provide independent submittals for each category itemized below.
 - a. Submit a coordinated schedule clearly defining intent of multiple submissions. Include a proposed date of each submission with a detailed description of submittal content to be included in each submission.
 - b. Include an updated schedule in each subsequent submission with changes highlighted to easily track the changes made to previous submitted schedule.
- B. Bid Compliance Report (Include with Bid Submission):
 1. Include with your bid, a general statement of compliance of Section 230900 Automatic Temperature Control for HVAC, except as noted.

2. For each non-compliance item; identify the article, number and title, section number, and indicate the following:
 - a. Exception - meets the functional intent. Identify all differences in specific functions stated in the given paragraph and provide a description of what is excluded or how they intend to meet the function specified.
 - b. Does Not Comply - cannot meet they specified function and will not provide.
3. Furnish the following additional information as part of the compliance report.
 - a. Name of manufacturers interface software and protocol used.
 - b. Name of manufacturer's gateways or routers used, including protocol and communications network type used.
 - c. Name of manufacturer's controllers used and communication protocol.
 - d. Name of manufacturer web server and programming software and protocol used.
 - e. Name of the BAS Contractor's intended electrical (installing) sub-contractor, if any.
 - f. A list of any exceptions taken to the sequences of operation included with the Contract Documents.
 - g. Documentation that illustrates the representative graphics, system navigational features, alarm management, setpoint adjustment, trend displays, programming logic tools, and other important features of the human-machine interface software.
4. The BAS Contractor may include additional information they choose beyond that listed above; however, this information shall be separated from the above information in a clearly identified, independent Appendix.

C. System Description: (Include with Bid Proposal)

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. System and product operation under each potential failure condition including, but not limited to, the following:
 - a. Loss of power.
 - b. Loss of network communication signal.
 - c. Loss of controller signals to inputs and outputs.
 - d. Operator workstation failure.
 - e. Server failure.
 - f. Gateway failure.
 - g. Network failure
 - h. Controller failure.
 - i. Instrument failure.
 - j. Control damper actuator failure.
3. Description of testing plans and procedures.
4. Description of Owner training.

D. Qualification Data: (Include with Bid Proposal)

1. Systems Provider Qualification Data:
 - a. Resume of project manager assigned to Project.
 - b. Resumes of application engineering staff assigned to Project.
 - c. Resumes of installation and programming technicians assigned to Project.
 - d. Resumes of service technicians assigned to Project.
 - e. Brief description of past project including physical address, floor area, number of floors, building system cooling and heating capacity, and building's primary function.
 - f. Description of past project DDC system, noting similarities to Project scope and complexity indicated.
 - g. Names of staff assigned to past project that will also be assigned to execute work of this Project.
 - h. Owner contact information for past project including name, phone number, and e-mail address.

- i. A minimum of three (3) client references for whom similar or larger projects in size and scope were completed. The projects shall have been completed within the last four (4) years, but no more recently than 6 months.
 - j. Architect and Engineer contact information for past project including name, phone number, and e-mail address.
 2. Manufacturer's qualification data.
 3. Testing agency's qualifications data.
- E. Product Data - for each type of product include the following:
 1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 3. Product description with complete technical data, performance curves, and product specification sheets.
 4. Installation, operation and maintenance instructions including factors effecting performance.
 5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.
 - a. Workstations.
 - b. Servers.
 - c. Printers.
 - d. Gateways.
 - e. Routers.
 - f. Protocol analyzers.
 - g. DDC controllers.
 - h. Enclosures.
 - i. Electrical power devices.
 - j. UPS units.
 - k. Accessories.
 - l. Instruments.
 - m. Control dampers and actuators.
 6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
 7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.
- F. Software Submittal:
 1. Cross-referenced listing of software to be loaded on each operator workstation, server, gateway, and DDC controller.
 2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
 3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
 4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
 5. Listing and description of each engineering equation used with reference source.
 6. Listing and description of each constant used in engineering equations and a reference source to prove origin of each constant.
 7. Description of operator interface to alphanumeric and graphic programming.
 8. Description of each network communication protocol.
 9. Description of system database, including all data included in database, database capacity and limitations to expand database.

10. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
 11. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.
- G. Manufacturer's Product Data including:
1. Hardware--cutsheets, product descriptions, and engineering information.
 2. Engineering--design requirements for initial installations and/or additions to existing systems.
 3. Installation--mounting and connection details for field hardware, accessories, and central site equipment.
 4. Field hardware set-up, checkout, and tuning techniques.
 5. Central site set-up, software loading, and checkout techniques.
- H. Shop Drawings
1. Drawings shall show proposed layout and installation of all equipment and the relationship to other parts of the work. Shop drawings shall include the following:
 - a. Bill of materials of equipment indicating quantity, manufacturer, and model number.
 - b. Schematic flow diagrams of:
 - 1) Each controlled HVAC central system showing **chillers, boilers, pumps, dampers, valves,** and control devices.
 - 2) Each controlled HVAC equipment item showing components fans, coils, dampers, **valves,** and control devices.
 - c. Complete wiring diagrams showing all power, signal, and control wiring. Include wire types.
 - d. Details of control panel faces, including controls, instruments, and labeling.
 - e. Written description of sequence of operation.
 - f. Schedule of dampers including size, leakage, and flow characteristics. Include damper size and type, actuator type, torque and damper actuator part numbers.
 - g. Schedule of airflow measuring stations.
 - h. Schedule of steam and water flow measuring stations / meters. The flow meter selection, product application, and submittal process and requirements shall be as described above for airflow measuring stations.
 - i. Proposed point naming conventions.
 - j. Physical locations of control equipment, including main computer HMI, controllers, sub-controllers, and other equipment requiring access or electric power.
 - k. Points list for each HVAC system or HVAC equipment item being controlled.
 - l. Tag number of devices and any other details required to demonstrate that the system will function properly.
 - m. Include a trunk cable schematic diagram depicting Tier 1 (head end) controllers, Tier 2 controllers, control panel locations and a description of the communication type, media and protocol. Division 23 and 26 contractors shall provide these diagrams for their portions of work, but the BAS Contractor shall be responsible for integrating those diagrams into the overall trunk cable schematic diagrams for the entire Wide Area Network (WAN).
 2. Shop drawings shall clearly indicate intended sequence of operation for all equipment.
 3. For DDC system include configuration diagrams showing all panel types and locations. Submittal data shall include descriptions of software, calculations, communications network and workstations. Submit software flowcharts or program printouts to verify compliance with specifications. Include the overall point's list. Revisions made as a result of the submittal process, during the installation, start-up or acceptance portion of the project, shall be accurately reflected in the "as-built" graphic software flow diagrams herein required by this specification.

4. Shop drawings shall include a list of color graphics indicating monitored systems, data (connected and calculated) point addresses, output schedule, and operator notations.
5. Scaled drawings showing the location of all wall mounted DDC panels, wall mounted sensors, and similar devices.

I. Graphics Submittal:

1. This submittal shall occur after the primary submittal described above, but not less than 4 weeks prior to the planned date for installing graphics into the system in the field.
2. Include a copy of each of the graphics developed for the Graphic User Interface including a flowchart (site map) indicating how the graphics are to be linked to one another for system navigation. The graphics are intended to be 90% complete at this stage with the only remaining changes to be based on review comments from the A/E design team and/or Owner.
 - a. The graphics submitted shall be the actual graphics intended to be utilized on this project, and shall be completely job specific.
 - b. Generic or typical graphics are not acceptable, however a single typical graphic may be submitted for types of equipment where this project has multiple, identically controlled pieces of equipment (e.g. VAV boxes, fan coils, etc.). Where installation procedures, or any part thereof, are required to be in accordance with the recommendations of the manufacturer of the material being installed, printed copies of these recommendations shall be furnished to the Architect/Engineer prior to installation. Installation of the item will not be allowed to proceed until the recommendations are received.

J. Project Specific User Manual to be provided at time of training:

1. System reference material shall contain as a minimum, an overview of the system, its organization, the concepts of networking and central site/field hardware relationships as well as the following:
 - a. Activating the central site
 - b. Central site screen menus and their definitions
 - c. Establishing setpoints and schedules
 - d. Uploading and downloading software, setpoints, schedules, operating parameters and status between the central site and field hardware
 - e. Collecting trend data and generating trend plots
 - f. Enabling alarms and messages
 - g. Report generation
 - h. Backing up software and data files
 - i. Using the central site with 'third party' software
2. Software Documentation:
 - a. Shall contain a listing of the alarm and message conditions, which may be detected for each piece of controlled equipment and the standard alarm and message texts, which can be displayed when those conditions exist.
 - b. A graphic flow diagram for each software application program provided as part of this project.
 - c. Graphics generation.
 - d. At the completion of the project and after final acceptance of the system, the ATC Subcontractor shall provide a complete backup of all system software on CD. Include:
 - 1) Final "As-Built" version of graphics
 - 2) Final "As-Built" version of DDC controller programming

1.12 INFORMATIONAL SUBMITTALS

- A. Field quality-control / commissioning test reports.
 - 1. Phase I - General Performance Testing reports.
 - 2. Phase II - Operational Sequence Testing reports.
- B. Closeout Submittals
 - 1. Operation and Maintenance Data:
 - a. Submit operation and maintenance data under provisions of Division 01.
 - b. Include systems descriptions, set points, and controls settings and adjustments.
 - c. Include inspection period, cleaning methods, recommend cleaning materials, and calibration tolerances.
 - d. Provide owner instruction under provisions of Division 01. Use operation and maintenance data as a training manual.
 - 2. Graphics:
 - a. Submit screen captures of control graphics for each system and each equipment item for approval.

1.13 OPERATION AND MAINTENANCE DATA

- A. Operation and Maintenance Data: For DDC system to include in emergency, operation, and maintenance manuals.
 - 1. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
 - b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
 - c. As-built versions of submittal Product Data.
 - d. Names, addresses, e-mail addresses, and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
 - e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control, and changing set points and variables.
 - f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
 - g. Engineering, installation, and maintenance manuals that explain how to:
 - 1) Design and install new points, panels, and other hardware.
 - 2) Perform preventive maintenance and calibration.
 - 3) Debug hardware problems.
 - 4) Repair or replace hardware.
 - h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
 - i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
 - j. List of recommended spare parts with part numbers and suppliers.
 - k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
 - l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.

- m. Licenses, guarantees, and warranty documents.
- n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
- o. Owner training materials.

1.14 SEQUENCING, SCHEDULING, AND COORDINATION

- A. Coordinate work under provisions of General and Supplementary Conditions, Division 01 and Division 23, and ensure system is completed and commissioned by Date of Substantial Completion.
- B. Coordinate installation of system components with installation and checkout of mechanical systems equipment such as air handling units, VAV terminal boxes, gas fired radiant heaters, etc.

1.15 WARRANTY

- A. Base Bid: All devices and components shall be warranted for a period of **two (2) years** following the date of final acceptance by the Owner. The warranty period shall not start until all systems under project are accepted by the Owner. No partial warranty shall be permitted.
 - 1. This warranty shall include all labor and material. Any defects arising during the warranty period shall be corrected without cost to the Owner. During the warranty period, the contractor's service personnel shall be available to be physically present at the facility within twenty-four (24) hours for emergency repairs.

1.16 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.

1.17 COORDINATION

- A. Coordinate location of thermostats, humidistats, and other exposed control sensors with Owner and Architect before installation. Obtain approval for final locations from Owner and Architect prior to installation.

1.18 FACTORY MOUNTED EQUIPMENT CONTROLS

- A. BAS Provider Scope and Responsibilities:
 - 1. Provide integration of factory supplied controls into the Building BAS. Factory supplied control points shall be programmed into the operator's interface, system applications and graphics software and operate seamlessly with the Building BAS.
 - 2. Coordinate and resolve incompatibility issues that arise between control products provided under this Section and those provided under other Sections or Divisions of the contract document specifications.
 - 3. Communication Gateway Connections: Extend the appropriate / required portion of the BAS network and connect to all packaged equipment controls, all air and water flow meters, and any devices provided with communications gateways.

- a. BAS graphics shall incorporate all 'communication' points available through integration gateways provided with packaged equipment controls, air and water flow meters, and other devices provided with such communications gateways.
- B. Division 23 Contractor's Scope and Responsibilities:
 - 1. The Division 23 Contractor shall ensure that the equipment manufacturer's representative is on-site during the BAS commissioning process to ensure full integration of factory controls with the BAS.
 - 2. All equipment furnished with controls that are furnished and installed by the manufacturer shall have BACnet MSTP or BACnet IP communication capability from the equipment manufacturer.
 - a. Modbus TCP/IP may be acceptable, only if BACnet MSTP or BACnet IP is not offered by the equipment manufacturer AND the use of Modbus TCP/IP includes complete BAS control and monitoring communication through a Modbus - BACnet gateway incorporated into the BAS and is approved by the Architect / Engineer and the BAS sub-contractor prior to installation.
- C. Representatives from each manufacturer providing factory mounted controls and the BAS subcontractor shall cooperate in the integration of the individual systems operation prior to bid and during field installation, TAB services, and commissioning / functional testing.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. Base Bid: Johnson Controls Facility Explorer, Niagara Platform (furnished and installed by OZ Enterprises located at 60 Abele Road, Suite 1101, Bridgeville, PA 15017).
- B. Alternate 1: Siemens, Talon Niagara Platform, (Located at 400 Mosites Way, Suite 400, Pittsburgh, PA 15205).
- C. Alternate 2: KMC, Niagara Platform (furnished and installed by Building Control Systems located at 523 West Main Street, Carnegie, PA)

2.02 GENERAL

- A. The Owner shall have full rights to all programming software and to all passwords.
- B. All DDC controllers must have proportional-integral (PI) or proportional-integral-derivative (PID) algorithms incorporated into their programming.
- C. Control signals from the Building Automation System (BAS) to all controlled components must be the analog type signal. Pulse signals, or floating point control signals, are not acceptable.
- D. All DDC controls shall be fully BACNet, LONWorks, and/or MODBus compatible and shall be EtherNet compatible.

2.03 SOFTWARE LICENSE AGREEMENT AND SERVICE TOOLS

- A. It is the Owners expressed goal to implement an open system that will allow products from a single supplier to be seamlessly integrated into a unified system in order to provide flexibility for expansion, maintenance, and service of the system.

- B. The BAS provider shall provide to the Owner a perpetual software and firmware licensing agreement as a condition of this Contract that after being signed by the Owner shall grant use of all programs and application software to Owner.
- C. The Owner shall take ownership of all proprietary material generated or used in the execution of this project as a requirement of this Contract.
1. The Owner shall be the named perpetual license holder of all software associated with any and all incremental work on the project(s), including all configuration and service software tools, hardware, firmware, or documentation that was used in the development, programming, or commissioning of the system for this project.
 2. In addition, the Owner shall receive ownership of all job specific configuration documentation, data files, programming tools, and application-level software developed. This shall include all custom, job-specific software code, with the Tridium Niagara platform, NAC(s), BAS Building Automation Server(s), and any related LAN / WAN / Intranet and Internet connected routers and devices.
 - a. Materials shall be provided in native, virtual formats.
 - b. Copies shall be furnished on the network area controller, database server, and on separate physical media (DVD or flash drive).
 - c. If Niagara BAS is provided, all control devices furnished by this Section shall be programmable directly from the Niagara 4 Workbench embedded toolset upon completion of the project. The use of configurable or programmable controllers that require additional software tools for post-installation maintenance shall not be acceptable.
 3. The BAS supplied for this project shall use an open access licensing procedure, and any and all required admin-level IDs and passwords for full access to any component or software program shall be provided to the Owner.
 4. The Niagara framework supplied for this project shall use an open access licensing procedure, so that the Owner will not need to authorize changes to the license to enable passwords used by the BAS Supplier needed for access to any system component or software program shall be provided to the Owner.
 - a. All Niagara instances regardless of brand ID shall contain an open Niagara Capability Statement where all attributes are "***" for open. A locked NiCS (Niagara Compatibility Statement) will not be acceptable.
 - b. The Owner shall receive all administrator level passwords for engineering toolset at the first training session. The Owner shall have full licensing and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the system.
 5. Licenses shall not rely on a physical license key, dongle, or similar device.
 6. Be advised that the Owner will be obtaining the services of a separate vendor, prior to final payment, to independently verify that all required configuration, programming, and service tools have been provided with the information and materials turned over the Owner at the conclusion of the project. Verification of an open license will also be performed.
 7. Provide a copy of the license certificate to the Owner and Architect / Engineer.
 8. Provide no less than three (3) of each type of proprietary hardware required to access the building controllers, if any (e.g., network adapters).
 9. Provide the passphrase for each server and building controller to permit un-encryption of the database.
- D. The Owner shall be granted no less than 5 years of software maintenance, at no additional cost.

2.04 WEB-BASED ACCESS TO BAS

- A. Provide a web-based interface to allow Owner the capability of bi-directional access to the new Building Automation System (BAS). The system shall support unlimited users using standard web browsers such as Internet Explorer and Netscape. The web server software shall operate on standard industry PC servers. Proprietary servers or "black boxes" are not acceptable. Web browser software shall be manufactured by the control system manufacturer and shall have the same look and feel as the operating system.
- B. For Local Area Network installations provide access to the control system via the Internet. The owner shall provide a connection to the Internet via high-speed cable modem, ADSL, ISDN, T1 or through the facility ISP. The owner shall pay for all monthly Internet access fees and connection charges.
- C. Web-based features shall include:
 - 1. Access to the BAS using workstation browsers, cell phones, and portable computers.
 - 2. Complete control of system operating parameters, such as schedules and setpoints, from virtually any modern communications device inside or outside of the building.
 - 3. The ability to use secure socket layers (SSL), wireless-access-protocol devices, digital subscriber lines, virtual private networks, and other emerging network architectures and technologies that are being developed for the entire Web community.
 - 4. Ability to monitor and control the EMS through any computer with web browser software and Internet or network access, not only certain computers running proprietary software.
 - 5. Reuse existing graphics for web pages or automatically generate web pages utilizing the same tools that are used to engineer the control system graphics. The web pages must be in sync with the actual control system. Systems in which the web pages must be hand crafted separately and which will have a different look than the EMS graphics will not be acceptable.
 - 6. Provide built-in firewall security to protect network. Use industry standard encryption of all communications between the web-based interface and the user.
- D. Web Browser Clients:
 - 1. System shall support web clients using a standard Web browser such as Internet Explorer, Netscape Navigator, etc.
 - 2. Web browser software shall run on Microsoft Windows platforms.
 - 3. Web browser shall provide the same view of the system, in terms of graphics, logs, alarms, and provide the same interface methodology as is provided by the HMI.
 - 4. Web browser client shall support at a minimum, the following functions:
 - a. User log-on identification and password shall be required. If unauthorized user attempts access the log-on screen is re-displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.
 - b. HTML programming shall not be required to display system graphics or data on a Web page. HTML editing of the Web page shall be allowed if the user desires a specific look or format.
 - c. Storage of graphical screens shall be in the Web Server without requiring any graphics to be stored on the client machine.
 - d. Real-time values displayed on a Web page shall update automatically without requiring a manual "refresh" of the Web page.
 - e. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - 1) Modify common application objects, such as set points, in a graphical manner.
 - 2) Commands to start and stop binary objects shall be done by clicking or double clicking, the selected object and selecting the appropriate command from the pop-up menu.
 - 3) View logs, charges, and trend reports.
 - 4) View and acknowledge alarms.

- f. Loading of additional software at the web-client is not acceptable. This must be performed via upload from the web-server.
 - g. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired link.
5. Tower Engineering shall be provided with full web browser client access including web address and all passwords with owner's approval.

2.05 DDC NETWORK PANEL

- A. Each Network Panel shall have sufficient memory to support its own operating system and databases, including: Control processes; Energy management applications; Alarm management applications including custom alarm messages for each level alarm for each point in the system; historical/trend data for points all hardwired I/O points and all set-points; maintenance support applications; custom processes; operator I/O; web-based communications; and manual override monitoring.
- B. DDC Network Panel shall provide at least two RS-232C serial data communication ports for operation of operator I/O devices such as industry standard printers, operator terminals, modems and portable laptop operator's terminals. DDC Network Panel shall allow temporary use of portable devices without interrupting the normal operation of permanently connected printers or terminals.
- C. Network Panel shall continuously perform self-diagnostics, communication diagnosis and diagnosis of all panel components. The DDC Controller shall provide both local and remote annunciation of any detected component failures, low battery conditions or repeated failure to establish communication.
- D. Isolation shall be provided at all peer-to-peer network terminations, as well as all field point terminations to suppress induced voltage transients consistent with IEEE Standards 587-1980.
- E. In the event of the loss of normal power, there shall be an orderly shutdown of all DDC controllers to prevent the loss of database or operating system software. Non-volatile memory shall be incorporated for all critical controller configuration data and battery backup shall be provided to support the real-time clock and all volatile memory for a minimum of 72 hours.
 - 1. Upon restoration of normal power, the DDC controllers shall automatically resume full operation without manual intervention.
 - 2. Should DDC controller's memory be lost for any reason, the user shall have the capability of reloading the DDC controllers via the local RS-232C port, via telephone line dial-in or from a network workstation PC.
- F. A single process shall be able to incorporate measured or calculated data from any and all other DDC Controllers on the network. In addition, a single process shall be able to issue commands to points in any and all other DDC Controllers on the network.
- G. DDC Network Panel shall have the ability to perform any or all the following energy management routines:
 - 1. Time-of-day scheduling, Calendar-based scheduling, Holiday scheduling, temporary schedule overrides
 - 2. Start-Stop Time Optimization, Automatic Daylight Savings Time Switchover, Night setback control
 - 3. Economizer switchover Fan speed/CFM control
 - 4. Peak demand limiting, Temperature-compensated duty cycling
- H. Processes shall be able to generate operator messages and advisories to operator I/O devices. A process shall be able to directly send a message to a specified device or cause the execution of a dial-up connection to a remote device such as a cell phone or pager.

- I. Alarm management shall be provided to monitor and direct alarm information to operator devices. Each DDC Network Panel shall perform distributed, independent alarm analysis and filtering to minimize operator interruptions due to non-critical alarms, minimize network traffic and prevent alarms from being lost. At no time shall the ability to report alarms be affected by either operator or activity at a PC workstation, local I/O device or communications with other panels on the network.
- J. A variety of historical data collection utilities shall be provided to manually or automatically sample, store and display system data for all points identified by the Owner. The ATC Subcontractor shall trend all hardwired I/O points as well as all set points.
 - 1. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.
- K. DDC Controllers shall automatically accumulate and store run-time hours for digital input and output points as specified in the point I/O summary. DDC Controllers shall automatically sample, calculate and store consumption totals on a daily, weekly or monthly basis. DDC Controllers shall have the ability to count events such as the number of times a pump or fan system is cycled on and off.
- L. DDC Network Panel shall provide optimal start/stop feature that integrates schedules and DDC controller setpoints and temperatures to optimize setpoint temperatures with occupancy and un-occupancy modes. Must include adaptive modeling to self-correct by using historical data of thermal characteristics of building.
- M. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password. Provide a minimum of 5 levels of access control.
- N. Reports shall be generated and directed to workstation displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - 1. A general listing of all points in the network.
 - 2. List of all points in alarm, in override status, locked out, disabled.
 - 3. DDC Controller trend overflow warning.
 - 4. List all weekly schedules and holiday programming.
 - 5. List of limits and dead bands.
- O. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - 1. Add/delete/modify stand-alone DDC Network Panels, application specific controllers, PC interface.
 - 2. Add/delete/modify points of any type and all associated point parameters, tuning constants, control loops, custom control processes.
 - 3. Add/delete/modify alarm reporting definition, energy management applications, totalization, historical data trending.
 - 4. Add/delete/modify time and calendar-based programming, graphic displays, operator passwords.
- P. Provide automatic web-based and dial-up communications as specified. Automatic dial-up communications shall include the following features as a minimum:
 - 1. Dial-Out - Manual dial-out to cell phones and pagers shall be accomplished using only a mouse to select and request the desired remote connection.

- Q. Communications cards:
1. Communications cards shall be provided and employed as the means of communications between all DDC control panels and application specific controllers.

2.06 PROGRAMMABLE CONTROLLERS (PRC)

- A. Each PRC shall operate as a stand-alone controller capable of performing its specified control responsibilities independently of other controllers in the network. Each PRC shall be a microprocessor-based, multi-tasking, real-time digital control processor.
- B. Controllers shall include all point inputs and outputs necessary to perform the specified control sequences. Provide each central system controller with sufficient memory to accommodate point databases, operating programs, local alarming and local trending. All databases and programs shall be stored in non-volatile EEPROM or a minimum of 72-hour battery backup shall be provided. All programs shall be field-customized to meet the user's exact control strategy requirements.
- C. Local alarming and trending capabilities shall be provided for convenient troubleshooting and system diagnostics. Alarm limits and trend data information shall be user-definable for any point.
- D. Each controller shall have connection provisions for a portable operator's terminal. This tool shall allow the user to display, generate or modify all point databases and operating programs. All new values and programs may then be restored to EEPROM via the programming tool.
- E. Each controller performing space temperature control shall be provided with a matching room temperature sensor. The sensor may be either RTD or thermistor type providing the following minimum performance requirements are met:
- ◆ Accuracy: $\pm 0.5^{\circ}\text{F}$
 - ◆ Operating Range: 35° to 115°F
 - ◆ Set Point Adjustment Range: 55° to 95°F
 - ◆ Set Point Modes: Independent Heating, Cooling, Night Setback-Heating, Night Setback-Cooling
 - ◆ Calibration Adjustments: None required
 - ◆ Installation: Up to 100 feet from Controller
1. Each room temperature sensor shall include a terminal jack integral to the sensor assembly. The terminal jack shall be used to connect a portable operator's terminal to control and monitor all hardware and software points associated with the controller. In lieu of an internal jack, provide a separate terminal jack mounted on a stainless steel wall plate adjacent to the sensor to facilitate direct access to the controller via the terminal.
 2. Each room sensor shall also include the following auxiliary devices: Setpoint Adjustment Dial, Temperature Indicator, and Override Switch.
 - a. The setpoint adjustment dial shall allow for modification of the temperature by the occupant. Setpoint adjustment may be locked out, overridden, or limited as to time or temperature through software by an authorized operator at a web-based workstation, DDC Controller, or via the portable operator's terminal.
 - b. An override switch shall initiate override of the night setback mode to normal (day) operation when activated by the occupant. The override function may be locked out, overridden or limited as to the time through software by an authorized operator at the central workstation, DDC Controller or via the portable operator's terminal.

3. Provide flush-mount type sensors for all rooms. These shall be Siemens model 540-520 or equivalent.
 4. Coordinate the final check-out of the terminal units with the Testing and Balancing Subcontractor.
- F. Each controller shall perform its primary control function independent of other DDC controller or if communication is interrupted. Reversion to a fail-safe mode of operation during communications interruption is not acceptable. The controller shall receive its real-time data from the DDC Network Panel time clock to insure continuity. Each controller shall include algorithms incorporating proportional, integral and derivative (PID) gains for all applications. All PID gains and biases shall be field-adjustable by the user via terminals as specified herein. This functionality shall allow for tighter control of space conditions and shall facilitate optimal occupant comfort and energy savings.

2.07 PC-BASED OPERATOR WORKSTATION

- A. A personal computer operator workstation shall be provided for command entry, information management, network alarm management and database management functions.
1. Motherboard: With 8 integrated USB 3.0 ports, integrated 10/100/1000 Ethernet adapter, integrated audio, bios, and hardware monitoring.
 2. Processor: 7th Generation Intel Core I5 processor, minimum 3.4 GHz.
 3. Random-Access Memory: Minimum 12 GB DDR4 2400 Mhz.
 4. Graphics: Dual Video Graphics Adapter (DVI & HDMI), minimum 3840 x 2160 pixels, 2 GB video memory.
 5. Monitor: Minimum 24 inches, 1920 x 1080 LCD color flat screen with height adjustment.
 6. Keyboard: QWERTY, 105 keys in ergonomic shape.
 7. Hard-Disk Drive: Dual 240GB in RAID1.
 8. DVD-ROM Read/Write Drive: Minimum x24.
 9. Mouse: Three button, optical.
 10. Uninterruptible Power Supply: 2 kVA.
 11. Operating System: Microsoft Windows 10 Enterprise with high-speed Internet access.
 12. Additional Ports: Minimum of two parallel and two asynchronous serial ports for connections of peripherals.
 - a. ASHRAE 135 Compliance: Workstation shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
 - b. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.
- B. Provide a computer operator workstation as described. Coordinate location of workstation with the Owner.
- C. **In addition to the workstation required to be provided by the ATC Subcontractor**, any Owner furnished personal computer shall be capable of being utilized as an operator workstation via web-based access for command entry, information management, network alarm management and database management functions. All real-time control functions shall be resident in the DDC Controllers to facilitate greater fault tolerance and reliability.
1. If graphics and other software must be resident on an Owner furnished personal computer, the ATC Subcontractor shall coordinate with the Owner to determine which Owner furnished personal computer(s) shall be provided with the software.
- D. **Provide a black-and-white laser-jet printer and/or a color ink jet printer** near the computer for printing alarms, reports and graphics. The ink jet printer shall have the following minimum requirements:
1. Printer - black-and-white, laser-jet type as follows:
 - a. Print Head: Minimum 1200 x 1200 dpi resolution.
 - b. Paper Handling: Minimum of 250 sheet trays.
 - c. Print Speed: Minimum of 120 characters per second.

2. Printer - color, ink-jet type as follows:
 - a. Print Head: Minimum 4800 x 1200 dpi optimized color resolution.
 - b. Paper Handling: Minimum of 100 sheets.
 - c. Print Speed: Minimum of 17 pages per minute in black and 12 pages per minute in color.
- E. The Owner furnish a printer for printing network alarms.
- F. Basic Interface Description:
1. Web-based operator workstation interface software shall minimize operator training through the use of English language prompting, English language point identification and industry standard PC application software. The software shall provide, as a minimum, the following functionality:
 - a. Scheduling and override of building operations
 - b. Complete alarm reporting and manipulation
 - c. Configuration of all reports and point summaries
 - d. Collection and analysis of historical data
 - e. Editing, programming, storage and downloading of controller databases
 - f. Graphical viewing and control of environment
 2. Definition and construction of dynamic color graphic displays.
 3. Provide a graphical user interface which shall minimize the use of a typewriter style keyboard through the use of a mouse or similar pointing device and "point and click" approach to menu selection. Users shall be able to start and stop equipment or change setpoints from graphical displays through the use of a mouse or similar pointing device
 4. The software shall provide a multi-tasking type environment that allows the user to run several applications simultaneously. The mouse shall be used to quickly select and switch between multiple applications. This shall be accomplished through the use of Microsoft Windows or similar industry standard software that supports concurrent viewing and controlling of systems operations.
 5. Multiple-level password access protection shall be provided to allow the user/manager to limit workstation control, display and data base manipulation capabilities as he deems appropriate for each user, based upon an assigned password.
 - a. A minimum of five levels of access shall be supported:
 - b. A minimum of 50 unique passwords, including user initials, shall be supported. Operators will be able to perform only those commands available for their respective passwords. Menu selections displayed shall be limited to only those items defined for the access level of the password used to log-on.
 - c. The system shall automatically generate a report of log-on/log-off time and system activity for each user. User-definable, automatic log-off timers of from 5 to 60 minutes shall be provided to prevent operators from inadvertently leaving devices on-line.
 6. Reports shall be generated and directed to workstation displays, printers or disk. As a minimum, the system shall allow the user to easily obtain the following types of reports:
 - a. A general listing of all points in the network
 - b. List of all points in alarm, in override status, locked out, disabled
 - c. DDC Controller trend overflow warning
 - d. List all weekly schedules and holiday programming
 - e. List of limits and dead bands

G. Scheduling

1. Provide a graphical spreadsheet-type format for simplification of time-of-day scheduling and overrides of building operations. Provide the following spreadsheet graphic types as a minimum.
2. Weekly schedules shall be provided for each building zone or piece of equipment with a specific occupancy schedule. Each schedule shall include columns for each day of the week as well as holiday and special day columns for alternate scheduling on user-defined days. Equipment scheduling shall be accomplished by simply inserting occupancy and vacancy times into appropriate information blocks on the graphic. In addition, temporary overrides and associated times may be inserted into blocks for modified operating schedules. After overrides have been executed, the original schedule will automatically be restored.
3. Zone schedules shall be provided for each building zone as previously described. Each schedule shall include all commandable points residing within the zone. Each point may have a unique schedule of operation relative to the zone's occupancy schedule, allowing for sequential starting and control of equipment within the zone. Scheduling and rescheduling of points may be accomplished easily via the zone schedule graphic.
4. Monthly calendars for a 24-month period shall be provided which allow for simplified scheduling of holidays and special days in advance. Holidays and special days shall be user-selected with the pointing device and shall automatically reschedule equipment operation as previously defined on the weekly schedules.

H. Collection and Analysis of Historical Data

1. Provide trending capabilities that allow the user to easily monitor and preserve records of system activity over an extended period of time. All system I/O points and set-points will be automatically trended and any other system points selected by the owner may be trended automatically at time-based intervals or changes of value, both of which shall be user-definable. Trend data may be stored on hard disk for future diagnostics and reporting.
2. Trend data report graphics shall be provided to allow the user to view all trended point data. Reports may be customized to include individual points or pre-defined groups of at least 6 points. Provide additional functionality to allow any trended data to be transferred easily to an off-the-shelf spreadsheet package such as Excel Spreadsheet. This shall allow the user to perform custom calculations such as energy usage, equipment efficiency and energy costs and shall allow for generation of these reports on high-quality plots, graphs and charts.
3. Provide additional functionality that allows the user to view trended data on trend graph displays. Displays shall be actual plots of both static and/or real-time dynamic point data. A minimum of 4 points may be viewed simultaneously on a single graph, with color selection and line type for each point being user-definable. Displays shall include an 'X' axis indicating elapsed time and a 'Y' axis indicating a range scale in engineering units for each point. The 'Y' axis shall have the ability to be manually or automatically scaled at the user's option. Different ranges for each point may be used with minimum and maximum values listed at the bottom and top of the 'Y' axis. All 'Y' axis data shall be color-coded to match the line color for the corresponding point.
 - a. Static graphs shall represent actual point data that has been trended and stored on disk. Exact point values may be viewed on a data window by pointing or scrolling to the place of interest along the graph. Provide capability to print any graph on the system printer for use as a building management and diagnostics tool.
 - b. Dynamic graphs shall represent real-time point data. Any point or group of points may be graphed, regardless of whether they have been predefined for trending. The graphs shall continuously update point values. At any time, the user may redefine sampling times or range scales for any point. In addition, the user may pause the graph and take "snapshots" of screens to be stored on the workstation disk for future recall and analysis. As with static graphs, exact point values may be viewed and the graphs may be printed.

I. Dynamic Color Graphic Displays

1. Color graphic floor plan displays and system schematics for each piece of mechanical equipment shall be provided by the ATC Subcontractor to optimize system performance analysis and speed alarm recognition. As indicated in the point I/O summary, these shall include air handling units, chilled water systems and hot water boiler systems, etc.
2. The operator interface shall allow users to access the various system schematics and floor plans via a graphical penetration scheme, menu selection or text-based commands.
3. Dynamic temperature values, humidity values, flow values and status indication shall be shown in their actual respective locations and shall automatically update to represent current conditions without operator intervention.
4. The windowing environment of the PC operator workstation shall allow the user to simultaneously view several graphics at a time to analyze total building operation or to allow the display of a graphic associated with an alarm to be viewed without interrupting work in progress.
5. Graphic generation software shall be provided to allow the user to add, modify or delete system graphic displays.
 - a. The ATC Subcontractor shall provide libraries of pre-engineered screens and symbols depicting standard air handling unit components (e.g., fans, cooling coils, filters, dampers, etc.), complete mechanical systems (e.g., constant volume-terminal reheat, VAV, etc.) and electrical symbols.
 - b. Graphical displays can be created to represent any logical grouping of system points or calculated data based upon building function, mechanical system, building layout or any other logical grouping of points which aids the operator in the analysis of the facility. To accomplish this, the user shall be able to build graphic displays that include point data from multiple DDC Controllers.

J. System Configuration and Definition

1. All temperature and equipment control strategies and energy management routines shall be definable by the operator. System definition and modification procedures shall not interfere with normal system operation and control.
2. The system shall be provided complete with all equipment and documentation necessary to allow an operator to independently perform the following functions:
 - a. Add/delete/modify stand-alone DDC Global Control panels, Programmable Controllers, Operator Workstations
 - b. Add/delete/modify points of any type and all associated point parameters, tuning constants, control loops, custom control processes
 - c. Add/delete/modify alarm reporting definition, energy management applications, totalization, historical data trending
 - d. Add/delete/modify time and calendar-based programming, graphic displays, operator passwords

K. Additional Workstation Software

1. Provide automatic dial-up communications to cell phones and pagers as specified. Automatic dial-up communications shall include the following features as a minimum:
2. Dial-Out
 - a. Manual dial-out from the workstation to cell phones and pagers shall be accomplishable using only a mouse to select and request the desire remote connection.
3. Dial-Out.
 - a. Alarms shall automatically be sent to one or more workstations for display at the terminal and for hard copy printout.
 - b. Alarm Management: Alarms shall be placed into the following categories and the Operator shall be notified of the alarm and its category:

- 1) Critical - Events that may result in building damage or occupant danger such as smoke/fire, freezestat activation, liquid detector, low space temperature, and power outage. With this alarm, up to 5 of the Owner's service representatives shall be notified automatically via telephone or pager.
 - 2) Urgent - Events that may result in occupants being uncomfortable for a short period such as high temp, high humidity, etc. With this alarm, up to 5 of the Owner's service representatives shall be notified automatically via text message.
 - 3) Maintenance - Events that require routine maintenance such as high filter differential pressure, high CO2, etc.
4. Trend data shall be scheduled for automatic updating to the workstation at operator-selected times. The operator shall also have the option of manually collecting trend data at any time.
 5. The DDC system must support the capability of a remote PC or laptop allowing access to DDC system via the web.

2.08 PORTABLE LAPTOP COMPUTER.

- A. Provide a laptop computer to serve as a remote monitor interface to BAS. Minimum hardware configuration shall include: minimum 80GB hard drive, 8X DVD-ROM, mouse, integral keyboard, integral 17-inch flat screen, minimum 2.6 GHz dual core Intel processor or equivalent, 1 GB DDR2 SDRAM, Windows XP or Vista operating system, a built-in wireless card, and 9-cell extended life batteries.
- B. Laptop shall communicate wirelessly to the DDC controllers, or may be wired to each DDC controller using a portable wire, allowing repair and maintenance personnel to perform diagnostics, interrogate any point, and reprogram in the field. Provide interface equipment including cabling and software as required to allow connection of laptop to room thermostats, field panels, main panels, etc.
- C. Functionality of the laptop connected at the Global DDC panel:
 1. Access all DDC networked controllers located in the building.
 2. Access all graphics that are available on Central Workstation.
 3. Display all point, selected point and alarm point summaries.
 4. Display trending and totalization information.
 5. Command, change setpoint, enable/disable any system point.
- D. Connection of a POT to a DDC panel shall not interrupt nor interfere with normal network operation in any way, prevent alarms from being transmitted or preclude centrally-initiated commands and system modification.
- E. Portable operator terminal access to controller shall be password-controlled.

2.09 FIELD DEVICES AND EQUIPMENT

- A. Temperature Sensors: Temperature transmitters shall be 2-wire, averaging or single point 1000 OHM platinum RTD element with $\pm .5$ degrees accuracy. Room sensors and immersion type sensors shall be the single point type. Duct sensors shall be the averaging type, nickel element, 17 feet in length evenly strung across the face area of the duct.
 1. For units with space sensor or space thermostat, provide the following:
 - a. Temperature display showing actual measured temperature and setpoint.
 - b. Setpoint adjustment switch for a minimum of ± 3 degrees of adjustment.
 - c. Override switch to allow switching from unoccupied to occupied mode for a timed period programmed by software.

2. Room Sensor and Room Thermostat Accessories:
 - a. Thermostat and Sensor Covers: For all thermostats.
 - b. Insulating Bases: For thermostats located on exterior walls.
 - c. Thermostat and Sensor Guards: Metal wire guard mounted on separate base for thermostats and sensors located in public areas. Cast aluminum guard with cast aluminum base plate shall be similar to Johnson Controls model GRD10A-601.
 - d. Adjusting Key: As required for device.

B. Non-DDC Thermostats

1. Electric Low Limit Duct Thermostat (Freezestat): Snap-acting, double pole, double throw, manual reset switch which trips if temperature sensed across any 12 inches of bulb length is equal to or below setpoint, requiring minimum 20 feet length of bulb. Provide one thermostat for every 20 square feet.
2. Line-Voltage, On-Off Thermostats: Bimetal-actuated, open contact or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type with heat anticipator, integral manual Auto-Off selector switch subbase. UL listed for electrical rating.

C. Other Electronic Sensors

1. Current Sensing Relays: Provide current status switch for pump and fan status. Must be able to detect belt loss and motor failure. Switch shall be 100% solid state and have adjustable setpoint from 1 to 135 Amps. Veris Industries Hawkeye model H-708 or equivalent.
2. Humidity Sensors: bulk polymer sensor element. Multiple signal and power output including 4-20 ma, 0-10vDC; loop and 24v power.
 - a. Space RH Transmitter: With locking cover to match room sensors. $\pm 3\%$, accuracy from 5% to 95% RH.
 - b. Duct and Outside Air RH Transmitter: With element guard and mounting plate. $\pm 3\%$ accuracy from 5 to 95% RH.
3. Carbon Dioxide Sensor and Transmitter:
 - a. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1) Kele, model KCD-W-V.
 - 2) Digital Control Systems, model 308 WC.
 - 3) Airsense, Model 310e.
 - b. Sensing Technology: Non-dispersive, infrared.
 - c. Measurement Range: 0-2000 ppm.
 - d. Accuracy: 3% of reading; or ± 40 ppm + 2% of reading.
 - e. Repeatability: ± 20 ppm.
 - f. Calibration Interval: 5 years.
4. Velocity, Differential, and Static Pressure Sensors:
 - a. Pressure sensors shall be Setra, Modus or equal. The sensors shall have a 0 to .25" w.g. range for space applications and they shall have a range of 0 to 1" W.G. or 0 to 5" w.g. for duct applications unless noted otherwise. The range of the sensor shall be 10 to 25 percent above maximum (negative or positive) for fan control.
 - b. Air Velocity Sensors: The air velocity transducer shall utilize both a velocity sensor and a temperature sensor to accurately measure air velocity (in SFPM, standard feet per minute). The built-in temperature sensor shall automatically correct the flowrate for temperature variations. Both sensors shall be rugged glass-coated platinum resistance detectors (RTDs). The circuit shall heat the velocity sensor to a constant temperature differential above ambient temperature and shall measure the cooling effect of the air flow providing excellent low velocity sensitivity and high accuracy. The sensor shall have a negligible pressure drop. The mass flowrate in SCFM (standard

cubic feet/minute) shall be obtained by multiplying the SFPM velocity indicated by the by the sensor by the cross-sectional area of the duct in square feet. Accuracy of the sensor shall be 1.5% FS at room temperature. The sensor shall have a 4 to 20 mA output.

c. The sensors shall provide a 4 to 20 milli-amp output and they shall have an end-to-end accuracy of \pm .25% with repeatability of 0.5%.

d. Differential Pressure Transmitters:

1) General air and water pressure transmitter requirements shall be as follows:

- a) Pressure transmitters shall be constructed to withstand 100% pressure over-range without damage, and to hold calibrated accuracy when subject to a momentary 40% over-range input.
- b) Pressure transmitters shall transmit a 0 to 5 VDC, 0 to 10 VDC, or 4 to 20 mA output signal.
- c) Differential pressure transmitters used for flow measurement shall be sized to the flow sensing device, and shall be supplied with Tee fittings and shut-off valves in the high and low sensing pick-up lines to allow the balancing Contractor and Owner permanent, easy-to-use connection.
- d) A minimum of a NEMA 1 housing shall be provided for the transmitter. Transmitters shall be located in accessible local control panels wherever possible.

2) Building differential air pressure applications (-1" to +1" w.c.):

- a) The differential pressure transmitter shall be of industrial quality and transmit a linear, 4 to 20 mA output in response to variation of differential pressure or air pressure sensing points.
- b) The differential pressure transmitter shall have non-interactive zero and span adjustments that are adjustable from the outside cover and meet the following performance specifications:
 - -1.00 to +1.00 w. c. input differential pressure ranges (Select range appropriate for system applications).
 - 4-20 mA output
 - Maintain accuracy up to 20 to 1 ratio turndown
 - Reference accuracy: +02.% of full span.

D. Airflow Measurement System

1. General:

- a. Airflow measurement devices (AMDs) shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node. Thermal dispersion devices that indirectly heat a thermistor are not acceptable.
- b. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
- c. Airflow measurement shall be field configurable to determine the average actual or standard mass airflow rate. Actual airflow rate calculations shall have the capability of being field adjusted by the transmitter for altitudes other than sea level.
- d. Temperature output shall be field configurable to provide either the velocity-weighted duct average temperature or simple arithmetic average temperature.
- e. The manufacturer's authorized representative shall review and approve placement and operating airflow rates for each measurement location indicated on the plans.

f. Excluded Devices:

- 1) Vortex shedding airflow measurement devices.
- 2) Pitot tubes, pitot arrays, piezo-rings and other differential pressure measurement devices
- 3) Measurement technologies using "chip-in-glass", "chip-in-epoxy" or other "chip" type thermistors for the heated sensor component are not acceptable.

2. Main Ducts Application:

a. Sensor Probes:

- 1) Sensor probes shall be constructed of gold anodized, **6063 aluminum alloy tube**.
- 2) Sensor probe mounting brackets shall be constructed of 304 stainless steel.
- 3) Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper. PVC jacketed internal wiring is not acceptable.
- 4) Probe internal wiring connections shall consist of solder joints and spot welds. Connectors of any type within the probe are not acceptable. Printed circuit boards within the probe are not acceptable.
- 5) Probe internal wiring connections shall be sealed and protected from the elements and suitable for direct exposure to water.
- 6) Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67°F to 392 °F and continuous and direct UV exposure. Plenum rated PVC jacket cables are not acceptable.
- 7) Each sensor probe cable shall be provided with a connector plug with gold plated pins for connection to the transmitter.
- 8) Each sensor probe shall contain one or more independently wired sensing nodes.
- 9) Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter.
- 10) Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy. Devices that use epoxy or glass encapsulated chip thermistors are not acceptable.
- 11) Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
- 12) Each sensor node shall be individually calibrated to NIST-traceable airflow standards at a minimum of 16 calibration points.
- 13) The number of independent sensor nodes provided shall be as follows:

Area ft ² [m ²]	# of Sensor Nodes
≤ 0.5 [≤ 0.047]	1
> 0.5 & ≤ 1 [≤ 0.093]	2
> 1 & ≤ 2 [> 0.093 & ≤ 0.186]	4
> 2 & ≤ 4 [> 0.186 & ≤ 0.372]	6
> 4 & ≤ 8 [> 0.372 & ≤ 0.743]	8
> 8 & ≤ 12 [> 0.743 & ≤ 1.115]	12
> 12 & ≤ 14 [> 1.115 & ≤ 1.30]	14
> 14 [> 1.30]	16

- a) A total of 4 probes shall be required for openings with an aspect ratio ≤ 1.5 and with an area ≥ 25 ft².

b. Transmitter:

- 1) A remotely located microprocessor-based transmitter shall be provided for each measurement location.
- 2) The transmitter shall be comprised of a main circuit board and interchangeable interface card.
- 3) All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
- 4) All printed circuit boards shall be electroless nickel immersion gold (ENIG) plated.
- 5) All receptacle plug pins shall be gold plated.
- 6) The transmitter shall be capable of determining the average airflow rate and temperature of the sensor nodes. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network) and individual sensor output (IR-interface).
- 7) The transmitter shall be capable of providing a high and/or low airflow alarm.
- 8) The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
- 9) The transmitter shall be provided with a 16-character, alpha-numeric, LCD display. The airflow rate, temperature, airflow alarm and system status alarm shall be visible on the display.
- 10) The transmitter shall be provided with two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals and one isolated RS-485 (field selectable BACnet MS/TP or Modbus) network connection.
- 11) Analog output signals shall provide the total airflow rate and be field configurable to output one of the following:
 - a) temperature
 - b) airflow alarm
 - c) system status alarm
- 12) Network communications shall provide the average airflow rate, temperature, airflow alarm, system status alarm, individual sensor node airflow rates and individual sensor node temperatures.
- 13) Provide a Bluetooth low energy interface card and software capable of viewing/modifying all transmitter setup parameters, transmitter diagnostics and running the field adjustment wizard via an Android or iOS phone or tablet. The software shall be capable of capturing and displaying the average airflow and temperature of the device and the airflow and temperature of each sensor node. The software shall allow for setup parameters and airflow/temperature data to be saved on the phone or be emailed to a specified client
- 14) The transmitter shall be powered by 24 VAC and use a switching power supply that is over-current and over-voltage protected.
- 15) The transmitter shall use a "watchdog" timer circuit to ensure continuous operation in the event of brown-out and/or power failure.

c. Performance:

- 1) Each sensing node shall have an airflow accuracy of $\pm 2\%$ of reading over an operating range of 0 to 5,000 FPM.
- 2) Accuracy shall include the combined uncertainty of the sensor nodes and transmitter. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
- 3) Each sensing node shall have a temperature accuracy of $\pm 0.15^\circ\text{F}$ over an operating range of -20°F to 160°F .

- d. Listings and Certifications:
 - 1) The AMD shall be UL873 Listed as an assembly. Devices claiming compliance with the UL Listing based on individual UL component listing are not acceptable.
 - 2) The AMD shall be BTL Listed.
- e. Manufacturer: Ebtron model GTx116-P+ as represented by Specified Solutions Inc., (412) 346-1200.

E. Automatic Air Dampers

1. Provide opposed blade dampers as shown on Drawings. Dampers shall be AMCA 500 rated and operate within a temperature range of -40° to 200°F.
2. Standard Automatic Air Dampers:
 - a. Extruded aluminum (6063T5) damper frame shall not be less than .080-inches in thickness. Damper frame to be 4-inches deep.
 - b. Blades to be extruded aluminum (6063T5) profiles.
 - c. Blade seals shall be of extruded EPDM. Frame seals shall be extruded silicone. Seals shall be secured in an integral slot within the aluminum extrusions.
 - d. Bearings shall be composed of a Celcon inner bearing fixed to a 7/16-inches 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.
 - e. Linkage hardware shall be 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.
 - f. Dampers are to be designed for operation in temperatures ranging between -40°F and 212°F.
 - g. Dampers shall be available with either opposed blade action or parallel blade action.
 - h. Leakage shall not exceed 3 cfm/ft² against 1" w.g. differential static pressure.
 - i. Pressure drop of a fully open 48-inches x 48-inches damper shall not exceed 0.02-inches w.g. at 1000 fpm.
 - j. Dampers shall be made to size required without blanking off free area.
 - k. Dampers shall have flanges.
 - l. For dampers that consist of two or more sections in both height and width, intermediate or tubular steel structural support shall be provided to resist applied pressure loads.
 - m. Installation of dampers must be in accordance with current manufacturer's installation guidelines provided with each shipment of dampers. Technical information available on the damper manufacturer's website shall supersede and take precedence over all information contained within its printed catalog if the information on its website is more current.
 - n. Standard automatic air dampers shall be TAMCO Series 1000 Air-Foil Control Damper, as manufactured by T. A. Morrison & Co., Inc. and as supplied by BCS, Inc. (Tel: 412-279-7774), or approved equal.
3. Low Temperature Thermally Broken Automatic Air Dampers:
 - a. Extruded aluminum (6063T5) damper frame shall not be less than .080-inches in thickness. Damper frame shall be 4-inches deep.
 - b. Entire frame shall be thermally broken by means of polyurethane resin pockets, complete with thermal cuts.
 - c. Blades shall be extruded aluminum (6063T5) profiles, internally insulated with expanded polyurethane foam and shall be thermally broken. Complete blade shall have an insulating factor of R-2.29 and a temperature index of 55.
 - d. Blade and frame seals shall be of extruded silicone and be secured in an integral slot within the aluminum extrusions.
 - e. Bearings shall be composed of a Celcon inner bearing fixed to a 7/16-inches 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

- f. Linkage hardware shall be 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.
- g. Dampers shall be designed for operation in temperatures ranging between -40°F and 185°F.
- h. Dampers shall be available with either opposed blade action or parallel blade action.
- i. Leakage shall not exceed 3 cfm/ft² against 1-inch w.g. differential static pressure.
- j. Pressure drop of a fully open 48-inches x 48-inches damper shall not exceed 0.03-inches w.g. at 1000 fpm.
- k. Dampers shall be made to size required without blanking off free area.
- l. Dampers shall have flanges.
- m. For dampers that consist of two or more sections in both height and width, intermediate or tubular steel structural support shall be provided to resist applied pressure loads.
- n. Installation of dampers must be in accordance with current manufacturer's installation guidelines provided with each shipment of dampers. Technical information available on the damper manufacturer's website shall supersede and take precedence over all information contained within its printed catalog if the information on its website is more current.
- o. Low temperature thermally broken automatic air dampers shall be TAMCO Series 9000BF Thermally Insulated Control Damper with Thermally Broken Frame, as manufactured by T. A. Morrison & Co., Inc. and as supplied by BCS, Inc. (Tel: 412-279-7774), or approved equal.

F. Damper Actuators

- 1. Size for torque required for damper seal at maximum design conditions.
- 2. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle; directly couple and mount to the valve bonnet stem; or ISO-style direct-coupled mounting pad.
- 3. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
- 4. Overload Protection: The actuator shall be overload protected electronically throughout rotation.
- 5. Fail Safe Operation: Mechanical fail safe shall incorporate a spring-return mechanism. Electronic fail safe shall incorporate an active balancing circuit to maintain equal charging rates among the super capacitors with a visual indication of the fail-safe status on the actuator face, and with the following:
 - a. Power fail position field adjustable between 0 to 100% in 10-degree increments
 - b. A 2-second operational delay, field adjustable between 0 and 10 seconds
 - c. Capability of changing the fail-safe position through an integrated switch without removing the mounted actuator.
- 6. Power Requirements: 24-volts AC/DC or 120-volts AC
- 7. Proportional Actuators shall be software configurable through an EEPROM without the use of actuator mounted switches. Programmable functions shall include a scalable operating range from 0.5 - 32.0 volts DC with a 2.0-volt DC (min) span; variable runtime; and data logging.
- 8. Temperature Rating: -22°F to +122°F
- 9. Housing: NEMA type 2 for indoor locations and NEMA type 4X for outdoor locations.
- 10. Actuator shall be UL listed.
- 11. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.
- 12. Provide binary damper position feedback contacts for 2-position dampers and analogue damper position feedback contacts for modulating dampers.

2.10 CONTROL PANEL ENCLOSURES

- A. Control panel enclosures shall be NEMA 1 enclosures constructed of minimum 16-gauge steel or minimum 14-gauge aluminum. Control panel enclosures shall have a perforated metal subpanel for mounting of control components and panels. Control panel enclosures shall have a hinged door and keyed lock and with manufacturer's standard shop-painted finish. Provide common keying for all panels.

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Install in accordance with manufacturer's instructions.
- B. Verify location of thermostats, humidistats, and other exposed control sensors with Drawings and room details before installation. Also, confirm locations of thermostats, humidistats, and other exposed control sensors with Architect and/or Owner prior to rough-in. Install devices 48 inches above the floor to comply with ADA requirements.
 - 1. Install averaging elements in ducts and plenums in crossing or zigzag pattern.
- C. Mount outdoor reset thermostats and outdoor sensors indoors, with sensing elements outdoors. Provide sun shield for sensing element.
- D. Provide separable sockets for liquids and flanges for air bulb elements.
- E. Locate all control panel enclosures within mechanical or electrical equipment rooms.
 - 1. Consideration may be given to locating control panel enclosures in spaces other than mechanical or electrical equipment rooms that are typically unoccupied, such as Storage Rooms, Janitor Closets, etc. The ATC Subcontractor must coordinate and obtain approval for each proposed location with the Architect and/or Owner prior to installation.
 - 2. Under no circumstances shall control panel enclosures be installed in finished rooms or rooms intended for occupancy unless such locations are specifically requested by the Owner.
- F. Install guards on thermostats in the following locations:
 - 1. Entrances.
 - 2. Stairwells.
 - 3. Public corridors.
 - 4. Public restrooms.
 - 5. Other public areas.
- G. Install software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation.
- H. Connect and configure equipment and software to achieve sequence of operation specified.
- I. Install automatic air dampers where required by Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls."
 - 1. Install standard automatic air dampers in supply airstreams and return airstreams where both sides of the damper will be exposed to conditioned air.
 - 2. Install low temperature thermally broken automatic air dampers in exhaust airstreams, outdoor airstreams and relief airstreams where one side of the damper will be exposed to ambient conditions or unconditioned air.
- J. Install damper motors on outside of duct in warm areas only. Do not install damper motors in locations exposed to outdoor temperatures.
- K. Install labels and nameplates to identify control components in accordance with Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

- L. Install refrigerant instrument wells, valves, and other accessories in accordance with Division 23 Section 23 2300 "Refrigerant Piping."

3.02 AIRFLOW MEASUREMENT SYSTEM INSTALLATION

- A. Install airflow measurement systems (measuring stations) in locations specified in Division 23 Section 23 0993 "Sequence of Operations for HVAC Control."
- B. Install airflow measuring stations in accordance with manufacturer's placement guidelines. A written report shall be submitted to the Architect and Engineer if any discrepancies are found.
- C. Adjusting:
 - 1. The airflow measuring stations shall not be adjusted to match field measurements without approval from the Architect or Engineer when installations do not comply with the manufacturer's suggested placement guidelines. Field adjustment, when required, shall be accomplished using transmitter firmware that calculates adjustment gain and offset coefficients based on one or two reference measurements. Adjustment of the signal value in the host controller is discouraged.

3.03 AUTOMATIC AIR DAMPER INSTALLATION

- A. Install automatic air dampers where required by Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls."
 - 1. Install standard automatic air dampers in supply airstreams and return airstreams where both sides of the damper will be exposed to conditioned air.
 - 2. Install low temperature thermally broken automatic air dampers in exhaust airstreams, outdoor airstreams and relief airstreams where one side of the damper will be exposed to ambient conditions or unconditioned air.
- B. Install damper motors on outside of duct in warm areas only. Do not install damper motors in locations exposed to outdoor temperatures.

3.04 WIRING INSTALLATION

- A. Run all line voltage control wiring in conduit in accordance with the National Electric Code and the requirements specified in Division 26, Sections "Basic Electrical Requirements;" "Basic Electrical Materials and Methods;" "Raceways;" "Wires and Cables;" "Cabinets, Boxes, and Fittings;" "Supporting Devices;" and "Electrical Identification."
- B. Power for controls shall be obtained from the nearest normal/emergency power panel.
- C. All low voltage power wiring shall be as described below:
 - 1. Provide "plenum-rated" cable for low voltage wiring.
 - a. Except where otherwise prohibited by applicable codes, conductors and cables operating at less than 30 volts and having "plenum type" insulation listed for compliance with NEC Article 300-22(c) are permitted to be installed without raceways above accessible suspended acoustic ceilings. Accessible suspended ceilings are defined as those having access panels, un-splined tiles for access purposes, and unclipped lay-in tiles for access purposes, or other approved access means at intervals of not more than 20 feet from one another.

- b. Where conductors or cables are installed in compliance with the above, the cables shall be neatly supported clear of the ceiling system by means of approved pre-formed nylon tie devices. Supports shall be accessible. Maintain a minimum spacing of than 18" between parallel runs of control wiring and wiring of other systems.
- 2. Run control wiring in EMT conduit in Mechanical rooms and other exposed wall and ceiling locations.
- D. Connect manual-reset limit controls independent of manual control switch positions.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.05 MANUFACTURER'S FIELD SERVICES

- A. Commission and start control systems. Use attached Commissioning Forms and submit completed forms to Owner and Engineer before training and final punchlist.

3.06 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 percent of span.
 - b. Check analog outputs using milli-ampere meter at 0, 50, and 100 percent 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 percent of span using a precision-resistant source.
 - 5. Flow:
 - a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent 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 percent 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 percent 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 percent 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 percent 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. Setup the occupied/unoccupied DDC equipment time schedules based upon time schedules. Setup the initial occupied/unoccupied system temperature and humidity setpoints. Setup the initial local temperature adjustment ranges. Coordinate with the Owner to establish the initial values for schedules, setpoints, and ranges.
- C. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide a minimum of two (2) visits to Project during other than normal occupancy hours for this purpose.

3.07 DEMONSTRATION

- A. Provide all verification testing prior to functional performance testing.
- B. Provide systems demonstration under provisions of Division 01.
- C. Demonstrate complete operation of systems including Sequence of Operation after Date of Substantial Completion. The Owner or his appointed representative shall be given the opportunity to witness the functional performance testing and the successful demonstration of the operating sequences. The ATC Subcontractor shall provide the Owner or his appointed representative a minimum of 14-days notice prior to functional performance testing. Also, the ATC Subcontractor shall provide the Owner or his appointed representative a minimum of 14-days notice prior to demonstration of the operating sequences.

3.08 ON-SITE TESTING

- A. Provide Engineer-approved operation and acceptance testing of the complete system. Complete Functional Test Checklist as outlined at end of this section for each piece of mechanical equipment controlled by ATC on this project. The Engineer, the Owner, and/or Owner representative may witness all tests and shall be given sufficient notice prior to any tests being conducted.
- B. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Provide a detailed cross-check of each sensor within the system by making a comparison between the reading at the sensor and a standard traceable to the National Bureau of Standards.
- C. Provide a cross-check of each control point within the system by making a comparison between the control command and the field-controlled device. For each DDC Controller test DDC software sequence to confirm a match with design sequence. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Submit the results of functional and diagnostic tests and calibrations to the Engineer for final system acceptance as shown on Functional Test Checklist.
- D. Compliance Inspection Checklist: Submit the requested items of information to the Owner's Representative and Architect/Engineer for verification of compliance to the project specifications. Failure to comply with the specified information shall constitute non-performance of the contract. The Subcontractor shall submit written justification for each item in the checklist that he is unable to comply with. The Owner's Representative and the Architect/Engineer will initial and date the checklist to signify Subcontractor's compliance before acceptance of system.

3.09 SERVICE AND GUARANTEE

- A. General Requirements: Provide all services, materials and equipment necessary for the successful operation of the entire BAS system for a period of two years after completion of successful performance test. Provide necessary material required for the work. Minimize impacts on facility operations when performing scheduled adjustments and non-scheduled work. Without additional cost, provide software upgrades issued during the warranty period.
- B. Description of Work: The adjustment and repair of the system includes all computer equipment, software updates, transmission equipment and all sensors and control devices. Provide the manufacturer's required adjustments and all other work necessary.
- C. Personnel: Provide qualified personnel to accomplish all work promptly and satisfactorily. Owner shall be advised in writing of the name of the designated service representative, and of any changes in personnel.
- D. Emergency Service: Owner will initiate service calls when the system is not functioning properly. Qualified personnel shall be available to provide service to the complete system. Furnish owner with a telephone number where service representative can be reached at all times. Service personnel shall be at the site within 8 hours after receiving a request for service. Restore the control system to proper operating condition within 24 hours.
- E. Operation: Performance of scheduled adjustments and repair shall verify operation of the system as demonstrated by the initial performance test.
- F. Systems Modifications: Provide any recommendations for system modification in writing to Owner. Do not make any system modifications, including operating parameters and control settings, without prior approval of Owner. Any modifications made to the system shall be incorporated into the operations and maintenance manuals, and other documentation affected.
- G. Software: Provide all software updates during the warranty period and verify operation in the system. These updates shall be accomplished in a timely manner, fully coordinated with the system operators, and shall be incorporated into the operations and maintenance manuals, and software documentation.

3.10 TRAINING

- A. The ATC Subcontractor shall provide competent instructors to give full instruction to designated personnel in the adjustment, operation and maintenance of the system installed rather than a general training course. Instructors shall be thoroughly familiar with all aspects of the subject matter they are to teach. It is the intent of the Owner to become thoroughly versed in the operation and programming of the DDC system so as to make full use of system capabilities and be able to revise graphics. All information and documentation necessary to do this work must be provided.
 - 1. Provide 40-hours of on-site training for Owner's operating personnel. Split training into minimum five (5) 8-hour sessions to be completed during the period of warranty. Coordinate/Schedule training sessions with the Owner a minimum of 14-days in advance. Training shall include:
 - a. Explanation of drawings, operations, and user manuals
 - b. Walk-thru of the job to locate control components
 - c. Explanation of manual and automatic control devices
 - d. DDC Controller and PRC operation/function
 - e. Operation of operator's terminal, Central computer workstation and laptop computer
 - f. Hands on training of Central computer workstation menus and commands to include fully functioning system
 - g. Operator control functions including graphic generation and field panel programming
 - h. Explanation of maintenance manuals
 - i. Explanation of adjustment, calibration, and replacement procedures

- B. Since the Owner may require personnel to have more comprehensive understanding of the hardware and software, the ATC Contractor must make additional training available. If the Owner requires such training, it will be contracted at a later date. Provide description of available local and factory customer training.
- C. Prepare the following checklist for each piece of mechanical equipment that is controlled by ATC DDC. **Refer to Division 01 Section "Commissioning Requirements" for additional requirements.**

Functional Test Checklist

FT-__

Includes installation and wiring checkout, sensor and device calibration, and functional performance testing.

1. Participants

Party	Participation	Date

- The checklist items are all successfully completed.....__ YES __ NO

2. Installation Checks

Check if Okay. Enter comment or note number if deficient.

For each Terminal Unit

Check	Equip Tag->						Notes
Air Systems							
Fans and Dampers							
Filter pressure differential measuring device installed and functional (magnehelic, inclined manometer, etc.).							
Dampers close tightly and all dampers (OSA, RA, EA, etc.) stroke fully without binding and spans calibrated and BAS reading site verified.							
All damper linkages have minimum play.							
Low limit freeze stat sensor located to deal with stratification & bypass.							
Variable Speed Drive operating properly.							
Electrical and Controls							
Safeties in place and operable							
Control system interlocks installed and functional							
Smoke detectors in place							
All control devices and wiring complete.							
Specified point-to-point checks have been completed.							
Specified sequences of operation and operating schedules have been implemented with all variations documented							

3. Sensor and Actuator Calibration

For each Terminal Unit

Sensor or Actuator & Location	Location OK	1st Gauge or BAS Value	Instr. Meas'd Value	Final Gauge or BAS Value	Pass Y/N?
DAT					
RAT					
Space Temp					
etc					

Sensor & Location	Location OK	1st Gauge or BAS Value	Instr. Meas'd Value	Final Gauge or BAS Value	Pass Y/N?

4. Device Calibration Checks. The actuators or devices listed below must be checked for calibration.

Device or Actuator & Location	Procedure / State	1st BAS Value	Site Observation	Final BAS Reading	Pass Y/N
Main OSA damper position**	1. Closed				
	2. Full open				
Return air damper position **	1. Closed				
	2. Full open				

5. Functional Performance Testing Record

Use one test record for each RTU, etc containing DDC Controller by ATC.

Seq. ID	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Note
	FAN OFF	Standby Check. With Units Commanded off by BAS.	Verify by visual inspection that: Return Air Dampers in AHU are Open and Outside Air Dampers and Relief Dampers are Closed, Cooling Coil Valve is Closed, Hot Water Coil - Valve is Open.		
	UNIT STARTUP	With Units Commanded on by BAS.	Supply Fan Starts.		
	TEMPERATURE CONTROL ENTHALPY/ ECONOMIZER	1. Utilizing BAS, Record OSA & RA Temp. and OSA & RA Humidity. 2. Calculate Enthalpy of OSA. 3. Utilizing Enthalpy calculations, modulate dampers such that Enthalpy of OSA is less than Enthalpy of Return Air at revised conditions.	Outdoor Air Dampers and Return Air Dampers should modulate to maintain Enthalpy/Economizer setpoint. Cooling Coil Valves should be closed.		
	DISCHARGE AIR OR SPACE TEMPERATURE	Modulate heating and/or cooling to maintain setpoint.	Verify that AHU System maintains setpoint by modulating/staging HVAC equipment.		
	DISCHARGE TEMPERATURE RESET	If reset required, test at different temperatures. Utilizing BAS Trend Logging, at 6 min intervals and record DAT setpoint, DAT.	Verify that Discharge Air Temperature Setpoint is reset at increments according to programmed time intervals to maintain schedule.		
	SMOKE CONDITIONS	Interfacing with EC, simulate a fire mode with the Fire Alarm System.	Verify that AHU System returns to FAN OFF Status, with OSA and Relief Dampers in a Closed Position.		
	WARMUP CONTROL	Place Units' BAS Control Mode into Warm-up. Overwrite RAT Sensor Reading to be 65°F. Then overwrite RAT Sensor Reading to be 72°F.	Verify that dampers assume a 100% Return Air Mode. Then verify that unit returns to Normal Operation Mode.		
	FREEZE CONDITION	Simulate a low temperature condition at low limit detection thermostat of below 35°F.	Verify that system alarms, fan stop, OSA Dampers close, RA dampers open and Heating Valve Opens.		
	FILTER DROP	Reset the Filter Differential Pressure to exceed the setting recommended by the filter manufacturer.	Verify that the BAS reports an alarm.		

Seq. ID	Mode ID	Test Procedure (including special conditions)	Expected Response	Pass Y/N	Note
	REVIEW	Review schedules, current setpoints and sequences with Sequence of Control and Control Drawings prepared by ATC.	Submit approved differences to be incorporated into As-Built.		

- END OF TEST -

END OF SECTION 23 0900

SECTION 23 0923.16 - GAS INSTRUMENTS

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. Section Includes the Following Gas Instruments:
 - 1. Carbon-dioxide sensors and transmitters.
 - 2. Nitrogen Dioxide sensors and transmitters
 - 3. Multipoint carbon-monoxide and nitrogen dioxide monitoring system.
- B. Related Requirements:
 - 1. Section 23 0900 Automatic Temperature Control for HVAC for control equipment and software, relays, electrical power devices, uninterruptible power supply units, wire, cable, and installation practices.
 - 2. Section 23 0993 "Sequence of Operations for HVAC Controls" for requirements that relate to Section 23 0923.16.
 - 3. Provide pricing for annual calibration of sensors and equipment.
- C. Electrical Requirements:
 - 1. Provide all power wiring, control wiring, and conduit for all Gas Monitor panels, and Gas sensors, except as detailed within. Provide all electrical work associated with the Gas Instruments control system including:
 - a. Providing all line voltage and low voltage power wiring and conduit in accordance with all local codes, the National Electric Code (latest edition), and Division 26.
 - 1) Power circuits shall be run from normal/emergency power panel(s).
 - b. Providing all line voltage and low voltage control wiring, concealed in conduit in accordance with local codes, the National Electric Code (latest edition), and Division 26.
 - 1) Power circuits shall be run from normal/emergency power panel(s).
 - 2) All low voltage electrical control wiring throughout the building shall be as described in Part 3 of this Section.

1.03 ACTION SUBMITTALS

- A. Product Data - for each type of product, including the following:
 - 1. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
 - 2. Installation instructions, including factor affecting performance.
 - 3. Product description with complete technical data, performance curves, product specification sheets.

- B. Shop Drawings
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include diagrams for power, signal, and control wiring.
 - 3. Number-coded identification system for unique identification of wiring, cable, and tubing ends.

1.04 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plan drawings and corresponding product installation details, drawn to scale, on which wall-mounted instruments located in finished space are shown and coordinated with each other, showing relationship to light switches, fire alarm devices, and other installed devices using input from installers of the items involved.
- B. Product Test Reports: For each product, for tests performed by manufacturer and witnessed by a qualified testing agency.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas instruments to include in operation and maintenance manuals.

1.06 INSTALLATION:

- A. Gas Instruments shall be furnished and installed by one of the following companies:
 - 1. Base Bid: OZ Enterprises (located at 60 Abele Road, Suite 1101, Bridgeville, PA 15017).
 - 2. Alternate 1: Siemens (located at 400 Mosites Way, Suite 400, Pittsburgh, PA 15205).
 - 3. Alternate 2: Building Control Systems (located at 523 West Main Street, Carnegie, PA)

PART 2 - PRODUCTS

2.01 SENSORS AND TRANSMITTERS

- A. Subject to compliance with requirements, provide Honeywell Model E3SM + E3SCO Carbon Monoxide sensor/transmitters and Model E3SM + E3NO2 Nitrogen Dioxide sensor/transmitters or a comparable product by one of the following:
 - 1. MSA
 - 2. Tox-Alert
 - 3. Approved equivalent
- B. Transmitter will be powered by the control panel power supply rated at 24 Vac. 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.
- C. When placed in a network configuration the transmitter will 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) will be activated at programmable set points (and programmable time delays) through the control panel. An LCD display will provide gas concentration readings.

- D. Transmitter will be capable of operating within relative humidity ranges of 5-95% and temperature ranges of -4° F to 104°F.
- E. 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.
- F. The transmitter shall be equipped with a plug-in gas monitoring cartridge having a smart sensor that is capable of self-testing.
- G. For local activation of audible alarms, the transmitter shall have an on-board device able to generate an audible output of 85 dBA @ 10 feet.
- H. Description:
 - 1. E3SM Toxic and Combustible Gas Detector: Honeywell E3Point, Surface-mount, Modbus/BACnet Selectable, 24Vac/dc, -40 to 50°C (-40 to 122°F)
 - a. Size: 20.56 x 14.90 x 6.72cm (8.09 x 5.87 x 2.65") (H x W x D)
 - b. Power: 24 VAC nominal (17-27Vac), 50/60 Hz, 0.35A; 24 Vdc nominal (20-38Vdc)
 - c. Relay Output: 1 DPDT relay, 5A @ 250Vac; 5A @ 30Vdc
 - d. Communications: RS485 Modbus; BACnet MS-TP master
 - e. Display: 8-character, 2-line backlit LCD
 - f. Mounting Height:
 - 1) CO Sensor: 60 inches above finished floor.
 - 2) NO₂ Sensor: 48 inches above finished floor.
 - 2. E3SCO Sensor Cartridge: CO Cartridge (-4 to 122°F)
 - a. Resolution: 1 ppm
 - b. Range: 0-250 ppm
 - c. Alarm A: 25 ppm
 - d. Alarm B: 200 ppm
 - e. Alarm C 225 ppm
 - 3. E3NO2 Sensor Cartridge: NO₂ Cartridge (-40 to 122°F)
 - a. Resolution: 0.1 ppm
 - b. Range: 0-10 ppm
 - c. Alarm A: 0.7 ppm
 - d. Alarm B: 2 ppm
 - e. Alarm C 9 ppm
- I. Construction:
 - 1. House electronics in a polycarbonate or ABS plastic enclosure. Provide equivalent of NEMA 250, Type 1 enclosure for wall-mounted space applications and NEMA 250, Type 4 for duct-mounted applications.
 - 2. Equip with digital display for continuous indication of carbon-dioxide concentration.
- J. Performance:
 - 1. Measurement Range: As indicated above.
 - 2. Accuracy: Within 2 percent of reading, plus or minus 30 ppm.
 - 3. Repeatability: Within 1 percent of full scale.
 - 4. Temperature Dependence: Within 0.05 percent of full scale over an operating range of 25° to 110°F.
 - 5. Long-Term Stability: Within 5 percent of full scale after more than five years.
 - 6. Response Time: Within 60 seconds.
 - 7. Warm-up Time: Within five minutes.

- K. Provide calibration kit. Turn over to Owner at start of warranty period.

2.02 MULTIPOINT CARBON MONOXIDE MONITORING SYSTEM

- A. Subject to compliance with requirements, provide Honeywell Model VA301C-DLC-BIP Controller or a comparable product by one of the following:
 - 1. MSA
 - 2. Tox-Alert
 - 3. Approved equivalent
- B. 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
- C. 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).
- D. BACnet: The controller must enable BACnet™ communication through its BACnet output using BACnet/IP protocol over twisted-pair Ethernet (10BaseT) wires.
- E. The controller must 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.
- F. The controller must include a real-time clock that enables operation of the outputs for a specific timeframe.
- G. 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.
- H. The controller will be capable of communicating with an annunciator panel that can serve as a remote display panel in a secondary control room.
- I. 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.
- J. Data logging: Data logging capability must provide long-term data logging to determine trends. The controller must collect data automatically and must store it on a digital Flash media card.
- K. Enclosure:
 - 1. NEMA 250, Type 1.
 - 2. Hinged and locking door, full size of face.
 - 3. House all system components. Multiple adjoining enclosures are acceptable if joined to a common support structure.
- L. Relay Module: Provide relay modules as necessary to meet project scope. Relays will be powered by the control panel's power output or by power transformer rated at 24 Volts AC or DC (always respect minimum voltage requirements at device). Module must be capable of communicating digitally with the Honeywell Analytics 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). Honeywell Analytics model 301-R8 or equivalent by MSA or Tox-alert

- M. Detector Guards
 - 1. Provide detector guards for each CO and NO₂ gas detector. The guard grid shall be made of 9-gauge steel wire. The guard must be designed to allow calibration without removing the guards.
- N. Calibration Equipment:
 - 1. Provide equipment necessary to automatically and manually calibrate the system, including, but not be limited to, the following:
 - a. Regular assembly.
 - b. Zero cap.
 - c. Calibration cap.
 - d. Two cylinders filled with calibration gas.
 - e. Instruction book.
 - f. Carrying case.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for instruments installed in piping to verify actual locations of connections before installation.
- C. Examine roughing-in for instruments installed in duct systems to verify actual locations of connections before installation.
- D. Prepare written report, endorsed by Installer, listing conditions detrimental to performance.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION - GENERAL

- A. The physical location of any dedicated system equipment shall be approved by both the design engineer and FM Energy Operations Center. Coordinate approval for locations of system equipment with the engineer and the University's project manager prior to installation.
- B. Furnish and install products required to satisfy more stringent of all requirements indicated.
- C. Install products level, plumb, parallel, and perpendicular with building construction.
- D. Install products in accord with the manufacturer's installation instructions and as required by authorities having jurisdiction.
- E. Properly support instruments, wiring, and conduit to comply with requirements indicated. Brace all products to prevent lateral movement and sway or a break in attachment when subjected to seismic loads.

- F. Fastening Hardware:
1. Stillson wrenches, pliers, and other tools that cause injury to or mar surfaces of rods, nuts, and other parts are prohibited for work of assembling and tightening nuts.
 2. Tighten bolts and nuts firmly and uniformly. Do not overstress threads by using excessive force or oversized wrenches.
 3. Lubricate threads of bolts, nuts, and screws with graphite and oil before assembly.
- G. Install products in locations that are accessible and that permit calibration and maintenance from floor, equipment platforms, or catwalks. Where ladders are required for Owner's access, confirm unrestricted ladder placement is possible under occupied condition.
- H. Integrate the Gas Instrument controls with the BAS specified in Sections 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC and 23 0993 SEQUENCE OF OPERATIONS FOR HVAC CONTROL.

3.03 BAS CONTRACTOR INTERFACE AND RESPONSIBILITY

- A. The BAS contractor shall be required to implement an interface between the BAS and the Gas Instrument System (GIS) which shall communicate with the BAS via BACnet. All communication shall be from the GIS to the BAS. The BAS shall not send any information to the GIS other than standard communication acknowledgements as dictated by the BACnet protocol. The BAS contractor shall be responsible for:
1. Entering the GIS in the BAS so it is a recognized component in the BAS.
 2. Entering the necessary data points in the BAS data base. These data points will serve as data values to be used as setpoints in the building control systems for values such as minimum outside air levels, overall ventilation rates, and others as indicated in the specification or on the drawings.
 3. Implementing the necessary control sequences to respond to the directions from the GIS. These directions will be integrated from a priority standpoint so that other control actions such as smoke control are not impeded.
 4. Provide qualified on-site staff during start-up of the GIS to ensure that communication is functional, that data values are received from the GIS, and that control sequences as a result of this data are implemented properly and effectively.

3.04 ELECTRICAL POWER AND RACEWAYS

- A. Furnish and install electrical power to products requiring electrical connections.
- B. Furnish and install circuit breakers. Comply with requirements in Section 26 2816 "Enclosed Switches and Circuit Breakers."
- C. Furnish and install power wiring. Comply with requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Furnish and install raceways. Comply with requirements in Section 26 0533 "Raceways and Boxes for Electrical Systems."

3.05 WIRING INSTALLATION

- A. Run all line voltage control wiring in conduit in accordance with the National Electric Code and the requirements specified in Division 26, Sections "Basic Electrical Requirements;" "Basic Electrical Materials and Methods;" "Raceways;" "Wires and Cables;" "Cabinets, Boxes, and Fittings;" "Supporting Devices;" and "Electrical Identification."

- B. Power for controls shall be obtained from the nearest normal/emergency power panel.
- C. All low voltage power wiring shall be as described below:
 - 1. Run control wiring in EMT conduit in Mechanical rooms and other exposed wall and ceiling locations.
- D. Connect manual-reset limit controls independent of manual-control switch positions.
- E. Connect hand-off-auto selector switches to override automatic interlock controls when switch is in hand position.

3.06 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Each piece of wire, cable, and tubing shall have the same designation at each end for operators to determine continuity at points of connection. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
- B. Install engraved phenolic nameplate with instrument identification on face.

3.07 MANUFACTURER'S FIELD SERVICES

- A. Commission and start control systems.
- B. Check instruments for proper location and accessibility.
- C. Check instruments for proper elevation, orientation, insertion depth, or other applicable considerations that impact performance.
- D. Test and calibrate equipment to demonstrate operation of functions described above under sequence of operation by manufactures certified service technician.
- E. Provide testing kits (including gas bottles) for testing and calibration by Commission technician.

3.08 ADJUSTMENT, CALIBRATION, AND TESTING

- A. Description:
 - 1. Calibrate each instrument installed that is not factory calibrated and provided with calibration documentation.
 - 2. Provide a written description of proposed field procedures and equipment for calibrating each type of instrument. Submit procedures before calibration and adjustment.
 - 3. For each analog instrument, perform a three-point calibration test for both linearity and accuracy.
 - 4. Equipment and procedures used for calibration shall comply with instrument manufacturer's written recommendations.
 - 5. Provide diagnostic and test equipment for calibration and adjustment.
 - 6. Field instruments and equipment used to test and calibrate installed instruments shall have an accuracy of at least twice the instrument accuracy being calibrated. For example, an installed instrument with an accuracy of 1 percent shall be checked by an instrument with an accuracy of 0.5 percent.
 - 7. Calibrate each instrument according to instrument instruction manual supplied by manufacturer.
 - 8. If, after calibration, indicated performance cannot be achieved, replace out-of-tolerance instruments.
 - 9. Comply with field-testing requirements and procedures in ASHRAE Guideline 11, "Field Testing of HVAC Control Components," in the absence of specific requirements, and to supplement requirements indicated.

- B. Analog Signals:
 - 1. Check analog voltage signals using a precision voltage meter at zero, 50, and 100 percent.
 - 2. Check analog current signals using a precision current meter at zero, 50, and 100 percent.
 - 3. Check resistance signals for temperature sensors at zero, 50, and 100 percent of operating span using a precision-resistant source.
- C. Digital Signals:
 - 1. Check digital signals using a jumper wire.
 - 2. Check digital signals using an ohmmeter to test for contact.
- D. Meters: Check sensors at zero, 50, and 100 percent of Project design values.
- E. Sensors: Check sensors at zero, 50, and 100 percent of Project design values.
- F. Switches: Calibrate switches to make or break contact at set points indicated.
- G. Transmitters:
 - 1. Check and calibrate transmitters at zero, 50, and 100 percent of Project design values.
 - 2. Calibrate resistance temperature transmitters at zero, 50, and 100 percent of span using a precision-resistance source.

3.09 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain instrumentation and control devices.
- B. Coordinate gas instrument demonstration video with operation and maintenance manuals and classroom instruction for use by Owner in operating, maintaining, and troubleshooting.
- C. Record videos on DVD disks.
- D. Owner shall have right to make additional copies of video for internal use without paying royalties.

3.10 ON-SITE TESTING

- A. Provide Engineer-approved operation and acceptance testing of the complete system. The Engineer, the Owner, CxA, and/or Owner representative may witness all tests and shall be given sufficient notice prior to any tests being conducted.
- B. Field Test: When installation of the system is complete, calibrate equipment and verify transmission media operation before the system is placed on-line. All testing, calibrating, adjusting and final field tests shall be completed by the installer. Provide a detailed cross-check of each sensor within the system by making a comparison between the reading at the sensor and a standard traceable to the National Bureau of Standards.
- C. Provide a cross-check of each control point within the system by making a comparison between the control command and the field-controlled device. For each DDC Controller test DDC software sequence to confirm a match with design sequence. Verify that all systems are operable from local controls in the specified failure mode upon panel failure or loss of power. Submit the results of functional and diagnostic tests and calibrations to the Engineer for final system acceptance.

END OF SECTION 23 0923.16

SECTION 23 0993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment.

1.03 DEFINITIONS

- A. DDC: Direct digital control.
- B. ATC: Automatic Temperature Control.
- C. BAS: Building Automation System.
- D. AI: Analog Input.
- E. AO: Analog Output.
- F. DI: Digital Input.
- G. DO: Digital Output.
- H. VAV: Variable air volume.
- I. VF: Variable Frequency.
- J. AHU: Air Handling Unit.
- K. RTU: Rooftop Unit.
- L. CO₂: Carbon Dioxide

1.04 MISCELLANEOUS REQUIREMENTS

- A. The control strategies described in this section shall be used in conjunction with the Input/Output Summary Tables attached herein for engineering the control systems and preparing the required control drawings.

- B. The Input/Output Summary Tables and the sequence have been made to complement one another. The ATC Contractor shall interpret the sequences and the Input/Output Summary Tables such that if a device is called for in one and not the other, it will be treated as if called for in both.
- C. Control of all HVAC equipment shall be through the DDC system and by electric control as specified per individual sequence.
- D. Whether indicated or not, all temperature setpoints included in the sequences of this Section shall be adjustable.

PART 2 - PRODUCTS

- 2.01 Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for control equipment and devices.

PART 3 - EXECUTION

3.01 GENERAL REQUIREMENTS

- A. The following general applications software shall be required on all appropriate equipment [i.e. rooftop units, exhaust fans, terminal unit equipment, etc.] for the purpose of optimizing energy consumption while maintaining occupant comfort:
- B. Time of Day Scheduling [TOD]: The system shall be capable of the following scheduling features:
 - 1. Scheduling by building, area, zone, groups of zones, individually controlled equipment and groups of individually controlled equipment. Each schedule shall provide beginning and ending dates and times [hours: minutes]. A weekly repeating schedule, i.e., between 8:00 a.m. and 5:00 p.m., Monday through Friday shall constitute one schedule, not five.
 - 2. Dated schedules shall be entered up to 9 [nine] years in advance.
 - 3. Schedules shall be self-deleting when effective dates have passed.
 - 4. Leap years shall be adjusted automatically without operator intervention.
 - 5. For maximum speed in the communication of schedules, the operator shall have the ability to communicate schedules at the most efficient level with one scheduling command through the mouse interface. This ranges from system wide to individual zones, groups or pieces of equipment.
 - 6. The system shall allow the operator to designate any combination of equipment to form a group that can be scheduled with a single operator command through the mouse interface at the workstation. Any designated group shall have the capability to be a member of another group.
 - 7. The operator shall be able to make all schedule additions, modifications and deletions using the mouse and appropriate dialog boxes. In addition, the operator shall have the capability to edit all schedules off line and then download any or all schedule changes to the control modules with a single operator command through the mouse interface. In the event that a schedule in the control module is different from the workstation, the operator shall have the capability to upload any or all schedules from the control module to the workstation.
 - 8. The operator shall be able to view a color-coded forecast of schedules for instant overview of facilities schedules. Schedule graphic forecast shall include colored coded indication of all types of schedules, i.e., normal, holiday and override.
- C. Optimum Start/Stop [OSS]/Optimum Enable/Disable [OED]:
 - 1. Provide software to start and stop equipment on a sliding schedule based on the individual zone temperature and the heating/cooling capacity in °F/hour of the equipment serving that zone. The heating/cooling capacity value shall be operator adjustable. Temperature compensated peak demand limiting shall remain in effect during morning start up to avoid setting a demand peak.

D. Day/Night Setback [DNS]:

1. The system shall allow the space temperature to drift down [up] within a preset [adjustable] unoccupied temperature range. The heating [cooling] shall be activated upon reaching either end of the DNS range and shall remain activated until the space temperature returns to the DNS range.
2. The system shall be capable of closing all outside air and exhaust air dampers during the unoccupied period, except for 100% outside air units.
3. Unoccupied space temperature shall be monitored by the DDC temperature sensors located in the individual zones being controlled or within a representative room in the building if full DDC control is not being affected.
4. User shall be able to define, modify or delete the following parameters.
 - a. DNS setpoint temperature[s]
 - b. Temperature band for night heating operation
 - c. Period when the DNS is to be activated

E. Timed Local Override [TLO]:

1. The system shall have TLO input points that permit the occupants to request an override of equipment that has been scheduled OFF. The system shall turn the equipment ON upon receiving a request from the local input device. Local input devices shall be push button [momentary contact], wind-up timer, or ON/OFF switches as detailed in the I/O summary.
2. If a push button is used the system operator shall be able to define the duration of equipment ON time per input pulse and the total maximum ON time permitted. Override time already entered shall be canceled by the occupant at the input point. If a wind-up timer is used the equipment will stay in override mode until the timer expires. Year to date, month-to-date and current day override history shall be maintained for each TLO input point. History data shall be accessible by the operator at any time and shall be capable of being automatically stored on hard disk and/or printed on a daily basis.

F. Space Temperature Control [STC]: There shall be two space temperature setpoints, one for cooling and one for heating, separated by a dead band. Only one of the two setpoints shall be operative at any time. The cooling setpoint is operative if the actual space temperature has more recently been equal to or greater than the cooling setpoint. The heating setpoint is operative if the actual space temperature has more recently been equal to or less than the heating setpoint. There are two modes of operation for the setpoints, one for the occupied mode [example: heating = 72°F or cooling = 76°F] and one for the unoccupied mode [example: heating = 55°F or cooling = 90°F].

G. The occupied/unoccupied modes may be scheduled by time, date, or day of week.

1. If the actual space temperature is in the dead band between the heating setpoint and the cooling setpoint, the color displayed shall be green for the occupied mode, representing ideal comfort conditions. If in the unoccupied mode, the color displayed shall be gray representing 'after-hours' conditions.
2. If the space temperature rises above the cooling setpoint, the color shall change to yellow.
3. When space temperature falls below the heating setpoint, the color shall change to light blue.
4. All setpoints and offsets shall be operator definable. When in the occupied mode, start-up mode, or when heating or cooling during the night setback unoccupied mode, a request shall be sent over the network to other equipment in the HVAC chain, such as to an AHU fan that serves the space, to run for ventilation. The operator shall be able to disable this request function if desired.
5. When comfort conditions are warmer than ideal, indicated by the color yellow a request for additional cooling shall be sent over the network to other cooling equipment in the HVAC chain, such as a chiller. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.
6. When comfort conditions are cooler than ideal; indicated by the color light blue, a request for additional heating shall be sent over the network to other heating equipment in the HVAC chain, such as a boiler. This information is to be used for optimization of equipment in the HVAC chain. The operator shall be able to disable this function if desired.

7. The cooling [and heating] setpoints may be increased [decreased] under demand control conditions to reduce the cooling [heating] load on the building during the demand control period. Up to three levels of demand control strategy shall be provided. The operator may predefine the amount of setpoint increase [decrease] for each of the three levels. Each space temperature sensor in the building may be programmed independently.
8. An optimum start-up program transition from the unoccupied setpoints to the occupied setpoints. The optimum start-up algorithm considers the rate of space temperature rise for heating and the rate of space temperature fall for cooling under nominal outside temperature conditions; it also considers the outside temperature; and the heat loss and gain coefficients of the space envelope [AI: Space Temperature].
9. A PID control loop, comparing the actual space temperature to its setpoint, shall modulate the dampers [and heating coil valve or heating stages in sequence] to achieve the setpoint target.

3.02 GLOBAL VAV TERMINAL BOX PRIMARY AIR VALVE OPERATION

- A. Provide a DDC global primary air control valve point or software program override index signal to enable/ disable the VAV system primary air valves. This operation shall allow all the primary air valves in the respective VAV system to be positioned full open for balancing.

3.03 VAV AHU FAN [REMOTE DUCT] STATIC PRESSURE SETPOINT OPTIMIZATION

- A. The building automation system [BAS] shall continuously monitor the damper position of all VAV terminal units. The remote duct static pressure shall be mounted 2/3 the distance from the VAV RTU or AHU to the most remote terminal. The sensor must be mounted in a non-turbulent location.
- B. When any VAV damper is more than 95% [adj.] open, the remote duct static pressure setpoint shall be reset upward by 0.1 in W.C. [adj.] at a frequency of 15 minutes [adj.] until one of the following occur:
 1. No damper is more than 95% open.
 2. The remote duct static pressure setpoint has reset upward to the system maximum duct static pressure setpoint.
 3. The discharge duct static pressure has not reached the maximum discharge duct static pressure setpoint.
 4. The AHU variable-frequency drive is at the maximum speed setting.
 Exception: VAV terminal units scheduled with equal minimum and maximum airflow rates that operate as 100% open constant volume terminal units.
- C. When all VAV dampers are less than 85% [adj.] open, the remote duct static pressure setpoint shall be reset downward by 0.1 in W.C. [adj.] at a frequency of 15 minutes [adj.] until one of the following occur:
 1. At least one damper is more than 85% open or the static pressure setpoint has reset downward to the system minimum duct static pressure setpoint
 2. The AHU variable-frequency drive is at the minimum speed setting.
 Exception: VAV terminal units scheduled with equal minimum and maximum airflow rates that operate as 100% open constant volume terminal units.
- D. The control bands, setpoint increment values, setpoint decrement values and adjustment frequencies shall be adjusted to maintain maximum remote duct static pressure optimization with stable system control and maximum comfort control.
- E. The BAS shall have the capability of performing the following functions:
 1. Allow the operator to exclude "problem" zones that should not be considered when determining the optimized setpoint.

2. Read the status of the remote duct static pressure sensor and display the active duct static pressure reading on the status screen.
 3. Identify, and display to the user, the VAV box that serves the Critical Zone [that is, the zone with the most wide-open VAV damper]. This information shall update dynamically as the location of the Critical Zone changes based on building load, and remote duct static pressure setpoint optimization control.
- F. During the commissioning process, the ATC Subcontractor shall demonstrate the performance of remote duct static pressure optimization.

3.04 VENTILATION OPTIMIZATION

- A. The AHU outdoor-air damper shall be controlled to deliver required outdoor airflow at all load conditions during the occupied mode. The outdoor airflow setpoint for each AHU shall be as scheduled on the Drawings or shall be as indicated in its sequence of operations contained in this Section. The actual outdoor airflow shall be sensed at the outdoor air intake.
- B. The building DDC system shall include a time-of-day schedule to indicate whether the AHU is in the occupied mode or the unoccupied mode. When the schedule indicates that the AHU is in the unoccupied mode, the required outdoor airflow for the system shall be zero. When the schedule indicates that the AHU is in the occupied mode, the required outdoor airflow for the AHU shall equal the design minimum outdoor airflow rate, unless one of the following is true:
1. The AHU serves one or more zones or spaces equipped with a carbon dioxide [CO₂] sensor.
 - a. For those zones equipped with a CO₂ sensor, the required outdoor airflow for the zone shall be continuously calculated using the measured CO₂ concentration as an indicator of the current per-person ventilation rate.
 2. Ambient conditions are such that the AHU is operating in the economizer mode.
- C. If an AHU serves one or more zones or spaces equipped with a CO₂ sensor the DDC system shall modulate the outdoor air and return air dampers as follows:
1. If the CO₂ level in all spaces containing CO₂ sensors is below setpoint, then the outdoor air damper shall be placed in its low occupancy minimum outdoor position. The low occupancy minimum outdoor air position for each RTU is indicated in the AHU Schedule on the Drawings or is indicated in its sequence of operations contained in this Section.
 2. If the CO₂ level in any space rises above setpoint, and its terminal box primary air damper is in its maximum position, then the DDC system shall increase the unit's outdoor air quantity in 1% increments every 30 seconds until all space CO₂ levels are 50 ppm [adjustable] below their setpoint or the high occupancy minimum outdoor air position is reached.
 3. If the CO₂ level in all spaces is below setpoint, the DDC system shall reduce the unit's outdoor air quantity in 1% increments every 30 seconds until any space CO₂ level rises to within 25 ppm [adjustable] of its setpoint or the unit's low occupancy outdoor air position is reached.
- D. The CO₂ setpoint in each space shall be one of the following:
1. An Owner determined setpoint.
 2. A DDC determined setpoint that is 500 ppm above the outdoor air CO₂ concentration level as measured and averaged by two CO₂ sensors.
- E. If a space or zone containing a CO₂ sensor is served by a VAV terminal box or fan powered terminal box and its CO₂ level rises above setpoint, the DDC system shall increase the terminal box primary air damper position in increments of 25 cfm every 15 seconds until space CO₂ drops to a level of 50 ppm [adjustable] below its setpoint or the terminal box primary air damper reaches its maximum position. The DDC system shall not adjust/modulate the AHU outdoor air damper from its low occupancy minimum outdoor air position until the terminal box primary air damper reaches its

maximum position and the space CO₂ level continues to remain above setpoint for a time period of 90 seconds [adjustable]

- F. The DDC system shall not request a quantity of outdoor air that is above the AHU high occupancy minimum outdoor air position/quantity unless the current outdoor air temperature and humidity conditions permit economizer use and a system need for cooling exists.

3.05 A2L REFRIGERANT MONITORING SYSTEM (Under Construction)

- A. AHU-1 contains A2L refrigerants of a sufficient volume to be supplied with refrigerant monitoring system integral to the unit. Where these monitoring systems exist, provide the following sequence:
 - 1. When the monitoring system detects refrigerant of a sufficient concentration:
 - a. Deactivate compressor(s).
 - b. Activate the supply fan.
 - c. Open all VAV terminal box dampers connected to this AHU to 100%.
 - d. Send an alarm message to the DDC control system to indicate that the refrigerant monitoring system detected refrigerant.
 - e. Return the system to normal operation after the leak detection system has been manually reset.

3.06 MAKE-UP AIR UNIT MAU-1

- A. The constant volume make-up air unit [MAU] consists of an outside-air damper, a remote exhaust-air damper located at EF-1, a supply fan w/ VFD, a remote exhaust fan (EF-1), and a gas-fired heat exchanger. All actuators shall be electronic.
 - 1. The RTU will be furnished with a factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel. The remote control-panel will be equipped the following lights and switches:
 - a. On-off-auto fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, Type 1.
 - j. A BACNet interface device to accommodate full communication and compatibility with the ATC Subcontractor's building DDC system.
- A. The factory provided remote control panel shall include all control devices necessary to modulate the burner flame to accurately maintain a space temperature set point via 0-10 vdc BAS control signal and compensate for fluctuations in entering air temperature, air volume and % of OA using heating PID controls.
- B. Furnish the Gas Instrument control system specified in Section 23 0923.16 GAS INSTRUMENTS including each NO and CO sensor indicated on the Plans.
- C. The ATC Subcontractor shall furnish and install the MUA remote control panel and related equipment, the Gas Instrument controls, and shall provide all additional controls in order to control the MUA unit according to the operating sequence described below. The ATC Subcontractor shall coordinate his work with the MUA unit manufacturer.

- D. The DDC system shall determine through the time schedule program when to energize and de-energize the rooftop MAU.
- E. Gas Instrument Mode:
1. Whenever the gas instruments system detects CO levels above 25 PPM (adjustable) or NO2 levels above 0.3 ppm (adjustable) the make-up air fan and interlocked exhaust fan EF-1 shall energize and operate at 50% speed (adjustable).
 2. Whenever the gas instruments system detects CO levels above 100 ppm (adjustable) or NO2 levels above 1.0 ppm (adjustable) the make-up air fan and interlocked exhaust fan EF-1 shall operate at 100% speed.
 3. Whenever the gas instruments system detects CO levels have fallen below 25 PPM (adjustable) and the NO2 levels have fallen below 0.3 ppm (adjustable) the make-up air fan and interlocked exhaust fan EF-1 shall turn off.
 4. A minimum run time of 15 minutes (adjustable) shall apply whenever the MUA fan is called to operate.
 5. Outside Air and Exhaust Air Dampers: When the supply fan and exhaust fan are operating, the outside air damper and exhaust air damper shall be full [100%] open.
- F. Dehumidification Mode:
1. Whenever the space relative humidity rises above 60% (adjustable) the make-up air fan and interlocked exhaust fan EF-1 shall energize and operate at 100% speed (adjustable).
 2. Whenever the space relative humidity falls below 50% RH (adjustable) the make-up air fan and interlocked exhaust fan EF-1 shall turn off.
 3. A minimum run time of 15 minutes (adjustable) shall apply whenever the MUA fan is called to operate.
 4. Outside Air and Exhaust Air Dampers: When the supply fan and exhaust fan are operating, the outside air damper and exhaust air damper shall be full [100%] open.
- G. Heating Mode:
1. Whenever the MUA supply fan operates, the unit's gas fired heat exchanger burner shall be modulated to maintain discharge air temperature [DAT] setpoint. The DAT shall reset by space temperature. Provide a 2°F deadband between heating and cooling. The setpoints and the deadband of the reset schedule shall be adjustable by the Owner. The reset schedule shall be as follows:
- | | |
|-------------|-------------|
| Space | Discharge |
| Air | Air |
| <u>Temp</u> | <u>Temp</u> |
| 72°F | 72°F |
| 68°F | 76°F |
- H. Smoke Control: A duct mounted smoke detector, located in the exhaust air duct, shall stop the supply fan and exhaust fan, shall stop the energy recovery wheel, de-energize the gas-fired heat exchanger, and shall close the outside air and exhaust air dampers when products of combustion are detected in the exhaust airstream.
- I. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fan and exhaust fan, de-energize the gas-fired heat exchanger, and close the outside air and exhaust air dampers when operating in the Dehumidification Mode and the discharge air temperature drops below 50°F [adjustable].
- J. DDC Points List for Rooftop Make-up Air Unit MAU-1
1. AI Discharge Air Temperature [at unit outlet]
 2. AI Space Air Temperature
 3. AI Space Relative Humidity
 4. AI Supply Fan Variable Frequency Drive Status
 5. AI Exhaust Fan Variable Frequency Drive Status
 6. DI Supply Fan Status

7. DI Exhaust Fan Status
8. DI Gas-fired Heat Exchanger Burner Status
9. DI Low Discharge Air Temperature Alarm
10. AO Gas-fired Heat Exchanger Burner
11. AO Discharge Air Temperature Setpoint Adjust
12. AO Supply Fan Variable Frequency Drive Speed
13. AO Exhaust Fan Variable Frequency Drive Speed
14. DO Supply Fan Start/Stop
15. DO Exhaust Fan Start/Stop
16. DO Exhaust Air Damper Open/Close
17. DO Outside Air Damper Open/Close

- K. Coordinate the control system requirements with the requirements described in Division 23 Sections 23 0923.16 GAS INSTRUMENTS and 23 7339 INDOOR DIRECT FIRED HEATING AND VENTILATING UNITS.

3.07 VARIABLE AIR VOLUME AIR HANDLING UNIT AHU-1

- A. The variable air volume [VAV] air handling unit [AHU] shall be controlled via DDC type controls. The Subcontractor shall provide DDC control components to accomplish the sequence described below.
- B. The VAV AHU consists of an outside-air damper, a return air damper, a refrigerant [DX] cooling coil, dual supply fans with variable frequency [VF] drives, dual remote air-cooled condensing units, a gas fired heat exchanger, and a remote duct mounted exhaust/relief fan with VF drive. The VAV AHU shall be controlled by a DDC controller furnished by the Subcontractor. Actuators shall be electronic.
1. Provide the unit with an airflow station mounted in the outdoor airstream to measure the exact amount of outdoor air the unit introduces into the system.
- C. The DDC system shall determine through the start/stop optimization program and the time schedule program when to energize the VAV AHU for the warm-up mode prior to the area being occupied. The start/stop optimization program and time schedule program shall also determine when to de-energize the VAV AHU.
- D. When the VAV AHU is indexed to the warm-up or cool-down mode, the DDC system shall control it according to the following sequence:
1. During the warm-up mode:
 - a. The supply fan[s] shall be energized and shall run continuously while in the morning warm-up mode.
 - 1) A static pressure sensor, mounted 2/3 the distance from the VAV AHU to the most remote terminal, shall modulate the speed of the fan through its variable frequency drive to maintain the duct static pressure setpoint. The ATC Subcontractor shall determine the proper setpoint for the static pressure sensor during air system balancing operations and control system functional performance testing operations. Refer to the article entitled "VAV AHU Fan [Discharge Duct] Static Pressure Setpoint Optimization" in this Section for additional requirements.
 - b. The outside air damper shall be closed and its return air damper shall be open.
 - c. The remote exhaust/relief fan shall be de-energized and its associated motorized damper shall be closed.
 - d. The associated remote air-cooled condensing unit shall be de-energized.
 - e. The gas-fired heat exchanger shall be energized at full capacity and then shall be staged on and off or modulated to maintain space temperature at a setpoint of 72°F [adjustable]. The electric reheat coil in each VAV terminal box shall be locked out during the morning warm-up mode. Refer to the sequence described in the "VAV Terminal Boxes with Electric Reheat Coils" article in this Section for additional requirements.

2. During the cool-down mode:
 - a. The supply fan[s] shall be energized and shall run continuously while in the morning cool down mode.
 - 1) A static pressure sensor, mounted 2/3 the distance from the VAV AHU to the most remote terminal, shall modulate the speed of the fan through its variable frequency drive to maintain the duct static pressure setpoint. The ATC Subcontractor shall determine the proper setpoint for the static pressure sensor during air system balancing operations and control system functional performance testing operations. Refer to the article entitled "VAV AHU Fan [Discharge Duct] Static Pressure Setpoint Optimization" in this Section for additional requirements.
 - b. The outside air damper shall be closed and its return air damper shall be open.
 - c. The remote exhaust/relief fan shall be de-energized and its associated motorized damper shall be closed.
 - d. The air-cooled condensing units shall be energized at their full capacity and then their compressors shall be staged on and off to avoid overshoot and to maintain a space air temperature setpoint of 75°F [adjustable].
 - e. The gas fired heat exchanger shall be off.
- E. When the VAV AHU is indexed to the Occupied operating mode, the DDC system shall control it according to the following sequence:
 1. Supply Fan: The supply fan shall be energized and shall run continuously.
 - a. A static pressure sensor, mounted 2/3 the distance from the VAV AHU to the most remote terminal, shall modulate the speed of the fan through its variable frequency drive to maintain the duct static pressure setpoint. The ATC Subcontractor shall determine the proper setpoint for the static pressure sensor during air system balancing operations and control system functional performance testing operations. Refer to the article entitled "VAV AHU Fan [Discharge Duct] Static Pressure Setpoint Optimization" in this Section for additional requirements.
 2. Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]: When the VAV AHU is initially energized, the normally closed outdoor air damper shall remain in its full closed position and the normally open return air damper shall remain in its full-open position for a period of 60 seconds. After 60 seconds has elapsed, the outdoor air damper and return air damper shall be controlled as follows:
 - a. Normal Mode: The outdoor air damper shall initially be placed to induce the low occupancy minimum outdoor airflow scheduled on the drawings, as determined by an airflow station mounted in the unit's outdoor airstream. The DDC system shall then control the position of the outdoor air damper via the various space CO2 sensors located in high occupancy spaces served by the system according to the "Ventilation Optimization" article in this Section. The high occupancy minimum outdoor air damper position shall be as indicated in the schedule on the Drawings.
 - b. Economizer Mode: When free cooling is available and space temperature is above setpoint, the outside air damper and the return air damper shall be modulated to maintain the unit's discharge air temperature setpoint. The DDC system shall compare the enthalpy of the outside air to the enthalpy of the return/exhaust air to determine whether free cooling is available.
 - 1) The remote exhaust/relief air fan shall be energized and its associated motorized damper shall be open. The exhaust/relief fan's VF drive shall then be modulated to maintain a differential pressure of 0.03-inches w.g. [adjustable] measured between the space and the outdoors.
 - 2) Free cooling is available whenever the outdoor air enthalpy is less than 27.4 Btu/lb and the outside air temperature is less than the return air temperature.

3. Cooling Mode:

- a. The DDC system shall first determine whether free cooling is available. If free cooling is available, then the unit's outdoor air damper, return air damper, and exhaust fan and associated motorized damper and shall be controlled as previously described in the subparagraph entitled "Outdoor Air and Return Air Dampers [Comparative Enthalpy Economizer]" in this article.
- b. If free cooling is not available, the DDC system shall activate the cooling system.
- c. When the DDC system sends a signal to activate the cooling system, the DDC system shall start the lead packaged compressor and condensing unit (condensing unit). The DDC system shall stage the lead condensing unit compressors to maintain a supply air temperature setpoint of 55°F (adjustable). Whenever the lead condensing unit is operating at full capacity for a period of two minutes (adjustable) and the discharge air temperature rises above 57°F (adjustable), the DDC shall command the lag condensing unit to operate, and shall stage the compressors to meet demand.
 - 1) If the lead condensing unit fails to start [or fails during operation] as proven by current switches affixed to each compressor and each condenser fan, an alarm shall be sent to the DDC system operator's workstation informing the operator of the malfunction. The signal to the original lead condensing unit shall be disabled through DDC. The DDC system shall then send a signal for the lag condensing unit to start.
 - 2) The DDC system shall contain a run time program to automatically rotate the lead and lag condensing units when the accumulated run time exceeds predetermined number of hours.
- d. If the unit is operating in the heating mode, the associated condensing unit shall be de-energized.
- e. If the primary air damper in all VAV terminal boxes is at their minimum position, the discharge air temperature shall be reset upwards by 0.10°F every 30-seconds [adjustable] until one of the primary air dampers opens beyond its minimum position or until discharge air temperature reaches 60°F [adjustable].

4. Heating Mode:

- a. The DDC system shall modulate the gas heating section to maintain a discharge air temperature setpoint of 55°F (adjustable). If the unit is operating in the cooling mode, the gas fired heater shall be off.
- b. When the outside air temperature falls below 30°F (adjustable) the discharge air temperature shall be reset upwards by 0.10°F every 30-seconds (adjustable) until the discharge air temperature reaches 60°F (adjustable). The reverse shall occur whenever the outside air temperature rises above 30°F (adjustable) until the discharge air temperature falls to 55°F (adjustable).

5. Dehumidification: Provide space humidity sensor[s] and space temperature sensor[s] for the system. Refer to the drawings for the location of the space humidity sensor[s] and the space temperature sensor[s]. The DDC system shall calculate actual space dewpoint temperature based upon actual space temperature and actual space humidity. When the highest space dewpoint temperature rises above a setpoint of 55°F [adjustable], the unit shall be placed in its dehumidification mode. When placed in its dehumidification mode, the following shall occur:

- a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the compressors of the associated condensing unit sequentially.
- b. The VAV terminal box electric reheat coil shall be controlled to maintain space temperature according to the sequence described in the "VAV Terminal Boxes with Electric Reheat Coils" article in this Section.
- c. As the highest space dewpoint temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
- d. When the highest space dewpoint temperature drops below 54°F [adjustable], the unit shall be returned to its normal control mode.

- e. Provide the following points on the graphical display:
 - 1) AV [analog value] - Dew point temperature for each room with temperature and humidity sensors.
 - 2) AV - Lowest dew point temperature for the system.
 - 3) AV - Highest dew point for the system.
 - 4) AV - Dew point set-point.
- F. When the VAV AHU is indexed to the Unoccupied mode, the DDC system shall control it according to the following sequence:
 - 1. The supply fan[s] shall be de-energized.
 - 2. The outside air damper shall be closed and its return air damper shall be open.
 - 3. The remote exhaust/relief fan shall be de-energized and its associated motorized damper shall be closed.
 - 4. The associated remote air-cooled condensing units shall be de-energized.
 - 5. The gas fired heat exchanger shall be off.
 - 6. Dehumidification: When the highest space dewpoint temperature rises above a setpoint of 55°F [adjustable], the unit supply fan shall be energized, the unit's cooling system shall be controlled as described below, the unit's exhaust fan shall remain de-energized, the return air damper shall remain open and the outdoor air damper shall remain closed.
 - a. The leaving cooling coil air temperature shall be modulated down towards 50°F by staging the compressors of the associated condensing units sequentially.
 - b. The VAV terminal box electric reheat coil shall be controlled to maintain space temperature according to the sequence described in the "VAV Terminal Boxes with Electric Reheat Coils" article in this Section.
 - c. As the highest space dewpoint temperature drops towards 54°F [adjustable], the leaving cooling coil air temperature shall be modulated up towards 55°F by staging the unit's compressors off sequentially.
 - d. When space dewpoint temperature drops below 54°F [adjustable], the unit's supply fan[s] shall be de-energized, the unit's exhaust fan[s] shall remain de-energized, and the associated condensing unit's compressors shall be de-energized.
- G. Night Setback Mode: If the space temperature of any VAV terminal unit served by this air handling unit drops below the night setback temperature setpoint of 60°F [adjustable] when the VAV AHU is in the Unoccupied Mode, the following shall occur:
 - 1. The unit shall operate in the Warm-Up Mode.
 - 2. The unit shall revert back to the Unoccupied mode when the space temperature of each VAV terminal unit served by this air handling unit rises 2°F above the night setback temperature setpoint of 60°F [adjustable].
- H. Smoke Control: A duct mounted smoke detector, located in the return air duct, shall stop the supply fans, close the outside air damper, open the return air damper, de-energize the associated condensing unit **and** de-energize the gas heat exchanger when products of combustion are detected in the exhaust airstream.
- I. Provide a low temperature sensor mounted in the unit's discharge airstream to stop the supply fans, close the outside air damper, open the return air damper, de-energize the associated condensing unit **and** de-energize the gas heat exchanger when discharge air temperature drops below 45°F [adjustable].
- J. Provide a water level sensor mounted in the unit's drain pan to stop the supply fans, close the outside air damper, open the return air damper, de-energize the associated condensing unit **and** de-energize the gas heat exchanger when the water in the pan rises to within ½-inch [adjustable] of the top of the drain pan.

K. DDC Input/Output Points for VAV Air Handling Units AHU-1:

1. AI Mixed Air Temperature
2. AI Discharge Air Temperature [at unit outlet]
3. AI Discharge duct static pressure [at unit outlet]
4. AI Remote Duct Static Pressure Sensor [mounted 2/3 the distance from the VAV AHU to the most remote terminal]
5. AI Space Air Temperature
6. AI Space/Return Air Humidity
7. AI Outdoor Air Temperature
8. AI Outdoor Air Humidity
9. AI Space Differential Pressure
10. AI Discharge Temperature Setpoint Adjust
11. AI Space CO2 Level, each
12. AI Outside Airflow Rate
13. AI Supply Fan Variable Frequency Drive Status, each
14. AI Exhaust/Relief Fan Variable Frequency Drive Status
15. DI Supply Fan Status, each
16. DI Exhaust Fan Status
17. DI Manual Over-ride
18. DI Low Discharge Air Temperature Alarm
19. DI Smoke Detector Alarm
20. DI Drain Pan Water Level
21. DI Compressor Status [each]
22. DI Filter Pressure Differential
23. AO Discharge Temperature Setpoint Adjust
24. AO Outdoor Air Damper Position
25. AO Return Air Damper Position
26. AO Gas heat demand
27. AO Supply Fan Variable Frequency Drive Speed
28. AO Exhaust Fan Variable Frequency Drive Speed
29. DO Compressor On/Off [each compressor]
30. DO Relief Air Damper Open/Close
31. DO Supply Fan Start/Stop

L. Coordinate the control system requirements described in this Section with the requirements described in Division 23 Section 23 7313.16 INDOOR SEMI-CUSTOM AIR HANDLING UNITS

3.08 INFRARED HEATERS

- A. The radiant heating equipment manufacturer shall furnish the manufacturer's Modulating Heating Control equipment that will provide for modulation of the low-intensity radiant heating burner system firing rate based on differential air temperature, and operation of the vacuum pump. The system shall provide 100% input when more than 5 degrees below setpoint temperature. With milder outside temperatures, the system shall modulate input continuously (not staged) between 60% and 100% input.
- B. The BAS contractor shall install all controllers and control equipment furnished by the manufacturer.
- C. Provide space temperature sensors where indicated on drawings to control the operation of the infrared heaters as follows:
 1. When any of the space temperatures fall below a space temperature setpoint of 65°F (adjustable), the infrared heater control system shall be energized. When all space temperatures rise 10°F above the space temperature setpoint, the corresponding infrared heater shall be de-energized.

- D. Display and make adjustable the following status points through the BAS:
 - 1. Current Sensed Zone Temperatures
 - 2. Setpoint Temperatures
 - 3. Setback Setpoint Temperature
 - 4. Current Setpoint Adjustment Value
 - 5. Heat Power ON/OFF Indication (for each individual zone)
 - 6. Pump Power ON/OFF Indication
- E. Coordinate the control system requirements with the requirements as described in Division 23 Section 23 5523.13 LOW INTENSITY GAS FIRED RADIANT HEATERS.

3.09 EXHAUST FANS [AND SUPPLY FANS]

- A. Fan Status: Each fan shall be provided with a current sensor to monitor the operation of the fan.
- B. Damper Control: Each fan shall be provided with a motorized damper or automatic air damper.
 - 1. All in-line exhaust fans shall be provided with automatic air dampers. Refer to the "Automatic Air Damper" article in this Section for requirements.
- C. Continuous Control: Where indicated in the schedule on the Drawings, exhaust fans shall be wired to operate continuously.
- D. DDC Scheduled Control: Where indicated in the schedule on the Drawings, exhaust fans shall be energized and de-energized according to a DDC Time Schedule. Exhaust fans shall operate during the Occupied Mode and shall not operate during Unoccupied mode.
- E. Interlock Control: The ATC Subcontractor shall provide all interconnecting wiring and conduit required to interlock the following fans with the equipment listed:
 - 1. Exhaust fan EF-1 shall be interlocked with MAU-1 supply fan so that when MAU-1 supply fan operates EF-1 shall operate.
- F. Temperature Control: Where indicated in the schedule on the Drawings, a space temperature sensor shall be provided to control the operation of the exhaust fans as follows:
 - 1. When space temperature rises above a space temperature setpoint of 80°F [adjustable], the fan shall be energized. When space temperature drops 2°F below the space temperature setpoint, the fan shall be de-energized.
- G. Manual Control: The ATC Subcontractor shall provide all interconnecting control wiring between the ON/OFF switch and fan.
 - 1. ON/OFF Wall Switch: The fans indicated to have a wall switch in the schedule on the drawings shall be started and stopped via a ON/OFF wall switch. Coordinate location of each switch with the Architect and Owner.
- H. Building Pressure Control:
 - 1. EF-9: Control the remote relief/exhaust fan serving AHU-1 as described in article Variable Air Volume Air Handling Unit.

- I. Gas Instrument Control:
 - 1. Refer to Section 23 0923.16 GAS INSTRUMENTS for additional information
 - 2. Start respective exhaust fan when the CO or NO levels exceed setpoint.
 - 3. Operate the respective fan until all respective CO or NO levels sensed within the space fall below setpoint, or a minimum of 15 minutes (adjustable).
- J. DDC Points List for Exhaust Fans
 - 1. AI Space Temperature [each fan designated for temperature control]
 - 2. AI Exhaust/Relief Fan Variable Frequency Drive Status
 - 3. AO Exhaust Fan Variable Frequency Drive Speed
 - 4. DI Exhaust Fan Status [each fan]
 - 5. DO Exhaust Fan Start/Stop [each fan, except those wired for continuous operation]

3.10 AIR COOLED CONDENSING UNIT CU-1a and CU-1b

- A. The ATC subcontractor shall provide all interlock and control wiring between the air handling unit, DDC system controllers and the condensing unit as required by the condensing unit manufacturer in order to provide a complete and operational system.
- B. Refer to the "VAV Air Handling Units AHU-1 Sequence of Operation" article in this Section for additional operating sequence requirements for the condensing unit.
- C. Coordinate the control system requirements described in this Section with the requirements as described in Division 23 Section 23 6200 PACKAGED COMPRESSOR AND CONDENSER UNITS.

3.11 VARIABLE AIR VOLUME [VAV] TERMINAL BOXES WITH ELECTRIC REHEAT

- A. Each VAV terminal box shall be controlled via the building DDC system. The ATC Subcontractor shall provide DDC control components to accomplish the sequence described below.
- B. Each VAV terminal box shall have a primary air damper and a electric reheat coil. The ATC Subcontractor shall provide DDC control components to accomplish the sequence described below.
- C. The ATC Subcontractor shall furnish DDC controls to the VAV terminal box manufacturer for factory mounting and wiring by the terminal box manufacturer.
- D. VAV Terminal Box Cool-Down Mode:
 - 1. In the Cool-down Mode the air handling unit shall energize, the VAV terminal box primary air damper shall open to its maximum position, and the electric reheat coil shall remain de-energized.
 - 2. As space temperature approaches its cooling setpoint of 74°F [adjustable], the VAV terminal box primary air damper shall be modulated to its minimum occupied position.
 - 3. If space temperature drops below the heating setpoint of 72°F [adjustable], the VAV terminal box's electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F [adjustable].
- E. VAV Terminal Box Warm-up Mode:
 - 1. In the Warm-up Mode the air handling unit shall energize and the VAV terminal box primary air damper shall open to its minimum position.
 - 2. If space temperature is below the heating setpoint of 72°F [adjustable], the VAV terminal box's electric reheat coil shall be energized. As space temperature approaches the heating setpoint, the electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F [adjustable].

F. VAV Terminal Box Occupied Mode:

1. In the Occupied mode, the VAV terminal box primary air damper shall open to its minimum position. A space temperature sensor shall modulate the primary air damper between its minimum occupied position and its maximum occupied position to maintain cooling temperature setpoint of 74°F (adjustable).
2. When space temperature drops below the cooling temperature setpoint of 74°F (adjustable) toward the heating setpoint of 72°F (adjustable), the VAV terminal box primary air damper shall be modulated to its minimum occupied position.
3. If space temperature falls below the heating setpoint of 72°F (adjustable), the VAV terminal box's electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F (adjustable).
4. When the VAV terminal box's electric reheat coil on for more than 5 minutes (adjustable), and the space temperature drops below the heating setpoint of 72°F (adjustable), then the VAV terminal box shall modulate the primary air damper between its minimum occupied position and its maximum occupied heating position to maintain heating temperature setpoint of 72°F (adjustable).
5. The VAV terminal boxes that serve rooms having CO₂ sensors shall have dual minimum airflow setpoints. When the space or zone CO₂ concentration is above setpoint, the VAV terminal box shall increase the lower minimum airflow to the higher minimum airflow setpoint in 25 cfm increments every 15 seconds until CO₂ concentration in the space drops to a level of 50 ppm below setpoint or the terminal box primary air damper reaches its higher minimum airflow position. When the CO₂ concentration in the space drops to a level of 50 ppm below setpoint, the VAV terminal box shall decrease its primary air damper position in 25 cfm increments every 30 seconds until space CO₂ concentration rises to within 25 ppm of setpoint or the primary air damper's lower minimum airflow position is reached.

G. VAV Terminal Box Unoccupied/Night Setback Mode:

1. In the Unoccupied/Night Setback mode, the VAV terminal box primary air damper shall be at its minimum position and its electric reheat coil shall be de-energized. When room temperature drops below the night setback heating setpoint of 65°F [adjustable], the air handling unit supply fan shall energize, the VAV terminal box primary air damper shall open, and the VAV terminal box electric reheat coil shall energize. Once the space temperature rises 2°F [adjustable] above the night setback temperature setpoint, the air handling unit supply fan shall de-energize, the VAV terminal box primary air damper shall close, and the VAV terminal box electric reheat coil shall de-energize.
2. The override button on any of the room sensors shall override the night setback mode and shall place the VAV terminal boxes and its associated air handling unit into the Occupied mode for a timed period of 2-hours [adjustable]. Once the timed period is complete, the system shall revert back to the night setback mode.

H. Each VAV terminal box shall be provided with a discharge air temperature sensor located downstream of the terminal box reheat coil. The sensor will be utilized for trouble-shooting purposes.

I. Coordinate the control system requirements with the requirements as described in Division 23 Section 23 3600 AIR TERMINAL UNITS.

J. DDC Input/Output Points for VAV Terminal Boxes with Electric Reheat Coils:

1. AI Space/Zone Temperature
2. AI Discharge Air Temperature
3. AI Space/Zone Airflow Rate
4. AI Space/Zone CO₂ level
5. AO Terminal Box Damper
6. AO Electric Reheat Coil Output
7. DI Local Occupied/Unoccupied Override

3.12 VARIABLE AIR VOLUME [VAV] TERMINAL BOXES WITH ELECTRIC REHEAT COILS AND ELECTRIC RADIANT CEILING PANELS

- A. Each VAV terminal box shall be controlled via the building DDC system. The ATC Subcontractor shall provide DDC control components to accomplish the sequence described below.
- B. Each VAV terminal box shall have a primary air damper and a electric reheat coil. The ATC Subcontractor shall provide DDC control components to accomplish the sequence described below.
- C. The ATC Subcontractor shall furnish DDC controls to the VAV terminal box manufacturer for factory mounting and wiring by the terminal box manufacturer.
- D. VAV Terminal Box Cool-Down Mode:
 - 1. In the Cool-down Mode the air handling unit shall energize, the VAV terminal box primary air damper shall open to its maximum position, and the electric reheat coil shall remain de-energized.
 - 2. As space temperature approaches its cooling setpoint of 74°F [adjustable], the VAV terminal box primary air damper shall be modulated to its minimum occupied position.
 - 3. If space temperature drops below the heating setpoint of 72°F [adjustable], the VAV terminal box's electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F [adjustable].
- E. VAV Terminal Box Warm-up Mode:
 - 1. In the Warm-up Mode the air handling unit shall energize and the VAV terminal box primary air damper shall open to its minimum position.
 - 2. If space temperature is below the heating setpoint of 72°F [adjustable], the VAV terminal box's electric reheat coil shall be energized. As space temperature approaches the heating setpoint, the electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F [adjustable].
- F. VAV Terminal Box w/ electric Radiant Heat Occupied Mode when the outdoor air temperature is less than 60°F (adjustable):
 - 1. In the Occupied mode, whenever the outside air temperature is less than 60°F (adjustable) the VAV terminal box primary air damper shall open to its minimum position. A space temperature sensor shall modulate the primary air damper between its minimum occupied position and its maximum occupied position to maintain cooling temperature setpoint of 74°F (adjustable).
 - 2. When space temperature drops below the cooling temperature setpoint of 74°F (adjustable) toward the heating setpoint of 72°F (adjustable), the VAV terminal box primary air damper shall be modulated to its minimum occupied position.
 - 3. If space temperature drops below the heating setpoint of 72°F (adjustable), then the electric ceiling radiant heaters shall be cycled on and off to maintain a minimum space temperature of 72°F (adjustable).
 - 4. If space temperature falls below the heating setpoint of 72°F (adjustable), and the electric ceiling radiant heaters are on, the VAV terminal box's electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F (adjustable).
 - 5. When the VAV terminal box's electric reheat coil on for more than 5 minutes (adjustable), and the space temperature drops below the heating setpoint of 72°F (adjustable), then the VAV terminal box shall modulate the primary air damper between its minimum occupied position and its maximum occupied heating position to maintain heating temperature setpoint of 72°F (adjustable).
 - 6. The VAV terminal boxes that serve rooms having CO₂ sensors shall have dual minimum airflow setpoints. When the space or zone CO₂ concentration is above setpoint, the VAV terminal box shall increase the lower minimum airflow to the higher minimum airflow setpoint in 25 cfm increments every 15 seconds until CO₂ concentration in the space drops to a level of 50 ppm below setpoint or the terminal box primary air damper reaches its higher minimum airflow position. When the CO₂ concentration in the space drops to a level of 50 ppm below setpoint, the VAV terminal box shall decrease its primary air damper position in 25 cfm increments every 30 seconds until space CO₂ concentration rises to within 25 ppm of setpoint or the primary air damper's lower minimum airflow position is reached.

- G. VAV Terminal Box w/ Electric Radiant Ceiling Panels Occupied Mode when the outdoor air temperature is greater than 60°F (adjustable):
1. In the Occupied mode, whenever the outside air temperature is greater than 60°F (adjustable) the VAV terminal box primary air damper shall open to its minimum position. A space temperature sensor shall modulate the primary air damper between its minimum occupied position and its maximum occupied position to maintain cooling temperature setpoint of 74°F (adjustable).
 2. When space temperature drops below the cooling temperature setpoint of 74°F (adjustable) toward the heating setpoint of 72°F (adjustable), the VAV terminal box primary air damper shall be modulated to its minimum occupied position.
 3. If space temperature falls below the heating setpoint of 72°F (adjustable), the electric radiant ceiling panels shall remain off, and the VAV terminal box's electric reheat coil shall be modulated to maintain a minimum space temperature of 72°F (adjustable).
 4. When the VAV terminal box's electric reheat coil is operating at 100% capacity for more than 5 minutes (adjustable), and the space temperature drops below the heating setpoint of 72°F (adjustable), then the VAV terminal box shall modulate the primary air damper between its minimum occupied position and its maximum occupied heating position to maintain heating temperature setpoint of 72°F (adjustable).
- H. VAV Terminal Box Unoccupied/Night Setback Mode:
1. In the Unoccupied/Night Setback mode, the VAV terminal box primary air damper shall be at its minimum position and its electric reheat coil shall be de-energized. When room temperature drops below the night setback heating setpoint of 65°F [adjustable], the air handling unit supply fan shall energize, the VAV terminal box primary air damper shall open, and the VAV terminal box electric reheat coil shall energize. Once the space temperature rises 2°F [adjustable] above the night setback temperature setpoint, the **rooftop unit or** air handling unit supply fan shall de-energize, the VAV terminal box primary air damper shall close, and the VAV terminal box electric reheat coil shall de-energize.
 2. The override button on any of the room sensors shall override the night setback mode and shall place the VAV terminal boxes and its associated air handling unit into the Occupied mode for a timed period of 2-hours [adjustable]. Once the timed period is complete, the system shall revert back to the night setback mode.
- I. Each VAV terminal box shall be provided with a discharge air temperature sensor located downstream of the terminal box reheat coil. The sensor will be utilized for trouble-shooting purposes.
- J. Coordinate the control system requirements with the requirements as described in Division 23 Section 23 3600 AIR TERMINAL UNITS.
- K. DDC Input/Output Points for VAV Terminal Boxes with Electric Reheat Coils:
1. AI Space/Zone Temperature
 2. AI Discharge Air Temperature
 3. AI Space/Zone Airflow Rate
 4. AI Space/Zone CO₂ level
 5. AO Terminal Box Damper
 6. AO Electric Reheat Coil Output
 7. DI Local Occupied/Unoccupied Override
 8. DO Electric Radiant Ceiling Panel On/Off

3.13 ELECTRIC WALL HEATERS

- A. Each electric wall heater will be furnished with controls integral to the unit. Refer to Division 23 Section 23 8239.19 WALL AND CEILING UNIT HEATERS.
- B. Furnish and install electric wall heaters and electric ceiling heaters serving entry vestibules with an enabling relay that prevents operation of the equipment when the outside air temperature is greater than 45°F.

3.14 ELECTRIC UNIT HEATERS

- A. The ATC Subcontractor shall provide a wall mounted thermostat along with all necessary wiring and conduit for control of each electric unit heater. Refer to Division 23 Section 23 8239.16 PROPELLER UNIT HEATERS.
- B. When space temperature drops below setpoint, the wall mounted thermostat shall energize the electric unit heater's fan and electric coil. When space temperature rises 2°F above the space temperature setpoint, the unit heater's fan and electric coil shall be de-energized.

3.15 ELECTRIC CABINET UNIT HEATERS

- A. The ATC Subcontractor shall provide a wall mounted space temperature sensor along with all necessary wiring and conduit for control of each electric unit heater. Refer to Division 23 Section 23 8239.13 CABINET UNIT HEATERS.
- B. When space temperature drops below setpoint, the wall mounted thermostat shall energize the electric unit heater's fan and electric coil. When space temperature rises 2°F above the space temperature setpoint, the unit heater's fan and electric coil shall be de-energized.

3.16 DUCTLESS SPLIT FAN COIL UNITS AND ASSOCIATED CONDENSING UNITS

- A. The split fan coil unit/condensing unit manufacturer will furnish a remote wall control unit for each split fan coil unit.
- B. The automatic temperature control subcontractor shall provide all control wiring and conduit required to connect the various components associated with the split fan coil unit/condensing unit system.
- C. Coordinate the control system requirements with the requirements as described in Division 23 Section 23 8126 SPLIT SYSTEM AIR CONDITIONERS.
- D. Space temperature for rooms with split fan coil units shall be monitored. An alarm shall be sent to the DDC system operator's workstation if the zone temperature is greater than the cooling setpoint by a user definable amount [adjustable]. Coordinate alarm limits of each space with the Owner.
- E. DDC Input/Output Points for Ductless Split Fan Coil Units and Associated Condensing Units
 - 1. AI Space Air Temperature
 - 2. AI Setpoint Adjust

3.17 EMERGENCY GENERATOR

- A. The DDC system shall monitor the generator run status and generate log reports to remind the Owner of required inspections and routine maintenance.
- B. DDC Points List for Emergency Generator:
 - 1. DI Generator Status

3.18 AUTOMATIC AIR DAMPERS

- A. Automatic Air Dampers [In-line Exhaust Fans]: Each in-line exhaust fan's automatic air damper shall be controlled via the building DDC system. The ATC Subcontractor shall provide all wiring, conduit and DDC control components so that the damper is open when the fan is operating and the damper is closed when the fan is not operating.
- B. Automatic Air Dampers [Relief]: Each automatic air damper used for building relief either mounted in conjunction with louvers or gravity roof ventilators shall be modulated open and closed to maintain a positive differential pressure of 0.05-inches w.g. [adjustable] on that floor or wing of the building.
- C. DDC Input/Output Points for Automatic Air Dampers:
 - 1. AI Building Differential Pressure
 - 2. AO Automatic Air Damper Position

3.19 LIGHTING CONTROL

- A. The DDC system shall integrate with the lighting control system provided by the electrical contractor and specified in Section 26 0923 Lighting Controls via BACnet communication. The following capabilities shall be integrated:
 - 1. Control of individual devices, including, but not limited to, control of relay and dimming output.
 - 2. Reading of individual device status information. The available status will depend on the individual device type and capabilities, which may include but not be limited to, relay state, dimming output, power measurement, occupancy sensor status, and photocell sensor states or readings. All system devices shall be available for polling for devices status.
 - 3. Activation of pre-defined system Global Profiles.
 - 4. Activation of Profiles (local or global) and Preset Scenes from third party systems by receiving dry contact closure output signals or digital commands via RS-232/RS-485.
 - 5. Activation of demand response levels from Demand Response Automation Servers (DRAS) via the OpenADR 2.0a protocol.
- B. DDC Input/Output Points for Lighting Control:
 - 1. DO Lighting Zone On/Off [each]

3.20 MISCELLANEOUS COMMON POINTS

- A. The ATC Subcontractor shall provide the following sensors that shall be common to all sequences:
 - 1. A minimum of two [2] outdoor air temperature sensors shall be provided. These sensors shall be mounted on the north facing side of the building and shall be provided with sun shields [if necessary]. The temperature measurements from the two sensors shall be averaged. If a difference of more than 1°F is measured between the two sensors, an alarm shall be registered at the operator's workstation.
 - 2. A minimum of two [2] outdoor air humidity sensors shall be provided. The humidity measurements from the two sensors shall be averaged. If a difference of more than 2% RH is measured between the two sensors, an alarm shall be registered at the operator's workstation.
 - 3. A minimum of two [2] outdoor air CO2 sensors shall be provided. The CO2 measurements from the two sensors shall be averaged. If a difference of more than 30 ppm is measured between the two sensors, an alarm shall be registered at the operator's workstation.

B. DDC Input/Output Points for Miscellaneous Points

1. AI Outdoor Air Temperature [2 each]
2. AI Outdoor Air Relative Humidity [2 each]
3. AI Outdoor CO2 [2 each]

END OF SECTION 23 0993

SECTION 23 2113 - HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Condensate drain piping.

1.03 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Condensate Drain Piping: 150°F.

1.04 SUBMITTALS

- A. Shop Drawings:
 - 1. Detail, at 1/4 scale, the piping layout, fabrication of pipe anchors, hangers, supports for multiple pipes, alignment guides, expansion joints and loops, and attachments of the same to the building structure. Detail location of anchors, alignment guides, and expansion joints and loops.

PART 2 - PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Copper or Bronze Pressure-Seal Fittings:
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Stadler-Viega.
 - 2. Housing: Copper.

3. O-Rings and Pipe Stops: EPDM.
 4. Tools: Manufacturer's special tools.
 5. Minimum 200-psig working-pressure rating at 250°F.
- D. Copper, Mechanically Formed Tee Option: For forming T-branch on copper water tube.
1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. T-DRILL Industries Inc.
- E. Wrought-Copper Unions: ASME B16.22.

2.02 JOINING MATERIALS

- A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

- A. Condensate Drain Piping:
1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

3.02 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. Do not install piping in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the piping serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install piping adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- F. Install piping at indicated or required slopes.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Install piping to allow application of insulation.

- J. 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. Verify final equipment locations for roughing-in.
- O. Identify piping as specified in Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

3.03 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment." Comply with the following requirements for maximum spacing of supports.
- B. Piping shall be supported directly from the building substrate. Pipes are not permitted to be supported from other pipes, ducts, conduits, or cable tray.
- C. Install the following pipe attachments:
 - 1. Provide copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- 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.
- E. Support vertical runs at roof, at each floor, and at 10-foot intervals between floors.

3.04 PIPE JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. 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.

- F. Pressure-Sealed Joints: Use manufacturer-recommended tool and procedure. Leave insertion marks on pipe after assembly.

3.05 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated:
 - 1. Install unions, in piping NPS 2 (DN 50) and smaller at final connection to each piece of equipment.

3.06 FIELD QUALITY CONTROL

- A. Prepare hydronic piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, uninsulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. For coil condensate drain piping, subject piping system to hydrostatic 15-psig test pressure. Test pressure shall not exceed maximum pressure for any component in system under test.
 - 5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 - 6. Prepare written report of testing.

END OF SECTION 23 2113

SECTION 23 2300 - REFRIGERANT PIPING

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. Section Includes
 - 1. Refrigerant pipes and fittings.
 - 2. Refrigerant piping valves and specialties.
 - 3. Refrigerants.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of valve, refrigerant piping, and piping specialty.
- B. Shop Drawings
 - 1. Show layout of refrigerant piping and specialties, including pipe, tube, and fitting sizes; flow capacities; valve arrangements and locations; slopes of horizontal runs; oil traps; double risers; wall and floor penetrations; and equipment connection details.
 - 2. Show interface and spatial relationships between piping and equipment.
 - 3. Shop Drawing Scale: 1/4-inch equals 1 foot.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.06 PRODUCT STORAGE AND HANDLING

- A. Store piping with end caps in place to ensure that piping interior and exterior are clean when installed.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant:
 - 1. Suction Lines for Air Conditioning Applications: 300 psig
 - 2. Suction Lines for Heat Pump Applications: 535 psig
 - 3. Hot-Gas and Liquid Lines: 535 psig

2.02 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: AWS A5.8/A5.8M.
- E. Flexible Connectors: 500-psig minimum operating pressure; seamless tin-bronze core, high-tensile bronze-braid covering, and solder-joint end connections; dehydrated, pressure tested, minimum 7 inches long.

2.03 VALVES

- A. Service Valves: 500-psig pressure rating; forged-brass body with copper stubs, brass caps, removable valve core, integral ball check valve, and with solder-end connections.
- B. Thermostatic Expansion Valves: Comply with ARI 750; brass body with stainless steel parts; thermostatic-adjustable, modulating type; size and operating characteristics as recommended by manufacturer of evaporator, and factory set for superheat requirements; solder-end connections; with sensing bulb, distributor having side connection for hot gas bypass line, and external equalizer line.

2.04 REFRIGERANT PIPING SPECIALITIES

- A. Straight or Angle Type Strainers: 500-psig working pressure; forged-brass or steel body with stainless steel wire or brass-reinforced Monel screen of 80 to 100 mesh in liquid lines up to 1-1/8 inches, 60 mesh in larger liquid lines, and 40 mesh in suction lines; with screwed cleanout plug and solder-end connections.
- B. Moisture/Liquid Indicators: 500-psig maximum working pressure and 200°F operating temperature; all-brass body with replaceable, polished, optical viewing window with color-coded moisture indicator; with solder-end connections.
- C. Replaceable Core Filter Dryers: 500-psig maximum working pressure; heavy gauge protected with corrosion-resistant-painted steel shell, flanged ring and spring, ductile-iron cover plate with steel cap screws; wrought copper fittings for solder-end connections; with replaceable-core kit, including gaskets and the following:
 - 1. Filter Dryer Cartridge: Pleated media with solid core sieve with activated alumina, ARI 730 rated for capacity.

2.05 REFRIGERANTS

- A. ASHRAE 34, R-32.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS FOR REFRIGERANT R-410A

- A. Suction Lines NPS 1-1/2 (DN 40) and Smaller: Copper, Type ACR, annealed-temper tubing and wrought copper fittings with brazed joints.
- B. Hot gas and Liquid Lines: Copper, Type ACR, annealed-temper or drawn-temper tubing and wrought copper fittings with brazed joints.

3.02 VALVE AND SPECIALTY APPLICATIONS

- A. Furnish and install valve and refrigerant specialties in strict accord with the manufacturer's written installation instructions.
- B. Install refrigerant service valves in suction and discharge lines of compressor.
- C. Install service valve in liquid line upstream of expansion device for system charging.
- D. Install service valves on each side of strainers and dryers, in liquid and suction lines at evaporators.
- E. Install thermostatic expansion valves as close as possible to evaporator.
 - 1. If refrigerant distributors are used, install them directly on expansion-valve outlet.
 - 2. Install valve so diaphragm case is warmer than bulb.
 - 3. Secure bulb to clean, straight, horizontal section of suction line using two bulb straps. Do not mount bulb in a trap or at bottom of the line.
 - 4. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- F. Install pressure regulating and pressure relief valves as required by ASHRAE 15. Pipe pressure relief valve discharge to outside.
- G. Install liquid indicators in liquid line leaving condenser, in liquid line leaving receiver, and on leaving side of liquid solenoid valves.
- H. Install strainers immediately upstream from each automatic valve, including expansion valves, hot gas bypass valves, and compressor suction valves.

3.03 PIPING INSTALLATION

- A. Install refrigerant piping according to ASHRAE 15.
- B. Furnish and install refrigerant piping in strict accord with the manufacturer's written installation instructions.

- C. Basic piping installation requirements are specified in Division 23 Section 23 0500 "Common Work Results for HVAC."
- D. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.
- E. Arrange piping to allow inspection and service of compressor and other equipment. Install valves and specialties in accessible locations to allow for service and inspection.
- F. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation. Use sleeves through walls sized to permit installation of full-thickness insulation.
- G. Slope refrigerant piping as follows:
 - 1. Install horizontal hot gas discharge piping with a uniform slope downward away from compressor.
 - 2. Install horizontal suction lines with a uniform slope downward to compressor.
 - 3. Install traps and double risers to entrain oil in vertical runs.
 - 4. Liquid lines may be installed level.
- H. Install unions to allow removal of expansion valves and at connections to compressors and evaporators.
- I. When brazing, remove solenoid-valve coils and sight glasses; also remove valve stems, seats, and packing, and accessible internal parts of refrigerant specialties. Do not apply heat near expansion valve bulb.
- J. Hanger, support, and anchor products are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- K. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs.
 - 2. Spring hangers to support vertical runs.
- L. Install hangers with the following maximum spacing and minimum rod sizes:
 - 1. NPS 1/2 (DN 15): Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 5/8 (DN 18): Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1 (DN 25): Maximum span, 72 inches; minimum rod size, 1/4 inch.
 - 4. NPS 1-1/4 (DN 32): Maximum span, 96 inches; minimum rod size, 3/8 inch.
 - 5. For sizes not listed above, install hangers for copper tubing, with maximum horizontal spacing and minimum rod diameters, to comply with MSS SP-58, locally enforced codes, and authorities having jurisdiction requirements, whichever are most stringent.
- M. Support multi-floor vertical runs at least at each floor.

3.04 PIPE JOINT CONSTRUCTION

- A. Braze joints according to Division 23 Section 230500 "Common Work Results for HVAC."
- B. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide) during brazing to prevent scale formation.

3.05 SYSTEM LEAK TESTING

- A. Perform tests and inspections and prepare test reports.

B. Tests and Inspections:

1. Comply with ASME B31.5, Chapter VI.
2. Test refrigerant piping, specialties, and receivers. Isolate compressor, condenser, evaporator, and safety devices from test pressure if they are not rated above the test pressure.
3. Test high- and low-pressure side piping of each system separately at not less than the pressures indicated in Part 1 "Performance Requirements" article.
 - a. Fill system with nitrogen to the required test pressure.
 - b. System shall maintain test pressure at the manifold gauge throughout duration of test.
 - c. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - d. Remake leaking joints using new materials, and retest until satisfactory results are achieved.

3.06 SYSTEM CHARGING

A. Charge system using the following procedures:

1. Install core in filter-dryer after leak test but before evacuation.
2. Evacuate entire refrigerant system with a vacuum pump to a vacuum of 500 micrometers. 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. Provide full-operating charge.

END OF SECTION 23 2300

SECTION 23 3113 - METAL DUCTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Single-wall rectangular ducts and fittings.
 - 2. Single-wall round ducts and fittings.
 - 3. Sheet metal materials.
 - 4. Duct liner.
 - 5. Sealants and gaskets.
 - 6. Hangers and supports.

1.03 PERFORMANCE REQUIREMENTS

- A. Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in the "Duct Schedule" article in this Section.
- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1-2004.

1.04 SUBMITTALS

- A. Product data for each type of the following products:
 - 1. Liners and adhesives.
 - 2. Sealants and gaskets.
- B. Shop Drawings - plans, drawn to scale at a minimum of $\frac{1}{4}" = 1'-0"$, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Fabrication, assembly, and installation, including plans, elevations, sections, components, and attachments to other work.
 - 2. Factory and shop fabricated ducts and fittings.
 - 3. Duct layout indicating sizes, configuration, liner material, and static pressure classes.
 - 4. Elevation of top of ducts.
 - 5. Dimensions of main duct runs from building grid lines.
 - 6. Fittings.
 - 7. Reinforcement and spacing.
 - 8. Seam and joint construction.

9. Penetrations through fire rated and other partitions.
10. Equipment installation based on equipment being used on Project.
11. Locations for duct accessories, including dampers, turning vanes, and access doors and panels.
12. Hangers and supports, including methods for duct and building attachment and vibration isolation.
13. Suspended ceiling components.
14. Structural members to which duct will be attached.
15. Size and location of ceiling grid modules for acoustical tile.
16. Items penetrating finished ceiling including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Bulkheads.
 - g. Perimeter moldings.

PART 2 - PRODUCTS

2.01 SINGLE-WALL RECTANGULAR DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-4, "Transverse (Girth) Joints," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 1-5, "Longitudinal Seams - Rectangular Ducts," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Elbows, Transitions, Offsets, Branch Connections, and Other Duct Construction: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 2, "Fittings and Other Construction," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.02 SINGLE-WALL ROUND AND FLAT OVAL DUCTS AND FITTINGS

- A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static pressure class unless otherwise indicated.
- B. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Transverse Joints - Round Duct," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Seams - Round Duct and Fittings," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees," for static pressure class, applicable sealing requirements, materials involved, duct support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.03 SHEET METAL MATERIALS

- A. General Material Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. Stainless steel Sheets: Comply with ASTM A 480/A 480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be No. 2B, No. 2D, No. 3, or No. 4 as indicated in the "Duct Schedule" article.
- D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M) Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- E. Reinforcement Shapes and Plates: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
 - 1. Where black and galvanized steel shapes and plates are used to reinforce aluminum ducts, isolate the different metals with butyl rubber, neoprene, or EPDM gasket materials.
- F. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.04 DUCT LINER

- A. Fibrous Glass Duct Liner: Comply with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. CertainTeed Corporation; Insulation Group
 - b. Johns Manville
 - c. Knauf Insulation
 - d. Owens Corning
 - 2. Thickness and Minimum R-Value:
 - a. Ductwork Installed Indoors:
 - 1) Minimum thickness: 1½-inches.
 - 2) Minimum Installed R-value: 5.0 at 75°F mean temperature.

- 3) The minimum thickness may be reduced provided the manufacturer's literature indicates, for the thickness supplied, an R-Value which meets or exceeds 6.0 at 75°F mean temperature when tested in accordance with ASTM C 518.
3. Antimicrobial Erosion Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems.
 4. Water Based Liner Adhesive: Comply with NFPA 90A or NFPA 90B and with ASTM C 916.
 - a. 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).
- B. Insulation Pins and Washers:
1. Cupped Head, Capacitor discharge weld Pins: Copper or zinc coated steel pin, fully annealed for capacitor discharge welding, 0.135-inch diameter shank, length to suit depth of insulation indicated with integral 1½ - inch galvanized carbon steel washer.
 2. Insulation Retaining Washers: Self-locking washers formed from 0.016-inch (0.41-mm) thick galvanized steel; with beveled edge sized as required to hold insulation securely in place but not less than 1½-inches in diameter.
- C. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-19, "Flexible Duct Liner Installation."
1. Adhere a single layer of indicated thickness of duct liner with at least 90 percent adhesive coverage at liner contact surface area. Attaining indicated thickness with multiple layers of duct liner is prohibited.
 2. Apply adhesive to transverse edges of liner facing upstream that do not receive metal nosing.
 3. Butt transverse joints without gaps, and coat joint with adhesive.
 4. Fold and compress liner in corners of rectangular ducts or cut and fit to ensure butted-edge overlapping.
 5. Do not apply liner in rectangular ducts with longitudinal joints, except at corners of ducts, unless duct size and dimensions of standard liner make longitudinal joints necessary.
 6. Secure liner with mechanical fasteners 4-inches from corners and at intervals not exceeding 12 inches transversely; at 3-inches from transverse joints and at intervals not exceeding 18-inches longitudinally.
 7. Secure transversely oriented liner edges facing the airstream with metal nosings that have either channel or "Z" profiles or are integrally formed from duct wall. Fabricate edge facings at the following locations:
 - a. Fan discharges.
 - b. Intervals of lined duct preceding unlined duct.
 8. Terminate inner ducts with buildouts attached to fire damper sleeves, dampers, turning vane assemblies, or other devices. Fabricated buildouts (metal hat sections) or other buildout means are optional; when used, secure buildouts to duct walls with bolts, screws, rivets, or welds.

2.05 SEALANT AND GASKETS

- A. General Sealant and Gasket Requirements: Surface burning characteristics for sealants and gaskets shall be a maximum flame spread index of 25 and a maximum smoke developed index of 50 when tested according to UL 723; certified by an NRTL. Also, sealants and gaskets shall conform to UL 181A for metal ducts and UL 181B for flexible air ducts and flexible air connectors.
1. Closure systems uses to seal ductwork listed and labeled in accordance with UL 181A shall be marked "181A-P" for pressure sensitive tape, "181A-M" for mastic, or "181A-H" for heat sensitive tape. Closure systems uses to seal flexible air ducts and flexible air connectors shall comply with UL 181B shall be marked "181B-FX" for pressure sensitive tape, or "181B-M" for mastic.

B. Water Based Joint and Seam Sealant:

1. Type: Vinyl Acetate.
2. Solids Content: 69.2 percent.
3. Weight: 11.6 .2 lbs./gallon
4. Color: Grey.
5. Odor: Mild/Wet; Bland/Dry.
6. VOC: 22 gms. /ltr.
7. Viscosity: 140,000-180,000 CPS # 7 Brookfield, 20 RPM at 70°F.
8. Flammability: Non-Flammable.
9. Effect of Freezing: No damage - 3 Cycles.
10. Service: Indoor and outdoor use.
11. Storage Life: 6 Months at 70°F.
12. Cure Time: 48 hours.
13. Method of Application:
 - a. Brush, trowel, putty knife or caulking gun.
14. Product: Sealant shall be equivalent to Duro Dyne DDS-181.

C. Flanged Joint Sealant: Comply with ASTM C 920.

1. General: Single-component, acid-curing, silicone, elastomeric.
2. Type: S.
3. Grade: NS.
4. Class: 25.
5. Use: O.

D. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments (such as the wash bay): Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

E. Trapeze and Riser Supports:

1. Supports for Galvanized steel Ducts: Galvanized steel shapes and plates.
2. Supports for Stainless steel Ducts: Stainless steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

PART 3 - EXECUTION

3.01 DUCTWORK - GENERAL

- A. Dimensions of ductwork shown/noted on the Drawings indicate inside clear dimensions and do not account for duct liner. When duct liner is indicated to be provided in accordance with this Section of the Specifications and/or in accordance with Division 23 Section "HVAC Insulation," the size of the duct shall be increased to accommodate the thickness of the duct liner.
- B. Do not install ductwork in transformer vaults, elevator equipment rooms or electrical equipment rooms unless the ductwork serves HVAC equipment located in that room and is dedicated to provide cooling and/or heating to that room. Do not install ductwork adjacent to or above any surface of electrical controls, panels, switches, terminals, boxes or similar electrical equipment. Drip-pan protection shall not be permitted, except where detailed.

3.02 PROTECTION OF DUCT

- A. Immediately after fabrication, the duct shall be cleaned of all dirt, dust and debris. The ends of the duct section shall then be securely covered with plastic and strapping tape. The duct shall then be completely covered with cloth or plastic.
- B. When each duct section transported to the job site, the covering over the ends of each duct shall be maintained to prevent the entrance of dirt, dust and debris. In addition, all ducts shall be covered with plastic or cloth.
- C. Immediately after the duct arrives at the job site and prior to being installed, the covering over the ends of each duct shall be maintained to prevent the entrance of dirt, dust and debris. In addition, all ducts shall be covered with plastic or cloth.
- D. When each duct is installed, the plastic covering shall be removed. Once installed, the duct section shall be inspected for the existence of dirt or dust; if discovered, the duct section shall be cleaned of all dirt and dust. Unless the next section of duct is in the process of being installed, the end of the duct shall be securely covered with plastic and strapping tape.

3.03 DUCT INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of duct system. Indicated duct locations, configurations, and arrangements were used to size ducts and calculate friction loss for air handling equipment sizing and for other design considerations. Install duct systems as indicated unless deviations to layout are approved on Shop Drawings and Coordination Drawings.
- B. Install ducts according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Install round ducts in maximum practical lengths.
- D. Install ducts with fewest possible joints.
- E. Install factory or shop fabricated fittings for changes in direction, size, and shape and for branch connections.
- F. Unless otherwise indicated, install ducts vertically and horizontally, and parallel and perpendicular to building lines.

- G. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- H. Install ducts with a minimum clearance of 1 inch plus allowance for insulation thickness.
- I. Route ducts to avoid passing through transformer vaults and electrical equipment rooms and enclosures.
- J. Where ducts pass through non-fire rated interior partitions and exterior walls and are exposed to view, cover the opening between the partition and duct or duct insulation with sheet metal flanges of same metal thickness as the duct. Overlap openings on four sides by at least 1-1/2 inches.
- K. Where ducts pass through fire rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section 23 3300 "Air Duct Accessories" for fire and smoke dampers.
- L. Protect duct interiors from moisture, construction debris and dust, and other foreign materials.

3.04 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- C. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- D. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- E. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.05 ADDITIONAL INSTALLATION REQUIREMENTS FOR CLOTHES DRYER EXHAUST DUCT

- A. Install clothes dryer exhaust ducts without dips and traps that may hold lint.
- B. Install clothes dryer exhaust ducts in a manner to eliminate any interior projections that may collect lint. Clothes dryer exhaust ducts shall be completely smooth on the interior surface of the duct. Use of sheet metal screws, pop rivets and other similar connecting devices that will create interior projections is strictly prohibited.
- C. Clothes dryer exhaust duct shall be terminated with a vent cap having an integral backdraft damper.

3.06 DUCT SEALING

- A. Seal ducts for duct static pressure, seal classes, and leakage classes specified in "Duct Schedule" Article according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- B. Closure systems used to seal metal ductwork shall be installed in accordance with the manufacturer's installation instructions.

- C. Unlisted duct tape is not permitted as a sealant on any metal ducts.
- D. Duct connections to flanges of air distribution system equipment shall be sealed and mechanically fastened.
 - 1. Mechanical fasteners for use with flexible non-metallic air ducts shall comply with UL 181B and shall be marked "181B-C."

3.07 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Ducts shall be supported directly from the building substrate. Ducts are not permitted to be supported from other ducts, pipes, conduits, or cable tray.
- C. Building Attachments: Structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
- D. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1 (Table 4-1M), "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- E. Hangers Exposed to View: Threaded rod and angle or channel supports.
- F. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum interval of 16 feet.
- G. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.08 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section 23 3300 "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.09 PAINTING

- A. Paint interior of metal ducts that are visible through registers and grilles and that do not have duct liner. Apply one coat of flat, black, latex paint over a compatible galvanized steel primer. Paint materials and application requirements are specified in Division 09 painting Sections.

3.10 DUCT SCHEDULE

- A. Duct Material - fabricate ducts with galvanized sheet steel except as otherwise indicated on the Drawings and as follows:
1. Ducts installed in the Wash Bay: Stainless steel.
 2. Clothes Dryer Exhaust Ducts: Aluminum.
- B. Duct Pressure Class, SMACNA Seal Class, and SMACNA Leakage Class: Fabricate ducts for the following pressure, seal and leakage classes:
1. Supply air Ducts, Constant Air Volume System:
 - a. Pressure Class: Positive 2-inches wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
 2. Supply air Ducts, Variable Air Volume System, Upstream of Terminal Boxes:
 - a. Pressure Class: Positive 3-inches wg.
 - b. Seal Class: B.
 - c. SMACNA Leakage Class for Rectangular: 12.
 - d. SMACNA Leakage Class for Round and Flat Oval: 6.
 3. Supply air Ducts, Variable Air Volume System, Downstream of Terminal Boxes:
 - a. Pressure Class: Positive 2-inches wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
 4. Return air Ductwork:
 - a. Pressure Class: Negative 2-inches wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
 5. General Exhaust Air Ductwork:
 - a. Upstream of Exhaust Fan:
 - 1) Pressure Class: Negative 2-inches wg.
 - 2) Seal Class: C.
 - 3) SMACNA Leakage Class for Rectangular: 24.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 12.
 - b. Downstream of Exhaust Fan:
 - 1) Pressure Class: Positive 2-inches wg.
 - 2) Seal Class: C.
 - 3) SMACNA Leakage Class for Rectangular: 24.
 - 4) SMACNA Leakage Class for Round and Flat Oval: 12.
 6. Outdoor Air Ductwork:
 - a. Pressure Class: Negative 2-inches wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.

- 7. Relief Air Ductwork:
 - a. Pressure Class: Positive 1-inch wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- 8. Transfer Air Ductwork:
 - a. Pressure Class: Positive 1-inch wg.
 - b. Seal Class: C.
 - c. SMACNA Leakage Class for Rectangular: 24.
 - d. SMACNA Leakage Class for Round and Flat Oval: 12.
- C. Intermediate Reinforcement:
 - 1. Galvanized steel Ducts: Match duct material.
 - 2. Stainless steel Ducts: Match duct material.
 - 3. Aluminum Ducts: Match duct material.
- D. Duct Liner Application: Fabricate ducts with duct liner as described below except as otherwise indicated on the Drawings. Refer to Division 23 Section "HVAC Insulation" for additional requirements.
 - 1. Supply air ducts.
 - 2. Return air ducts extending from the unit intake to a location 50-feet upstream of the unit intake:
 - 3. Transfer air ducts.

END OF SECTION 23 3113

SECTION 23 3300 - AIR DUCT 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.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Manual volume dampers.
 - 2. Control dampers.
 - 3. Fire dampers.
 - 4. Flange connectors.
 - 5. Turning vanes.
 - 6. Duct mounted access doors.
 - 7. Flexible connectors.
 - 8. Flexible ducts.
 - 9. Duct accessory hardware.

1.03 SUBMITTALS

- A. Product Data - submit manufacturer's published data for each type of product indicated.
 - 1. Manual volume dampers.
 - 2. Control dampers.
 - 3. Fire dampers.
 - 4. Flange connectors.
 - 5. Turning vanes.
 - 6. Duct mounted access doors.
 - 7. Flexible connectors.
 - 8. Flexible ducts.
 - 9. Duct accessory hardware.
- B. Coordination Drawings: Refer to Division 23 Sections 23 0500 "Common Work Results for HVAC" and Section 23 3113 "Metal Ducts" for coordination drawing requirements. Show all duct accessories on coordination drawings. Also, include access panels and access doors required for access to duct accessories on coordination drawings.
- C. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilating Systems," and with NFPA 90B, "Installation of Warm Air Heating and Air Conditioning Systems."

- B. Comply with AMCA 500-D testing for damper rating.

1.05 EXTRA MATERIALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Fusible Links: Furnish quantity equal to 10 percent of amount installed, but not less than 5.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for acceptable materials, material thicknesses, and duct construction methods unless otherwise indicated. Sheet metal materials shall be free of pitting, seam marks, roller marks, stains, discolorations, and other imperfections.
- B. Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90 (Z275).
 - 2. Exposed-Surface Finish: Mill phosphatized.
- C. Stainless steel Sheets: Comply with ASTM A 480/A 480M, Type 304, and having a No. 2 finish for concealed ducts and finish for exposed ducts.
- D. Aluminum Sheets: Comply with ASTM B 209 (ASTM B 209M), Alloy 3003, Temper H14; with mill finish for concealed ducts and standard, 1-side bright finish for exposed ducts.
- E. Extruded Aluminum: Comply with ASTM B 221 (ASTM B 221M), Alloy 6063, Temper T6.
- F. Reinforcement Shapes and Plates: Galvanized steel reinforcement where installed on galvanized sheet metal ducts; compatible materials for aluminum and stainless steel ducts.
- G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 MANUAL VOLUME DAMPERS

- A. Standard, Steel, Manual Volume Dampers
 - 1. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - a. Air Balance Inc.; a division of Mestek, Inc.
 - b. American Warming and Ventilating; a division of Mestek, Inc.
 - c. Elgen
 - d. Flexmaster U.S.A., Inc.
 - e. McGill AirFlow LLC.
 - f. METALAIRE, Inc.
 - g. Nailor Industries Inc.
 - h. Pottorff; a division of PCI Industries, Inc.
 - i. Ruskin Company.
 - j. Vent Products Company, Inc.

2. Standard leakage rating.
3. Suitable for horizontal or vertical applications.
4. Frames:
 - a. Hat-shaped, galvanized steel channels, 0.064-inch minimum thickness. For stainless steel ducts, provide hat-shaped stainless steel channels, 0.064-inch minimum thickness.
 - b. Mitered and welded corners.
 - c. Flanges for attaching to walls and flangeless frames for installing in ducts.
5. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized steel, 0.064 inch thick. For stainless steel ducts, provide hat-shaped stainless steel channels, 0.064-inch minimum thickness.
6. Blade Axles: Galvanized steel or stainless steel.
7. Bearings:
 - a. Oil impregnated bronze bearings, molded synthetic bearings or stainless steel sleeve.
 - b. Dampers in ducts with pressure classes of 3-inch wg or less shall have axles full length of damper blades and bearings at both ends of operating shaft.
8. Tie Bars and Brackets: Galvanized steel.

2.03 CONTROL DAMPERS

- A. Control dampers shall be furnished by the Automatic Temperature Control Subcontractor. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for requirements.

2.04 FIRE DAMPERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 1. Air Balance Inc.; a division of Mestek, Inc.
 2. Arrow United Industries; a division of Mestek, Inc.
 3. Cesco Products; a division of Mestek, Inc.
 4. Greenheck Fan Corporation.
 5. McGill AirFlow LLC.
 6. METALAIRE, Inc.
 7. Nailor Industries Inc.
 8. NCA Manufacturing, Inc.
 9. Pottorff; a division of PCI Industries, Inc.
 10. Prefco; Perfect Air Control, Inc.
 11. Ruskin Company.
 12. Vent Products Company, Inc.
 13. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. General Requirements:
 1. Labeled according to UL 555 by an NRTL.

- C. Type:
1. Furnish static type fire dampers in systems where the fan is de-energized upon sensing smoke.
 2. Furnish dynamic type fire dampers in systems where the fan is not de-energized upon sensing smoke or where the fan is part of a smoke control system.
 - a. Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.
- D. Fire Rating: 1½-hours.
- E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners. For stainless steel ducts, furnish curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick stainless steel; with mitered and interlocking corners.
- F. Mounting Sleeve: Factory or field installed, galvanized sheet steel.
1. Minimum Thickness: 0.052 or 0.138 inch thick as required for the application, and of length to suit application.
 2. Exception: Omit sleeve where damper frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- G. Mounting Orientation: Vertical or horizontal as indicated on the drawings.
- H. Blades: Roll-formed, interlocking, 0.034-inch thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, galvanized steel blade connectors. For stainless steel ducts, blades shall be roll-formed, interlocking, 0.034-inch thick, stainless sheet steel. In place of interlocking blades, use full-length, 0.034-inch thick, stainless steel blade connectors.
- I. Horizontal Dampers: Include blade lock and stainless steel closure spring.
- J. Heat-Responsive Device: Replaceable, 165°F rated, fusible links.

2.05 FLANGE CONNECTORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Ductmate Industries, Inc.
 2. Nexus PDQ; Division of Shilco Holdings Inc.
 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Description: Roll-formed, factory fabricated, slide-on transverse flange connectors, gaskets, and components.
- C. Material: Galvanized steel.
- D. Gauge and Shape: Match connecting ductwork.

2.06 TURNING VANES

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. METALAIRE, Inc.
 - 4. SEMCO Incorporated.
 - 5. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Manufactured Turning Vanes for Metal Ducts: Curved blades of galvanized sheet steel; support with bars perpendicular to blades set; set into vane runners suitable for duct mounting.
- C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 4-3, "Vanes and Vane Runners," and 4-4, "Vane Support in Elbows."
- D. Vane Construction: Single wall.

2.07 DUCT MOUNTED ACCESS DOORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating; a division of Mestek, Inc.
 - 2. Cesco Products; a division of Mestek, Inc.
 - 3. Ductmate Industries, Inc.
 - 4. Elgen
 - 5. Flexmaster U.S.A., Inc.
 - 6. Greenheck Fan Corporation
 - 7. McGill AirFlow, LLC
 - 8. Nailor Industries Inc.
 - 9. Pottorff; a division of PCI Industries, Inc.
 - 10. Ventfabrics, Inc.
 - 11. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Duct mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 7-2 (7-2M), "Duct Access Doors and Panels," and 7-3, "Access Doors - Round Duct."
 - 1. Door:
 - a. Double wall, rectangular.
 - b. Galvanized sheet metal with insulation fill and thickness as indicated for duct pressure class.
 - c. Vision panel.
 - d. Hinges and Latches: 1-by-1-inch butt or piano hinge and cam latches.
 - e. Fabricate doors airtight and suitable for duct pressure class.
 - 2. Frame: Galvanized sheet steel, with bend-over tabs and foam gaskets.
 - 3. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two sash locks.
 - b. Access Doors up to 18 Inches Square: Two hinges and two sash locks.
 - c. Access Doors up to 24 by 48 Inches: Three hinges and two compression latches with outside and inside handles.
 - d. Access Doors Larger than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.08 DUCT ACCESS PANEL ASSEMBLIES

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Flame Gard, Inc.
 - 3. 3M
- B. Labeled according to UL 1978 by an NRTL.
- C. Panel and Frame: Minimum thickness 0.0528-inch carbon-steel where duct access panel assemblies are installed in carbon-steel ducts. Minimum thickness 0.0428-inch stainless steel where duct access panel assemblies are installed in stainless steel ducts.
- D. Fasteners: Carbon-steel for carbon-steel duct access panel assemblies; stainless steel for stainless steel duct access panel assemblies. Panel fasteners shall not penetrate duct wall.
- E. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000°F.
- F. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.09 FLEXIBLE CONNECTORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Duro Dyne Inc.
 - 3. Ventfabrics, Inc.
 - 4. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Materials: Flame-retardant or noncombustible fabrics.
- C. Coatings and Adhesives: Comply with UL 181, Class 1.
- D. Metal-Edged Connectors: Factory fabricated with a fabric strip having a minimum width of 5-3/4 inches attached to two strips of 2-3/4-inch wide, 0.028-inch thick, galvanized sheet steel or 0.032-inch-thick aluminum sheets. Provide metal compatible with connected ducts.
- E. Indoor System, Flexible Connector Fabric: Glass fabric double coated with neoprene.
 - 1. Minimum Weight: 26 oz./sq. yd.
 - 2. Tensile Strength: 480 lbf/inch in the warp and 360 lbf/inch in the filling.
 - 3. Service Temperature: Minus 40° to plus 200°F.
- F. High Corrosive Environment System (such as the Wash Bay), Flexible Connectors: Glass fabric with chemical-resistant coating.
 - 1. Minimum Weight: 14 oz./sq. yd.
 - 2. Tensile Strength: 450 lbf/inch in the warp and 340 lbf/inch in the filling.
 - 3. Service Temperature: Minus 67° to plus 500°F.

2.10 FLEXIBLE DUCTS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Flexmaster U.S.A., Inc.
 - 2. McGill AirFlow LLC.
 - 3. Ward Industries, Inc.; a division of Hart & Cooley, Inc.
- B. Insulated, Flexible Duct: UL 181, Class 1, 2-ply vinyl film supported by helically wound, spring-steel wire; fibrous-glass insulation; polyethylene vapor-barrier film.
 - 1. Pressure Rating: 10-inch wg positive and 1.0-inch wg negative.
 - 2. Maximum Air Velocity: 4000 fpm.
 - 3. Temperature Range: Minus 10° to plus 160°F.
 - 4. Insulation R-value: Insulation R-value shall be a minimum of 6.0. In addition, comply with ASHRAE/IESNA 90.1.
- C. Flexible Duct Connectors
 - 1. Clamps: Nylon strap in sizes 3 through 18 inches to suit duct size.

2.11 DUCT ACCESSORY HARDWARE

- A. Instrument Test Holes: Cast iron or cast aluminum to suit duct material, including screw cap and gasket. Size to allow insertion of pitot tube and other testing instruments and of length to suit duct insulation thickness.
- B. Adhesives: High strength, quick setting, neoprene based, waterproof, and resistant to gasoline and grease.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install duct accessories according to applicable details in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for metal ducts and in NAIMA AH116, "Fibrous Glass Duct Construction Standards," for fibrous-glass ducts.
- B. Install duct accessories of materials suited to duct materials; use galvanized steel accessories in galvanized steel and fibrous glass ducts, stainless steel accessories in stainless steel ducts, and aluminum accessories in aluminum ducts.
- C. Install control dampers at inlet of exhaust fans or exhaust ducts as close as possible to exhaust fan unless otherwise indicated.
- D. Install volume dampers at points on supply, return, and exhaust systems where branches extend from larger ducts. Install volume dampers a minimum of 5-feet from the diffuser, register or grille in which it is controlling airflow. Where dampers are installed in ducts having duct liner, install dampers with hat channels of same depth as liner, and terminate liner with nosing at hat channel.
 - 1. Volume damper shall be constructed of the same material as the duct in which it is to be installed.
- E. Install turning vanes in all mitered rectangular duct elbows with an angle greater than 45°.

- F. Set dampers to fully open position before testing, adjusting, and balancing.
- G. Install test holes at fan inlets and outlets and elsewhere as indicated.
- H. Install **fire dampers and smoke dampers** according to UL listing.
- I. Install duct access doors on sides of ducts to allow for inspecting, adjusting, and maintaining accessories and equipment at the following locations:
 - 1. On both sides of duct coils.
 - 2. Upstream and downstream from duct filters.
 - 3. At outdoor-air intakes and mixed-air plenums.
 - 4. At drain pans.
 - 5. Downstream from **control** dampers, and equipment.
 - 6. Adjacent to and close enough to fire or smoke dampers, to reset or reinstall fusible links. Access doors for access to fire or smoke dampers having fusible links shall be pressure relief access doors and shall be outward operation for access doors installed upstream from dampers and inward operation for access doors installed downstream from dampers.
 - 7. At each change in direction and at maximum 50-foot spacing.
 - 8. Upstream from turning vanes.
 - 9. Upstream or downstream from duct silencers.
 - 10. Control devices requiring inspection.
- J. Install access doors with swing against duct static pressure.
- K. Access Door Sizes: Access doors shall be sized as large as possible and practical, but shall not be less than 12 x 6 inches and shall not be greater than 25 x 25 inches.
- L. Label access doors according to Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- M. Install flexible connectors to connect ducts to equipment.
 - 1. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- N. Connect inlet of fan powered terminal boxes and VAV terminal boxes to supply ducts with maximum 12-inch length of flexible duct. Do not use flexible ducts to change directions.
- O. Connect each diffuser to duct directly or with maximum 96-inch length of flexible duct clamped or strapped in place. The flexible duct shall be permitted to have a total maximum change of direction not exceeding 90-degrees.
- P. Connect flexible ducts to metal ducts with nylon draw bands.
- Q. Install duct test holes where required for testing and balancing purposes.

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.

END OF SECTION 23 3300

SECTION 23 3423 - HVAC POWER VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Ceiling-mounted ventilators.
 - 2. In-line centrifugal fans.
 - 3. Propeller fans.

1.03 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on actual Project site elevations.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Also include plans, elevations, sections, details, and attachments to other work. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. In addition, include the following:
 - 1. Certified fan performance curves with system operating conditions indicated.
 - 2. Certified fan sound-power ratings.
 - 3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
 - 4. Material thickness and finishes, including color charts.
 - 5. Dampers, including housings, linkages, and operators.
 - 6. Roof curbs.
 - 7. Fan speed controllers.
 - 8. Wiring Diagrams: For power, signal, and control wiring.
- B. Field quality control reports.
- C. Operation and Maintenance Data: For each power ventilator, include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. AMCA Compliance: Fans shall have AMCA Certified performance ratings and shall bear the AMCA Certified Ratings Seal.
- C. UL Standards: Power ventilators shall comply with UL 705. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.06 COORDINATION

- A. Coordinate size and location of structural steel support members.

PART 2 - PRODUCTS

2.01 CEILING MOUNTED VENTILATORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. PennBarry
 - 4. Twin City Fan & Blower
- B. Housing: Steel, lined with acoustical insulation.
- C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.
- D. Motors:
 - 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated in the schedule on the Drawings. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Provide electronically commutated (EC) motors where indicated or scheduled.
 - 1) All EC motors shall be suitable for variable speed control via 0-10vdc, or 4-20mA control signal.
 - 2) EC motors intended for constant volume applications shall be equipped with a manually adjusted speed control positioning device.
 - c. Controllers: Refer to the schedule on the Drawings and to other Division 23 Sections for requirements for enclosed controllers and variable frequency controllers.
 - d. Electrical Devices and Wiring: Comply with requirements for electrical devices and connections specified in Division 26.
 - 2. Enclosure Type: Open drip-proof (ODP) or totally enclosed, fan cooled (TEFC).

- E. Grille: Plastic or Stainless steel or Aluminum or Painted aluminum louvered grille with flange on intake and thumbscrew attachment to fan housing.
- F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in.
- G. Isolation: Blower and motor shall be mounted on rubber isolators that isolate them from the fan housing.
- H. Accessories:
 - 1. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
- I. Controls: Refer to Division 23 Sections 23 0900 "Automatic Temperature Control for HVAC" and 23 0993 "Sequence of Operation for HVAC Controls" for requirements.
- J. Capacities and Characteristics: Refer to the schedule on the drawings.

2.02 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. PennBarry
 - 4. Twin City Fan & Blower
- B. Housing: Square, minimum 18-gauge galvanized steel or aluminum, bolted construction with integral inlet and outlet duct collars. Bolted access doors shall be located on three sides sealed with closed cell neoprene gasketing. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation.
- C. Direct-Drive Units: Motor mounted in airstream; factory wired to disconnect switch located on outside of fan housing. Units shall contain a fan wheel, inlet cone, and motor.
- D. Belt-Driven Units: Motor mounted on adjustable or pivoting base/plate for positive belt tensioning, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing. Belts shall be oil and heat resistant, static conducting.
- E. Fan Wheels: Aluminum, with backward inclined or airfoil blades welded to or machined cast into an aluminum hub. Fan wheel shall be statically and dynamically balanced.
- F. Motors
 - 1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated in the schedule on the Drawings. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Provide electronically commutated (EC) motors where indicated or scheduled.
 - 1) All EC motors shall be suitable for variable speed control via 0-10vdc, or 4-20mA control signal.
 - 2) EC motors intended for constant volume applications shall be equipped with a manually adjusted speed control positioning device.
 - c. Controllers: Refer to the schedule on the Drawings and to other Division 23 Sections for requirements for enclosed controllers and variable frequency controllers.

- d. Electrical Devices and Wiring: Comply with requirements for electrical devices and connections specified in Division 26.
- 2. Enclosure Type: Open drip-proof (ODP) or totally enclosed, fan cooled (TEFC).
- G. Bearings: Bearings shall be designed and individually tested specifically for use in air handling applications. Bearings shall be heavy duty construction and shall be the regreasable ball type in a pillow-block cast iron housing selected for a minimum L50 life in excess of 200,000 hours at maximum cataloged operating speed.
- H. Isolation: Blower and motor shall be mounted on rubber isolators that isolate them from the fan housing.
- I. Accessories:
 - 1. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 - 2. Fan Guards: Guard shall be ½-inch by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
- J. Controls: Refer to Division 23 Sections 23 0900 "Automatic Temperature Control for HVAC" and 23 0993 "Sequence of Operation for HVAC Controls" for requirements.
- K. Capacities and Characteristics: Refer to the schedule on the drawings.

2.03 PROPELLER FANS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Greenheck Fan Corporation
 - 2. Loren Cook Company
 - 3. PennBarry
 - 4. Twin City Fan & Blower
- B. Housing: Galvanized steel sheet with flanged edges and integral orifice ring with baked-enamel finish coat applied after assembly.
- C. Fan Wheels
 - 1. Replaceable, cast or extruded-aluminum, airfoil blades fastened to cast-aluminum hub; factory set pitch angle of blades.
- D. Fan Drive
 - 1. Resiliently mounted to housing.
 - 2. Statically and dynamically balanced.
 - 3. Selected for continuous operation at maximum rated fan speed and motor horsepower, with final alignment and belt adjustment made after installation.
 - 4. Extend grease fitting to accessible location outside of unit.
 - 5. Service Factor Based on Fan Motor Size: 1.4.
 - 6. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 - 7. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 - a. Ball-Bearing Rating Life: ABMA 9, L₁₀ of 100,000 hours.
 - 8. Direct Drive
 - 9. Belt Guards: Fabricate of steel for motors mounted on outside of fan cabinet.

E. Motors

1. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - a. Motor Sizes: Minimum size as indicated in the schedule on the Drawings. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - b. Provide electronically commutated (EC) motors where indicated or scheduled.
 - 1) All EC motors shall be suitable for variable speed control via 0-10vdc, or 4-20mA control signal.
 - 2) EC motors intended for constant volume applications shall be equipped with a manually adjusted speed control positioning device.
 - c. Controllers: Refer to the schedule on the Drawings and to other Division 23 Sections for requirements for enclosed controllers and variable frequency controllers.
 - d. Electrical Devices and Wiring: Comply with requirements for electrical devices and connections specified in Division 26.
2. Enclosure Type: Open drip-proof (ODP) or totally enclosed, fan cooled (TEFC).

F. Accessories:

1. Gravity Shutters: Aluminum blades in aluminum frame; interlocked blades with nylon bearings.
2. Motor Side Back Guard: Galvanized steel, complying with OSHA specifications, removable for maintenance.
3. Wall Sleeve: Galvanized steel to match fan and accessory size.
4. Weather shield Hood: Galvanized steel to match fan and accessory size.
5. Disconnect Switch: Non-fusible type, with thermal overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

G. Controls: Refer to Division 23 Sections 23 0900 "Automatic Temperature Control for HVAC" and 23 0993 "Sequence of Operation for HVAC Controls" for requirements.

H. Capacities and Characteristics: Refer to the schedule on the drawings.

2.04 SOURCE QUALITY CONTROL

- A. Certify sound power level ratings according to AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
- B. Certify fan performance ratings, including flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests according to AMCA 210, "Laboratory Methods of Testing Fans for Aerodynamic Performance Rating." Label fans with the AMCA-Certified Ratings Seal.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Ceiling Units: Suspend units from structure; use steel wire or metal straps.

- C. Support suspended units from structure using threaded steel rods and spring hangers having a static deflection of 1 inch. Vibration control devices are specified in Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."
- D. Install units with clearances for service and maintenance.
- E. Label units according to requirements specified in Division 23 Section 23 0553 "Identification for HVAC Piping and Equipment."

3.02 CONNECTIONS

- A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section 23 3300 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Ground equipment according to Division 26 Sections.
- D. Connect wiring according to Division 26 Sections.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. 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 cleaning and adjusting are complete.
 4. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation. Reconnect fan drive system, align and adjust belts, and install belt guards.
 5. Adjust belt tension.
 6. Adjust damper linkages for proper damper operation.
 7. Verify lubrication for bearings and other moving parts.
 8. Verify that manual and automatic volume control and fire and smoke dampers in connected ductwork systems are in fully open position.
 9. Disable automatic temperature control operators, energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
 10. Shut unit down and reconnect automatic temperature control operators.
 11. Remove and replace malfunctioning units and retest as specified above.
- C. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Prepare test and inspection reports.

3.04 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Comply with requirements in Division 23 Section 23 0593 "Testing, Adjusting, and Balancing for HVAC" for testing, adjusting, and balancing procedures.
- D. Replace fan and motor pulleys as required to achieve design airflow.
- E. Lubricate bearings.

3.05 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain power ventilators. Refer to Division 01 for additional requirements.

END OF SECTION 23 3423

SECTION 23 3600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section Includes
 - 1. Shutoff, single duct air terminal units.

1.03 SUBMITTALS

- A. Product Data: For air terminal units, including rated capacities, furnished specialties, sound-power ratings, and accessories. Also, include plans, elevations, sections, details, and attachments to other work. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. In addition, include the following:
 - 1. Wiring Diagrams: For power, signal, and control wiring.
 - 2. Liners and adhesives. Include product data.
 - 3. Sealants and gaskets. Include product data.
 - 4. Hangers and supports. Include methods for duct and building attachment, and vibration isolation.
- B. Field quality control reports.
- C. Operation and Maintenance Data: For air terminal units, include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. NFPA Compliance: Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."

1.05 COORDINATION

- A. Coordinate layout and installation of air terminal units and suspension system with other construction including light fixtures, electrical conduit and equipment, HVAC piping and equipment, plumbing piping and equipment, fire suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.01 SHUTOFF, SINGLE DUCT AIR TERMINAL UNITS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Anemostat Products; a Mestek Company
 - 2. Environmental Technologies, Inc.
 - 3. Krueger
 - 4. Nailor Industries Inc.
 - 5. Price Industries
 - 6. Titus
 - 7. Trane; a business of American Standard Companies
- B. Configuration: Volume damper assembly inside unit casing with control components inside a protective metal shroud.
- C. Casing: 0.034-inch steel or 0.032-inch aluminum, single wall.
 - 1. Casing Lining:
 - a. Polyurethane Foam Insulation: Adhesive attached, 1-inch thick, polyurethane foam insulation complying with UL 181 erosion requirements, and having a maximum flame-spread index of 25 and a maximum smoke-developed index of 50, for both insulation and adhesive, when tested according to ASTM E 84.
 - 2. Air Inlet: Round stub connection or S-slip and drive connections for duct attachment.
 - 3. Air Inlet Sensor: The air inlet sensor shall be the pitot tube type that measures both total inlet pressure and static inlet pressure. The inlet air sensor shall be the center averaging type and shall have multiple ports on the upstream side and multiple ports on the downstream side of the measurement chamber.
 - 4. Air Outlet: S-slip and drive connections.
 - 5. Access: Removable panels for access to parts requiring service, adjustment, or maintenance; with airtight gasket.
- D. Volume Damper: Galvanized steel with peripheral gasket and self-lubricating bearings.
 - 1. Maximum Damper Leakage: ARI 880 rated, 2 percent of nominal airflow at 3-inch wg inlet static pressure.
 - 2. Damper Position: Normally closed.
- E. Reheat Coil
 - 1. Electric Resistance Coil: Nickel-chromium heating wire, free of expansion noise and hum, mounted in ceramic inserts in a galvanized steel housing; with primary automatic, and secondary manual, reset thermal cutouts. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware. The coil shall be provided with the following features:
 - a. Access door interlocked disconnect switch.
 - b. Nickel chrome 80/20 heating elements.
 - c. Airflow switch for proof of airflow.
 - d. Fan interlock contacts.

- e. For coils exceeding rated power input of 48-amperes, provide fuses in terminal box for overcurrent protection.
 - f. Silicone controlled rectifier (SCR) controls. The electric heater must be capable of accepting a 0 to 10-volt DC signal and a 24-volt AC floating control signal.
- F. Electrical: The unit shall incorporate a single point control connection. All electrical components shall be enclosed in a single control box with access panel mounted on the side of the assembly. All controls shall be sealed from primary air flow. Units shall be ETL listed.
- G. DDC Controls
 - 1. Single package unitary controller and actuator specified in Division 23 Section 23 0900 "Automatic Temperature Control for HVAC." Also, refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control requirements.
 - a. DDC controls shall be furnished and field-installed by the ATC Subcontractor.
 - 2. Control Sequence: Refer to Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls" for operating control sequence requirements.
- H. Capacities and Characteristics: Refer to the schedule on the Drawings.

2.02 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Air Terminal Unit Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- C. Trapeze and Riser Supports: Steel shapes and plates for units with steel casings; aluminum for units with aluminum casings.

2.03 SOURCE QUALITY CONTROL

- A. Identification: Label each air terminal unit with plan number, nominal airflow, maximum and minimum factory set airflows, coil type, and ARI certification seal.
- B. Verification of Performance: Rate air terminal units according to ARI 880.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install air terminal units according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- B. Install air terminal units' level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.02 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
- C. Hangers Exposed to View: Threaded rod and angle or channel supports.
- D. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.03 CONNECTIONS

- A. Connect ducts to fan powered air terminal units according to Division 23 Section 23 3113 "Metal Ducts."
- B. Comply with safety requirements in UL 1995.
- C. Ground equipment according to Division 26.
- D. Connect wiring according to Division 26.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Inspect, test, and adjust field assembled components and equipment installation, including connections. Report results in writing.
- B. Tests and Inspections:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Remove and replace malfunctioning units and retest as specified above.

3.05 STARTUP SERVICE

- A. The HVAC Contractor shall perform the following startup service.
 - 1. Complete installation and startup check according to manufacturer's written instructions and do the following:
 - a. Verify that shipping restraints and packaging are removed.
 - b. Verify that inlet duct connections are as recommended by fan powered air terminal unit manufacturer to achieve proper performance.
 - c. Verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
 - d. Verify that controls and control enclosure are accessible.
 - e. Verify that control connections are complete.
 - f. Verify that nameplate and identification tag are visible.

- g. Energize motor and adjust fan to indicated rpm, and measure and record motor voltage and amperage.
- h. Verify that controls respond correctly according to the sequences described in Division 23 Section 23 0993 "Sequence of Operation for HVAC Controls."

3.06 DEMONSTRATION

- A. Engage a factory authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain fan powered air terminal units **and** shut-off, single duct air terminal units. Refer to Division 01.

END OF SECTION 23 3600

SECTION 23 3713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes ceiling and wall mounted diffusers, registers, and grilles.

1.03 SUBMITTALS

- A. Product data for each type of product indicated, include the following:
 - 1. Data Sheet: Indicate materials of construction, finish, and mounting details; and performance data including throw and drop, static pressure drop, and noise ratings.
 - 2. Diffuser, Register, and Grille Schedule: Indicate drawing designation, room location, quantity, model number, size, and accessories furnished.
 - 3. Color Chart: For diffusers, registers, and grilles with factory applied color finishes for color and finish selection by Architect.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, performance, and dimensional requirements of diffusers, registers and grilles, and are based on the specific equipment indicated. Refer to Division 01 for additional requirements.

PART 2 - PRODUCTS

2.01 DIFFUSER OUTLETS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Anemostat; a Mestek Company
 - 2. Krueger
 - 3. Price Industries
 - 4. Titus
 - 5. Nailor

B. Square Plaque Diffuser

1. Material: Steel.
2. Finish: Baked enamel, in a custom color selected by the Architect.
3. Face Size: 24 by 24 inches.
4. Face Style: Plaque.
5. Mounting: Surface or T-bar. Coordinate with Drawings.
6. Pattern: One-way, Two-way, Three-way or Four-way, core style as indicated on the Drawings.
7. Dampers: None.
8. Accessories:
 - a. Square to round neck adaptor, where required.
 - b. Equalizing grid.

2.02 REGISTERS

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

1. Anemostat; a Mestek Company.
2. Krueger.
3. Price Industries.
4. Titus.

B. Fixed Blade Louvered Return/Exhaust Register

1. Material: Steel.
2. Finish: Except for the following areas, all registers shall have a baked enamel finish in a custom color selected by the Architect.
 - a. Registers shall be brushed stainless steel in the Locker/Shower area.
 - b. Registers attached to exposed ductwork shall have a primed finish compatible for field painting.
3. Duct Connection: Refer to the Drawings.
4. Face Blade Arrangement: Fixed horizontal spaced 3/4 inch apart.
5. Frame: 1-1/4 inches wide.
6. Mounting: Countersunk screw or lay in. Coordinate with plans.
7. Damper Type: Opposed blade.
8. Accessories: None.

C. Adjustable Blade, Double Deflection Supply Register

1. Material: Steel.
2. Finish: Except for the following areas, all registers shall have a baked enamel finish in a custom color selected by the Architect.
 - a. Registers shall be brushed stainless steel in the Locker/Shower area.
 - b. Registers attached to exposed ductwork shall have a primed finish compatible for field painting.
3. Face Blade Arrangement: Adjustable horizontal spaced 3/4 inch apart.
4. Rear Blade Arrangement: Adjustable vertical spaced 3/4 inch apart.
5. Frame: Nominal 1 inch wide.
6. Mounting: Countersunk screw or lay in as required for the ceiling/wall installation.
7. Damper Type: Opposed blade.
8. Accessories: None.

2.03 GRILLES

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Anemostat; a Mestek Company
 - 2. Krueger
 - 3. Price Industries
 - 4. Titus
- B. Fixed Blade Louvered Return/Exhaust Grille:
 - 1. Material: Steel.
 - 2. Finish: Except for the following areas, all grilles shall have a baked enamel finish in a custom color selected by the Architect.
 - a. Grilles shall be brushed stainless steel in the Locker/Shower area.
 - b. Grilles attached to exposed ductwork shall have a primed finish compatible for field painting.
 - 3. Duct Connection: Refer to the Drawings.
 - 4. Face Blade Arrangement: Fixed horizontal spaced 3/4 inch apart.
 - 5. Frame: 1-1/4 inches wide.
 - 6. Mounting: Countersunk screw or lay in. Coordinate with plans.
 - 7. Damper Type: None.
 - 8. Accessories: None.
- C. Adjustable Blade, Double Deflection Supply Grille
 - 1. Material: Steel.
 - 2. Finish: Except for the following areas, all grilles shall have a baked enamel finish in a custom color selected by the Architect.
 - a. Grilles shall be brushed stainless steel in the Locker/Shower area.
 - b. Grilles attached to exposed ductwork shall have a primed finish compatible for field painting.
 - 3. Face Blade Arrangement: Adjustable horizontal spaced 3/4 inch apart.
 - 4. Rear Blade Arrangement: Adjustable vertical spaced 3/4 inch apart.
 - 5. Frame: Nominal 1 inch wide.
 - 6. Mounting: Countersunk screw or lay in as required for the ceiling/wall installation.
 - 7. Damper Type: None.
 - 8. Accessories: None.

2.04 SOURCE QUALITY CONTROL

- A. Verification of Performance: Rate diffusers, registers, and grilles according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."

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.
- 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, registers, and grilles with airtight connections to ducts and to allow service and maintenance of dampers, air extractors, and fire dampers.

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 23 3713

SECTION 23 3723 - HVAC GRAVITY VENTILATORS

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. Hooded ventilators.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product
- B. Shop Drawings: For gravity ventilators.
 - 1. Include plans, elevations, sections, details, ventilator attachments to curbs, and curb attachments to roof structure.
 - 2. Show weep paths, gaskets, flashing, sealant, and other means of preventing water intrusion.

1.4 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Roof-framing plans and other details, drawn to scale, and coordinated with each other, based on input from installers of the items involved:

1.5 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Ventilators shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated without permanent deformation of ventilator components, noise or metal fatigue caused by ventilator blade rattle or flutter, or permanent damage to fasteners and anchors. Wind pressures shall be considered to act normal to the face of the building.
 - 1. Basic Wind Speed: 110 MPH

2. Minimum 10 lb/sq. ft. multiplied by the maximum area of the mechanical component projected on a vertical plane that is normal to the wind direction, and 45 degrees either side of normal.
 3. Wind Loads, Basis: Determine loads based on a uniform pressure of 10 lbf/sq. ft., acting inward or outward.
 4. Snow Load: Unit to withstand a minimum of 20-lbf/sq. ft. snow load.
- B. Thermal Movements: Allow for thermal movements from ambient and surface temperature changes, without buckling, opening of joints, overstressing of components, failure of connections, or other detrimental effects.
1. Temperature Change (Range):
 - a. Ambient: 120°F.
 - b. Material Surfaces: 180°F.
- C. Water Entrainment: Limit water penetration through unit to comply with ASHRAE 62.1.
- D. Capacities and Characteristics: Refer to schedules provided on drawings.

2.2 FABRICATION

- A. Factory or shop fabricate gravity ventilators to minimize field splicing and assembly. Disassemble units to the minimum extent as necessary for shipping and handling. Clearly mark units for reassembly and coordinated installation.
- B. Fabricate frames, including integral bases, to fit in openings of sizes indicated, with allowances made for fabrication and installation tolerances, adjoining material tolerances, and perimeter sealant joints.
- C. Fabricate units with closely fitted joints and exposed connections accurately located and secured.
- D. Fabricate supports, anchorages, and accessories required for complete assembly.
- E. Perform shop welding by AWS-certified procedures and personnel.

2.3 HOODED VENTILATORS

- A. Description: Hooded round or rectangular penthouse for intake and relief air as indicated or scheduled.
- B. Manufacturers - subject to compliance with requirements, provide products by one of the following:
1. Greenheck Fan Corporation.
 2. Loren Cook Company.
 3. PennBarry; division of Air System Components.
 4. Twin City Fan & Blower.
- C. Source Limitations: Obtain hooded ventilators from single manufacturer.
- D. Construction:
1. Material, Galvanized Steel: Thickness required to comply with structural performance requirements, but not less than 0.064-inch-thick base and 0.040-inch-thick hood; suitably reinforced.
 2. Material, Aluminum: Thickness required to comply with structural performance requirements, but not less than 0.063-inch-thick base and 0.050-inch-thick hood; suitably reinforced.
 3. Insulation: None.
 4. Bird Screening: Galvanized-steel, 1/2-inch-square mesh wire or Aluminum, 1/2-inch-square mesh or flattened, expanded aluminum, 3/4-inch diamond mesh wire.

- E. Galvanized-Steel Finish:
 - 1. Surface Preparation: Clean surfaces of dirt, grease, and other contaminants. Clean welds, mechanical connections, and abraded areas, and repair galvanizing according to ASTM A780/A780M. Apply a conversion coating suited to the organic coating to be applied over it.
 - 2. Baked-Enamel Finish: Immediately after cleaning and pretreating, apply manufacturer's standard finish consisting of prime coat and thermosetting topcoat, with a minimum dry film thickness of 1 mil for topcoat and an overall minimum dry film thickness of 2 mils.
 - a. Color and Gloss: As selected by Architect from manufacturer's full range.
- F. Dampers:
 - 1. Location: Curb damper tray.
 - 2. Control: Motorized.
 - 3. Tray: Provide damper tray or shelf with opening 3 inches of size indicated.
- G. Roof Curbs: Galvanized-steel sheet; with mitered and welded corners; 1-1/2-inch-thick, rigid fiberglass insulation adhered to inside walls; and 1-1/2-inch wood nailer. Size as required to fit roof opening and ventilator base.
 - 1. Configuration: Self-flashing without a cant strip, with mounting flange.
 - 2. Overall Height: 14 inches.

2.4 SOURCE QUALITY CONTROL

- A. AMCA Certification for Hooded Ventilators: Test, rate, and label gravity ventilators in accordance with AMCA 511.

2.5 MATERIALS

- A. Aluminum Extrusions: ASTM B221, Alloy 6063-T5 or T-52.
- B. Aluminum Sheet: ASTM B209, Alloy 3003 or 5005, with temper as required for forming or as otherwise recommended by metal producer for required finish.
- C. Galvanized-Steel Sheet: ASTM A653/A653M, G90 zinc coating, mill phosphatized.
- D. Fasteners: Same basic metal and alloy as fastened metal or 300 Series stainless steel unless otherwise indicated. Do not use metals that are incompatible with joined materials.
 - 1. Use types and sizes to suit unit installation conditions.
 - 2. Use hex-head or Phillips's pan-head screws for exposed fasteners unless otherwise indicated.
- E. Post-Installed Fasteners for Concrete and Masonry: Torque-controlled expansion anchors made from stainless-steel components, with capability to sustain without failure a load equal to 4 times the loads imposed for concrete, or 6 times the load imposed for masonry, as determined by testing according to ASTM E488/E488M, conducted by a qualified independent testing agency.
- F. Bituminous Paint: Cold-applied asphalt emulsion complying with ASTM D1187/D1187M.

PART 3 - EXECUTION

3.1 INSTALLATION - GENERAL

- A. Install gravity ventilators level, plumb, and at indicated alignment with adjacent work.
- B. Secure gravity ventilators to roof curbs with zinc-plated hardware, that comply with the wind fastening requirements. Use concealed anchorages where possible. Refer to Section 07 7200 "Roof Accessories."
- C. Install gravity ventilators with clearances for service and maintenance.
- D. Label gravity ventilators according to requirements specified in Section 23 0553 "Identification for HVAC Piping and Equipment."
- E. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- F. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes, so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- G. Refer to Section 07 7200 "Roof Accessories" for flashing and counterflashing of roof curbs.

3.2 DUCT CONNECTIONS

- A. Duct installation and connection requirements are specified in Section 23 3113 "Metal Ducts" Drawings indicate general arrangement of ducts and duct accessories.

3.3 ADJUSTING

- A. Adjust damper linkages for proper damper operation.

END OF SECTION 23 3723

SECTION 23 3733 - LOUVERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Extruded Aluminum Stationary Wall Louvers.

1.03 DEFINITIONS

- A. Louver Terminology: Definitions of terms for metal louvers contained in AMCA 501 apply to this Section, unless otherwise defined in this Section or in referenced standards.
- B. Standard Free Area: Free area of a louver 48-inches wide by 48-inches high, identical to that provided.
- C. Maximum Standard Airflow: Airflow at point of beginning water penetration through a louver 48-inches wide by 48-inches high, identical to that provided.
- D. Drainable-Blade Louver: Louver designed to collect and drain water to exterior at sill by means of gutters in front edges of blades and channels in jambs and mullions.

1.04 PERFORMANCE REQUIREMENTS

- A. Structural Performance: Provide exterior metal louvers capable of withstanding the effects of loads and stresses from wind and normal thermal movement without evidencing permanent deformation of louver components including blades, frames, and supports; noise or metal fatigue caused by louver blade rattle or flutter; or permanent damage to fasteners and anchors.
- B. Air Performance, Water-Penetration, and Air Leakage Ratings: Provide louvers complying with performance requirements indicated, as demonstrated by testing manufacturer's stock units 48-inches wide by 48-inches high. Test units according to AMCA 500.

1.05 SUBMITTALS

- A. Product Data: For each type of product specified; include plans; elevations; sections; and details showing profiles, angles, and spacing of louver blades. Show unit dimensions related to wall openings and construction; free area for each size indicated; profiles of frames at jambs, heads, and sills; and anchorage details and locations.

1.06 QUALITY ASSURANCE

- A. Source Limitations: Obtain louvers and vents through one source from a single manufacturer where alike in one or more respects regarding type, design, or factory applied color finish.
- B. SMACNA Standard: Comply with SMACNA's "Architectural Sheet Metal Manual" recommendations for fabrication, construction details, and installation procedures.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. American Warming and Ventilating, Inc.
 - 2. Arrow United Industries.
 - 3. Greenheck Fan Corporation.
 - 4. Ruskin Manufacturing; Tomkins Industries, Inc.

2.02 EXTRUDED ALUMINUM STATIONARY WALL LOUVERS

- A. Fabrication: Hidden Support Style
 - 1. Basis Of Design: ELF6375X as manufactured by Ruskin Company.
 - 2. Frame:
 - a. Frame Depth: 6 inches.
 - b. Material: Extruded aluminum, Alloy 6063-T5.
 - c. Wall Thickness: 0.081-inch nominal.
 - 3. Blades:
 - a. Style: Horizontal "J".
 - b. Material: Formed aluminum, Alloy 6063-T5.
 - c. Wall Thickness: 0.081-inch nominal.
 - d. Angle: 37-1/2 degrees.
 - e. Centers: 5-29/32 inches nominal.
 - 4. Gutters: Drain gutter in head frame.
 - 5. Downspouts: Downspouts in jambs to drain head.
 - 6. Sill: Steeply angled integral sill eliminating areas of standing or trapped moisture where mold or mildew may thrive and effect indoor air quality.
 - 7. Fabrication:
 - 8. Mullion/Hidden Intermediate Support Style - Design incorporates visible mullions or frames at the perimeter of the louver and at section joints only. Rear-mounted hidden blade supports are utilized where required and do not interrupt the louver blade sightlines. The rear-mounted blade support depth varies depending on louver height and the design wind load.
 - 9. Assembly:
 - a. Factory assembled louver components. Welded construction.

B. Performance Data

1. Performance Ratings: AMCA licensed.
 - a. Based on testing 48 inch by 48-inch size unit in accordance with AMCA 500.
2. Free Area: 55 percent, nominal.
3. Maximum Recommended Air Flow through Free Area: 1010 feet per minute.
4. Maximum Pressure Drop (Intake): .175 inches w.g.
5. Water Penetration: Maximum of 0.01 ounces per square foot of free area at an air flow of 1010 feet per minute free area velocity when tested for 15 minutes.

C. Accessories

1. Bird Screen:
 - a. Aluminum: Aluminum, 1/2-inch mesh by 0.063-inch, inter-crimp.
 - b. Frame: Removable, rewirable.

D. Finishes

1. Baked Enamel.
2. Color: Custom selected by Architect.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates and openings, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Coordinate Setting Drawings, diagrams, templates, instructions, and directions for installation of anchorages that are to be embedded in concrete or masonry construction. Coordinate delivery of such items to Project site.

3.03 INSTALLATION

- A. Arrange for openings in building structure per Section 23 0500 COMMON WORK RESULTS FOR HVAC, Article "Coordination".
- B. Locate and place louver units' level, plumb, and at indicated alignment with adjacent work.
- C. Use concealed anchorages where possible. Provide brass or lead washers fitted to screws where required to protect metal surfaces and to make a weathertight connection.
- D. Form closely fitted joints with exposed connections accurately located and secured.
- E. Provide perimeter reveals and openings of uniform width for sealants and joint fillers, as indicated.

- F. Repair finishes damaged by cutting, welding, soldering, and grinding. Restore finishes so no evidence remains of corrective work. Return items that cannot be refinished in the field to the factory, make required alterations, and refinish entire unit or provide new units.
- G. Protect galvanized and nonferrous-metal surfaces from corrosion or galvanic action by applying a heavy coating of bituminous paint on surfaces that will be in contact with concrete, masonry, or dissimilar metals.
- H. Install concealed gaskets, flashings, joint fillers, and insulation, as louver installation progresses, where weathertight louver joints are required. Comply with Division 7 Section "Joint Sealants" for sealants applied during louver installation.

3.04 ADJUSTING, CLEANING, AND PROTECTING

- A. Periodically clean exposed surfaces of louvers that are not protected by temporary covering to remove fingerprints and soil during construction period. Do not let soil accumulate until final cleaning.
- B. Before final inspection, clean exposed surfaces with water and a mild soap or detergent not harmful to finishes. Thoroughly rinse surfaces and dry.
- C. Protect louvers from damage during construction. Use temporary protective coverings where needed and approved by louver manufacturer. Remove protective covering at the time of Substantial Completion.
- D. Restore louvers damaged during installation and construction so no evidence remains of corrective work. If results of restoration are unsuccessful, as determined by Architect, remove damaged units and replace with new units.
 - 1. Clean and touch up minor abrasions in finishes with air-dried coating that matches color and gloss of, and is compatible with, factory applied finish coating.

END OF SECTION 23 3733

SECTION 23 4100 - PARTICULATE AIR FILTRATION

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. Section Includes:
 - 1. Pleated panel filters.

1.03 DEFINITIONS

- A. HIPS: High-impact polystyrene.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of product. Include dimensions; operating characteristics; required clearances and access; rated flow capacity, including initial and final pressure drop at rated airflow; efficiency and test method; fire classification; furnished specialties; and accessories for each model indicated.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of filter to include in emergency, operation, and maintenance manuals.

1.06 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. Provide one complete set(s) of filters for each filter bank. If system includes prefilters, provide only prefilters.

1.07 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Deliver and store products in a clean, dry place.

- B. Comply with manufacturer's written rigging and installation instructions for unloading and moving to final installed location.
- C. Handle products carefully to prevent damage, breaking, denting, and scoring. Do not install damaged products.
- D. Protect products from weather, dirt, dust, water, construction debris, and physical damage.
 - 1. Retain factory-applied coverings on equipment to protect finishes during construction and remove just prior to operating unit.
 - 2. Cover unit openings before installation to prevent dirt and dust from entering inside of units. If required to remove coverings during unit installation, reapply coverings over openings after unit installation and remove just prior to operating unit.
 - 3. Replace installed products damaged during construction.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. ASHRAE Compliance:
 - 1. Comply with applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality"; Section 5 - "Systems and Equipment"; and Section 7 - "Construction and Startup."
 - 2. Comply with ASHRAE 52.2 for MERV for methods of testing and rating air-filter units.
- B. Comply with NFPA 90A and NFPA 90B.
- C. Comply with UL 900.
- 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.

2.02 PLEATED PANEL FILTERS

- A. Description: Factory-fabricated, self-supported, extended-surface, pleated, panel-type, disposable air filters with holding frames.
 - 1. Manufacturers: Subject to compliance with requirements, including but to the following:
 - a. AAF International
 - b. Airguard
 - c. Camfil Farr
 - d. Purafil, Inc.
- B. Source Limitations: Obtain from single source from single manufacturer.
- C. Filter Unit Class: UL 900, Class 1.
- D. Media: Cotton and synthetic fibers coated with nonflammable adhesive.
 - 1. Adhesive shall have a VOC content of 80 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
 - 2. Media shall be coated with an antimicrobial agent.
 - 3. Separators shall be bonded to the media to maintain pleat configuration.

4. Welded wire grid shall be on downstream side to maintain pleat.
 5. Media shall be bonded to frame to prevent air bypass.
 6. Support members on upstream and downstream sides to maintain pleat spacing.
- E. Filter-Media Frame: Cardboard frame with perforated metal retainer sealed or bonded to the media.
- F. Mounting Frames: Welded galvanized steel, with gaskets and fasteners; suitable for bolting together into built-up filter banks.
- G. Capacities and Characteristics:
1. Thickness or Depth: As scheduled below in Part 3 - Execution.
 2. MERV Rating: As scheduled below in Part 3 - Execution when tested according to ASHRAE 52.2.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine ducts, air-handling units, and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF FILTERS

- A. Position each filter unit with clearance for normal service and maintenance. Anchor filter holding frames to substrate.
- B. Install filters in position to prevent passage of unfiltered air.
- C. Install filter gauge for each filter bank.
- 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.
- E. Coordinate filter installations with duct and air-handling-unit installations.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. Test for leakage of unfiltered air while system is operating.
- C. Air filter will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

3.04 CLEANING

- A. After completing system installation and testing, adjusting, and balancing of air-handling and air-distribution systems, clean filter housings and install new filter media.

3.01 FILTER SCHEDULE

- A. Provide 2" thick pleated panel MERV 8 pre-filters in all air handling units.
- B. Provide 2" thick MERV 13 pleated panel final-filters in all air handling units.

END OF SECTION 23 4100

SECTION 23 5123 - GAS VENTS

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. Section Includes:
 - 1. Listed double-wall vents.

1.03 ACTION SUBMITTALS

- A. Product Data - for each type of product.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.
- B. Shop Drawings - for vents.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of hangers and seismic restraints.

1.04 INFORMATIONAL SUBMITTALS

- A. Sample Warranty: For special warranty.

1.05 QUALITY ASSURANCE

- A. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.
- B. All products furnished under this Section shall conform to the requirements of The National Fuel Gas Code, ANSI Z223.1 to the Canadian Standard ULC-S636, as a Class IIA, IIB and IIC, Type BH vent system. Components coming in direct contact with products of combustion shall carry the appropriate ULC listing.

PART 2 - PRODUCTS

2.01 LISTED SPECIAL GAS VENTS

- 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. Jeremias
 - 2. Van-Packer
 - 3. Metalfab
 - 4. Heatfab
- B. Description: Double-wall metal vents tested according to UL 1738 and rated for 480°F continuously, with positive or negative flue pressure complying with NFPA 211.
- C. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.
- D. Inner Shell: ASTM A959, Type 29-4C stainless steel.
- E. Outer Jacket: Aluminized steel.
- F. Accessories: Tees, elbows, increasers, draft-hood connectors, terminations, adjustable roof flashings, storm collars, support assemblies, thimbles, firestop spacers, and fasteners; fabricated from similar materials and designs as vent-pipe straight sections; all listed for same assembly.
 - 1. Termination: Round chimney top designed to exclude minimum 98 percent of rainfall.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATION

- A. Listed Special Gas Vent: Condensing gas appliances.

3.03 VENT SYSTEM LAYOUT

- A. The vent system shall be routed to maintain minimum clearance to combustibles as specified by the manufacturer.
- B. Vent installation shall conform to the manufacturer's installation instructions, its ULC listing and local codes.
- C. The vent system and breechings shall be inspected and cleaned before the final connection to the appliances.

3.04 INSTALLATION OF LISTED VENTS

- A. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Section 07 7200 "Roof Accessories."
- B. Comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.
- C. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer.
- D. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.
- E. Lap joints in direction of flow.

3.05 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 23 5123

SECTION 23 5523.13 - LOW INTENSITY, GAS FIRED, RADIANT HEATERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Forced-draft heaters.
 - 2. Burner Controls.
 - 3. Vacuum Pump
 - 4. Infrared Piping
 - 5. Reflectors
 - 6. System controls.

1.02 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings:
 - 1. Include plans, elevations, sections, and mounting attachment details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of high-intensity, gas-fired, radiant heaters, as well as procedures and diagrams.
 - 4. Include diagrams for power signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, elevations, and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Structural members to which equipment will be attached.
 - 2. Gas piping to heater installations
 - 3. Thermostats and wiring to heaters.
 - 4. Heater locations and clearance requirements.
 - 5. Other suspended ceiling components including the following:
 - a. Lighting fixtures.
 - b. Exhaust fans, ducts, air outlets and inlets.
 - c. Sprinklers.
- B. Field quality-control reports.
- C. Sample Warranty: For manufacturer's special warranties.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For gas-fired, radiant heaters to include in emergency, operation, and maintenance manuals.

1.05 WARRANTY

- A. Manufacturer's Special Warranty: Manufacturer agrees to repair or replace components of radiant heaters that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: All warranty periods listed below are from date of Substantial Completion.
 - a. Burner Assembly: Five years.
 - b. Heater Controls: One 1 year.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. CSA certified, with CSA Seal and certification number clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- B. UL listed and labeled, with UL label clearly visible on units indicating compliance with ANSI Z83.20/CSA 2.34.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

2.02 FORCED DRAFT BURNERS

- 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. Roberts-Gordon
 - 2. Detroit Radiant, HLV Series
- B. Description: Factory-assembled, [**indoor**] [**outdoor**], overhead-mounted, electrically controlled, low-intensity, infrared radiant heating units using gas combustion. Heater to have all necessary factory-installed wiring and piping required prior to field installation and startup.
- C. Fuel Type: Design burner for natural gas having characteristics same as those of gas available at Project site.
- D. Burner Assembly:
 - 1. Natural Gas burner assemblies consisting of heavy-duty cast-iron burner heads. Pre-wired gas controls with direct spark ignition module, and combustion air filters. Provide minimum numbers of burners indicated to insure proper radiant heat distribution. Fewer burners of larger capacity will not be accepted. Burners shall be designed for firing in tandem without adverse effects from combustion gases from upstream burners.
 - 2. Design firing rate of burners shall be 80,000 and 100,000 Btu's per hour as stated on drawings. Clearances to a combustible surface as measured from the tube surface shall not exceed 4" above, 60" below, 30" on each side.
 - 3. Premix Gas and Air: Provide burners to totally pre-mix air and gas required for combustion.

4. Constant Air/Gas Ratio: Provide burners designed to maintain constant proportion of fuel gas to filtered combustion air. Induce fuel gas and air at atmospheric pressure, and establish flow of both by means of negative pressure on the downstream side of the flow metering orifices. Design so that if combustion air flow is impeded for any reason, gas flow rate will decrease in constant proportion to maintain proper gas/air mixture for complete combustion.

E. Burner Controls:

1. Factory Wired: All burners shall be factory wired for 115 VAC with transformer for 24 VAC DSI operation and supplied with a grounded 24-30 inch (61–76 cm) three wire pigtail located at rear of burner
2. Fail-Safe Controls: To assure a high degree of fail-safe operation, the design shall preclude main flow of gas if any or all of the following abnormal conditions occur:
 - a. Power fails (Gas valves in burners close in safe position).
 - b. Main Valve fails in open position
 - c. Vacuum pump motor fails (Vacuum proving switch cuts power to burners).
3. Ignition Controls: All gas vacuum-firing burner units shall be equipped with a Direct Spark Ignition Module (DSI).
 - a. The DSI module shall have a 15-second flame safety time per ignition trial before lockout occurs.
 - b. The DSI module shall be capable of a minimum of 3 trials for ignition to provide maximum reliability.

F. Vacuum Pump 3/4 HP Option:

1. Outdoor Venting: The system shall vent all products of combustion outdoors by means of the vacuum pump.
2. Motor: Vacuum pump shall be equipped with a 3/4 horsepower, 60 hertz, 208-230/460 volts AC, 3450 RPM, three phase motor. This motor shall have thermal overload protection, high temperature sealed ball bearings, and shall be constructed in accordance with electric motor industry standards.
3. Housing: The scroll of this pump shall be cast iron with a minimum metal thickness of approximately 3/16 inch. The impeller wheel shall be pressure cast 319-alloy aluminum with a minimum metal thickness of approximately 3/32 inch.
4. Pressure Switch: Provide a low voltage (24 VAC) interlock circuit from the pressure switch (located at the inlet to the vacuum pump) to the controller to prove pump operation.

G. Reflectors - High Efficiency

1. Provide high radiant reflective (aluminum) reflectors installed over all heat exchanger tube.
2. Provide wide parabolic design reflector with 12 reflective surfaces and additional ribbing formed into reflector sides for added rigidity. Reflector shall be capable of producing an Infrared Factor (IF) as high as 15 when rated in accordance to AHRI standard 1330 for Radiant Output of Gas Fired Infrared Heaters.
3. Reflector shall reflect 100% of the infrared energy that it receives from the heat exchanger tube directly to the floor. In order to maximize radiant output and reduce convective heat losses, reflectors are to extend below the bottom of the heat exchanger tube. Provide continuous reflector over all tube and fitting heat exchanger surfaces.
4. Provide reflector end caps as necessary to reduce convective heat losses.
5. Fittings: Provide reflectors at all heat exchanger pipe terminations and each elbow with end caps to prevent convective heat from escaping.
6. Side Reflectors: Provide aluminum perimeter side extension reflectors in certain areas of layout where indicated or required. Side reflectors shall permanently attach to side of reflector and be secured to the pipe with side-reflector supports and two "Z" clips for each 8' (2.44 m) section of side reflector. Tilting of reflectors is not acceptable.
7. Reflectors shall be installed over the entire radiant pipe and tail pipe network as indicated on drawings.

H. Controls

1. Provide manufacturer's Modulating Heating Control: Modulating Heating Control shall provide for modulation of the low-intensity radiant heating burner system firing rate based on differential air temperature. The system shall provide 100% input when more than 5 degrees below setpoint temperature. With milder outside temperatures, the system shall modulate input continuously (not staged) between 60% and 100% input. The Modulating Heating Control shall provide the following features:
 - a. Variable Frequency Drive/Modulation: System shall modulate by adjusting the vacuum pressure via variable frequency drive based on speed referenced from controller, not motorized damper control. VFD shall be provided by the radiant-heating equipment manufacturer as an integral component of their capacity modulation controls.
 - b. Touchscreen Wifi capable modulating thermostat. The thermostat shall generate 0-10 volt speed signal to the Vacuum pump VFD. The motor speed of the Vacuum pump will modulate the burner firing rate without any additional burner wiring or mechanisms.
2. For each heated zone, provide the following automatic shutdown and set back control functions:
 - a. Status display indicating the following:
 - 1) Current Sensed Zone Temperatures
 - 2) Setpoint Temperatures
 - 3) Setback Setpoint Temperature
 - 4) Current Setpoint Adjustment Value
 - 5) Heat Power ON/OFF Indication (for each individual zone)
 - 6) Pump Power ON/OFF Indication
 - b. Provide manual timed override of heating from setback to occupied condition on each zone sensor. Timed-period shall be customizable for each zone at the sensor or touchscreen controls.
 - c. Manual setpoint temperature lower and upper offset adjustment shall be provided on each zone sensor. Adjustment range shall be specified via touchscreen controls.
3. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control devices that may be required.
4. Refer to Division 23 Section 23 0993 "Sequence of Operations for HVAC Controls" for operating sequences and other additional controls that may be required.

I. Infrared Piping - Radiant Piping - Heat Exchanger

1. Radiant Tube: Shall be new 4 in. O.D. Hot-Rolled steel tube X 16-gauge wall with an emissivity factor of 0.80 or greater.
2. Tail Pipe Tube: Shall be new 4 in. O.D. Porcelain Coated steel tube X 16-gauge wall with an emissivity factor of 0.80 or greater.
3. Fittings: Shall be 4 in O.D. Aluminized or Porcelain Coated steel X 16-gauge wall.
4. Hanging Materials: All system tubes must be supported in accordance with Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment". Pipe shall pitch down at least $\frac{1}{2}$ " in 20' on radiant lines and 1" in 20' on tailpipe lines toward the vacuum pump.
5. End Vent Assembly: Provide each open-end combustion chamber with an approved end-vent. Provide each reflector with an end-cap termination. Install according to manufacturer's installation operation and service manual and as shown on plans.
6. Condensate Neutralization Tube: Provide and install condensate neutralization tube as per the manufacture instructions in the installation operation and service manual.
7. Vent Terminals. Provide manufacturer's recommended vent terminals

- J. Combustion-Air Inlet:
 - 1. PVC ducted horizontal to outdoors through sidewall with vent caps.
- K. Accessories:
 - 1. Protective grilles mounted to reflectors to protect emitter tubing.
 - 2. Stainless steel flexible connector with manual valve for gas supply.
 - 3. Hanger chain with "S" hooks.
 - 4. 3/16-inch- diameter, galvanized-steel wire tubing hangers and reflector supports.
 - 5. Rigid mounting kits.
 - 6. Clearance warning plaque.
- L. Capacities and Characteristics: Refer to schedules provided on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine structures, substrates, areas and conditions, with Installer present, for compliance with requirements for installation tolerances, required clearances, and other conditions affecting performance of the Work.
- B. Examine roughing-in for fuel-gas piping to verify actual locations of piping connections before equipment installation.
- C. Prepare written report, endorsed by Installer, listing conditions detrimental to performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install gas fired infrared heaters as indicated, in accordance with manufacturer's installation operation and service manual and in compliance with applicable codes and approvals. Allow adequate space for servicing or removal of the unit without disturbing other piping or equipment.
- B. Equipment Installation: Install gas-fired, radiant heaters and associated gas features and systems according to NFPA 54.
- C. Clearances to Combustibles: Maintain clearance to combustibles outlined and printed on burner nameplate and in manufacturer's product data. Measure clearance distance from surface of heat exchanger or as indicated by approval agency's listing.
- D. Venting: Install vent piping as indicated on plans. Terminate where indicated on the drawings with a vent terminal assembly supplied by the manufacturer. The venting must be installed in accordance with the requirements within the installation operation and service manual and the following codes: United States: Refer to National Fuel Gas Code NFPA 54/ANSI Z223.1 - latest revision. Canada: Refer to Natural Gas and Propane Installation Code CSA B149.1 - latest revision.
- E. Suspended Units: Mount to substrate in accord with the manufacturer's installation instructions.
 - 1. Comply with requirements for hangers and supports specified in Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment."
- F. Maintain manufacturers' recommended clearances for combustibles.

3.03 CONNECTIONS

- A. Gas Piping: Furnished and installed by plumbing contractor in accord with Section 22 1616 "Facility Natural Gas Piping".
- B. Where installing piping adjacent to gas-fired, radiant heaters, allow space for service and maintenance.
- C. Vent Connections: Comply with Section 23 3113 "Metal Ducts" and with Section 23 5123 "Gas Vents."
- D. Electrical Connections: Comply with applicable requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
 - 1. Install electrical devices furnished with heaters but not specified to be factory mounted.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 2. Verify bearing lubrication.
 - 3. Verify proper motor rotation.
 - 4. 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. Gas-fired, radiant heaters will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.05 ADJUSTING

- A. Adjust initial-temperature set points.
- B. Adjust burner and other unit components for optimum heating performance and efficiency.

3.06 DEMONSTRATION

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

END OF SECTION 23 5523.13

SECTION 23 6200 - PACKAGED COMPRESSOR AND CONDENSER UNITS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Compressor and condenser units, air cooled, 6 to 120 tons.

1.02 ACTION SUBMITTALS

- A. Product Data: For each compressor and condenser unit.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
 - 2. Include equipment dimensions, weights and structural loads, required clearances, method of field assembly, components, and location and size of each field connection.
- B. Shop Drawings: For compressor and condenser units.
 - 1. Include plans, elevations, sections, and attachment details.
 - 2. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Startup service reports.
- C. Warranty: For special warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For compressor and condenser units to include in emergency, operation, and maintenance manuals.

1.05 COORDINATION

- A. Coordinate sizes and locations of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Sections 03 3000 "Cast-In-Place Concrete" and 23 0500 Common Work Results For HVAC."
- B. Coordinate location of piping and electrical rough-ins.

1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of compressor and condenser units that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Compressor failure.
 - b. Condenser coil leak.
 - 2. Warranty Period:
 - a. For Compressor: Five years from date of Substantial Completion.
 - b. For Parts: Five years from date of Substantial Completion.
 - c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

2.02 COMPRESSOR AND CONDENSER UNITS, AIR COOLED, 6 TO 120 TONS

- 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. Daikin
 - 2. Aeon
 - 3. JCI York
 - 4. Trane
- B. Description: Factory assembled and tested, air cooled; consisting of casing, compressors, condenser coils, condenser fans and motors, and unit controls.
- C. Compressor:
 - 1. Dual Scroll: Hermetic scroll compressors designed for tandem service with crankcase sight glass, crankcase heater, and back-seating service access valves on suction and discharge ports.
 - a. Capacity Control: 2-stage on-off compressor cycling with automatic pressure regulating (APR) valve on lead compressor for Rawal APR control.
 - 1) Provide suction line sensing bulbs, internal pressure regulation and desuperheating chamber to mix discharge and liquid refrigerant before introducing it into the suction line.
- D. Refrigerant: R-32.
- E. Condenser Coil: Seamless copper-tube, aluminum-fin coil, including subcooling circuit and back-seating liquid-line service access valve.
 - 1. Factory pressure test coils, then dehydrate by drawing a vacuum and fill with a holding charge of nitrogen or refrigerant.
 - 2. Provide factory-applied baked epoxy anti-corrosion coating to assembled coil.

- F. Condenser Fans - propeller-type vertical discharge; either directly or belt driven.
1. Include the following:
 - a. Permanently lubricated, ball-bearing motors.
 - b. Separate motor for each fan.
 - c. Dynamically and statically balanced fan assemblies.
- G. Operating and safety controls include the following:
1. Manual-reset, high-pressure cutout switches.
 2. Automatic-reset, low-pressure cutout switches.
 3. Low-oil-pressure cutout switch.
 4. Compressor-winding thermostat cutout switch.
 5. Three-leg, compressor-overload protection.
 6. Control transformer.
 7. Magnetic contactors for compressor and condenser fan motors.
 8. Timer to prevent excessive compressor cycling.
- H. Accessories:
1. APR Valve.
 2. Non-fused disconnect switch, factory mounted and wired, for single external electrical power connection. See Section 26 2816 "Enclosed Switches and Circuit Breakers."
 3. Low-noise fans.
 4. Vibration isolation spring mounts.
- I. Unit Casings: Designed for outdoor installation with weather protection for components and controls and with removable panels for required access to compressors, controls, condenser fans, motors, and drives. Additional features include the following:
1. Steel, galvanized or zinc coated, for exposed casing surfaces; treated and finished with manufacturer's standard paint coating.
 2. Perimeter base rail with forklift slots and lifting holes to facilitate rigging.
- J. Controls
1. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control devices that may be required.
 2. Refer to Division 23 Section 23 0993 "Sequence of Operations for HVAC Controls" for operating sequences and other additional controls that may be required.
- K. Capacities and Characteristics: Refer to schedule on drawings.

2.03 MOTORS

- A. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 23 0513 Common Motor Requirements for HVAC Equipment."
1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.

2.04 SOURCE QUALITY CONTROL

- A. Performance Ratings: Certify capacity performance ratings of compressor and condenser units in accordance with AHRI 210/240.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of compressor and condenser units.
- B. Examine roughing-in for refrigerant piping systems to verify actual locations of piping connections before equipment installation.
- C. Examine walls, floors, and roofs for suitable conditions where compressor and condenser units will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install units level and plumb, firmly anchored in locations indicated.
- B. Equipment Mounting:
 - 1. Install compressor and condenser units on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 3000 "Cast-In-Place Concrete."
 - 2. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."
- C. Maintain manufacturer's recommended clearances for service and maintenance.
- D. Loose Components: Install piping specialties, electrical components, devices, and accessories that are not factory mounted.

3.03 PIPING CONNECTIONS

- A. Comply with requirements for piping in Section 23 2113 "Hydronic Piping". Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to equipment, allow space for service and maintenance.
- C. Connect refrigerant piping to air-cooled compressor and condenser units; maintain required access to unit. Install furnished field-mounted accessories. Refrigerant piping and specialties are specified in Section 23 2300 "Refrigerant Piping."

3.04 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.

- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to 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 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC.

3.06 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - a. Inspect for physical damage to unit casing.
 - b. Verify that access doors move freely and are weathertight.
 - c. Clean units and inspect for construction debris.
 - d. Verify that all bolts and screws are tight.
 - e. Adjust vibration isolation and flexible connections.
 - f. Verify that controls are connected and operational.
- B. Start unit in accordance with manufacturer's written instructions and complete manufacturer's startup checklist.
- C. Measure and record airflow and air temperature rise over coils.
- D. Verify operation of condenser capacity control device.
- E. Verify that vibration isolation and flexible connections prevent vibration transmission to structure.

3.07 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Perform each visual and mechanical inspection and electrical test. Certify compliance with test parameters.
 - 2. Leak Test: After installation, charge system with refrigerant and oil and test for leaks. Repair leaks, replace lost refrigerant and oil, and retest until no leaks exist.
 - 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor operation and unit operation, product capability, and compliance with requirements.
 - 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 5. Verify manufacturer's required airflow over coils.
- C. Verify that vibration isolation and flexible connections prevent vibration transmission to structure.

D. Compressor and condenser units will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.08 DEMONSTRATION

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

END OF SECTION 23 6200

SECTION 23 7313.16 - INDOOR SEMI-CUSTOM AIR HANDLING UNITS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Indoor, semi-custom air-handling units.

1.02 ACTION SUBMITTALS

- A. Product Data - for each air handling unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - 6. Include certified coil-performance ratings with system operating conditions indicated.
 - 7. Include filters with performance characteristics.
 - 8. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each type and configuration of indoor, semi-custom air handling unit.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of indoor, semi-custom air-handling units, as well as procedures and diagrams.
 - 4. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Source quality-control reports.
- C. Startup service reports.
- D. Field quality-control reports.
- E. Sample Warranty: For manufacturer's warranty.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air-handling units to include in emergency, operation, and maintenance manuals.

1.05 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. Filters: One set(s) for each air-handling unit.

1.06 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of indoor, semi-custom air-handling units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 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. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of air-handling units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."
- E. Casing Leakage Performance: ASHRAE 111, Class A. The casing leakage rate shall not exceed 0.50 cfm per square foot of casing surface area at design static pressure up to a maximum of +5" w.c. in positive pressure sections and -6" w.c. in negative pressure sections.

2.02 CAPACITIES AND CHARACTERISTICS

- A. Refer to schedule provided on drawings.

2.03 INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- 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. Daikin

2. Carrier
3. Trane
4. JCI
5. Dunham Bush
6. Aeon

B. Unit Casings:

1. Frame: Modular and providing overall structural integrity without reliance on casing panels for structural support.
2. Base Rail:
 - a. Material: Galvanized steel.
 - b. Height: 6 inches.
3. Casing Joints: Hermetically sealed at each corner and around entire perimeter.
4. Double-Wall Construction:
 - a. Outside Casing Wall:
 - 1) Material, Galvanized Steel: Minimum 18 gauge thick.
 - b. Inside Casing Wall:
 - 1) Material, Galvanized Steel: Solid, minimum 18 gauge thick.
 - 2) Antimicrobial Coating: Applied during the manufacturing process.
5. Floor Plate:
 - a. Material, Galvanized Steel: minimum 18 gauge thick.
 - b. Antimicrobial Coating: Applied during the manufacturing process.
6. Casing Insulation:
 - a. Materials: Injected polyurethane foam insulation.
 - b. Casing Panel R-Value: Minimum R-13.
 - c. Insulation Thickness: 2 inches.
 - d. Thermal Break: Provide continuity of insulation with no through-casing metal in casing walls, floors, or roofs of air-handling unit.
7. Airstream Surfaces: Surfaces in contact with airstream are to comply with requirements in ASHRAE 62.1.
8. Static-Pressure Classifications:
 - a. For Unit Sections Upstream of Fans: Minus 2-inch wg.
 - b. For Unit Sections Downstream and Including Fans: 4-inch wg.
9. Panels, Doors, and Windows:
 - a. Panels:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.
 - 2) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement is to allow panels to be opened against airflow
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
 - b. Doors:
 - 1) Fabrication: Formed and reinforced, double-wall and insulated panels of same materials and thicknesses as casing.

- 2) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever latches, operable from inside and outside. Arrange doors to be opened against airflow. Provide safety latch retainers on doors so that doors do not open uncontrollably.
 - 3) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 4) Size: Large enough to allow for unobstructed access for inspection and maintenance of air-handling unit's internal components. At least 14 inches wide by full height of unit casing up to a maximum height of 60 inches.
 - c. Locations and Applications:
 - 1) Fan Section: Doors.
 - 2) Coil Section: Panels.
 - 3) Access Sections: Doors.
 - 4) Mixing Section: Doors.
- 10. Condensate Drain Pans:
 - a. Construction:
 - 1) Single-wall, stainless steel sheet with 2" thick closed cell or polyurethane foam insulation underneath.
 - b. Drain Connection:
 - 1) Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on one end of pan.
 - 2) Minimum Connection Size: 1-1/4" NPS.
 - 3) Drain connection centerline shall be a minimum of 3" above the base rail to aid in proper condensate trapping.
 - c. Slope: Minimum 0.125-in./ft. slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and from humidifiers and to direct water toward drain connection.
 - d. Length: Extend drain pan downstream from leaving face.
 - e. Width: Entire width of water producing device.
 - f. Depth: A minimum of 2 inches deep.
- C. Fan, Drive, and Motor Section:
 - 1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
 - 2. Fans: Centrifugal, galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.
 - 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings:
 - 1) Pre-lubricated and Sealed, Ball Bearings: Self-aligning, with an L-50 rated life of 200,000 hours in accordance with ABMA 9.
 - c. Housings, Plenum Fans: Steel frame and panel; fabricated without fan scroll and volute housing. Provide inlet screens for Type SWSI fans.
 - d. Plenum Fan Arrays: Uncontained as defined in AHRI 430. Steel or aluminum frame with inlet cone and structural framing around each fan built into an array of multiple fans. Provide backdraft dampers at each fan to prevent short circuiting of flow if one fan is not operating.
 - e. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard restrained vibration isolation mounting devices having a minimum static deflection of 1 inch.

3. Drive, Direct: Factory-mounted, direct drive.
4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Section 230500 "Common Work Results for HVAC."
 - b. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: Open, drip proof or totally enclosed, fan cooled.
 - d. Enclosure Materials: Cast iron.
 - e. Motor Bearings: Permanently lubricated ball bearings.
 - f. Efficiency: Premium Efficient motors as defined in NEMA MG 1.
 - g. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - h. Motors shall be electrically commutated or equipped with variable frequency drives.
 - i. Mount unit-mounted disconnect switches on exterior of unit.
5. Comply with Section 23 0513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT
6. Comply with Section 23 0512 VARIABLE-FREQUENCY MOTOR CONTROLLERS FOR HVAC EQUIPMENT.

D. Coil Section:

1. General Requirements for Coil Section:
 - a. Comply with AHRI 410.
 - b. Fabricate coil section to allow removal and replacement of coil for maintenance and to allow in-place access for service and maintenance of coil(s).
 - c. For multizone units, provide air deflectors and air baffles to balance airflow across coils.
 - d. Coils are not to act as structural component of unit.
2. Cooling Coils:
 - a. Refrigerant Coil:
 - 1) Tubes: Copper.
 - 2) Fins:
 - a) Material: Aluminum.
 - b) Fin Spacing: Maximum 12 fins per inch.
 - 3) Fin and Tube Joints: Mechanical bond.
 - 4) Headers: Seamless-copper headers with brazed connections.
 - 5) Frames: Galvanized steel.
 - 6) Coatings: None.
 - 7) Ratings: Designed, tested, and rated in accordance with ASHRAE 33 and AHRI 410.
 - a) Working Pressure: Minimum 300 psig.

E. Air Filtration Section:

1. Particulate air filtration is specified in Section 23 4100 "Particulate Air Filtration."

F. Dampers:

1. Outdoor- and Return-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel, aluminum, or extruded-aluminum dampers with compressible jamb seals and extruded-vinyl blade edge seals in opposed-blade arrangement with steel operating rods rotating in stainless steel sleeve bearings mounted in a single galvanized-steel, aluminum, or extruded-aluminum frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg, leakage Class 1, tested, rated, and labeled in accordance with AMCA 511.

2. Damper Operators: Comply with requirements in Section 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC.
3. Combination Filter and Mixing Section:
 - a. Cabinet support members are to hold 2-inch- thick, pleated, flat, permanent or throwaway filters with side access door.

G. Gas Heating Section:

1. The air handling unit shall include a natural gas heating section. The gas furnace shall be natural gas fired heating module(s) factory installed downstream of the supply air fan in the heat section. The heating module shall be a tubular design with in-shot gas burners.
2. The heating module shall be separated combustion with dedicated combustion air inlet, flue gas outlet and have an induced draft fan that will maintain a negative pressure in the heat exchanger tubes for the removal of the flue gases.
3. Gas-fired duct furnaces provided shall have a tubular heat exchanger constructed of Type 409 Stainless Steel .044 Min. Wall thickness produced to ASTM A268)
4. The Duct Furnace models shall be listed by Intertek Testing Services (ITS / ETL) for operation on Natural gas to the current edition of ANSI Z83.8 Standard for Gas-Fired Duct Furnaces. Duct furnaces are for installation on the positive pressure side of the circulating air blower, only.
5. Gas module shall have 10:1 modulating control operated through a 0-10 vdc signal from the BAS specified in Sections 230900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC and 23 0993 SEQUENCE OF OPERATIONS FOR HVAC CONTROL.
6. Each burner module shall have two flame roll-out safety protection switches and a high temperature limit switch that will shut the gas valve off upon detection of improper burner manifold operation. The induced draft fan shall have an airflow safety switch that will prevent the heating module from turning on in the event of no airflow in the flue chamber.
7. Field installed heating modules shall require a field ETL certification. The manufacturer's rooftop unit ETL certification shall cover the complete unit including the gas heating modules.
8. Individual Duct Furnaces shall incorporate a Direct Spark Ignition control module that is design certified by a recognized national testing agency. The control shall provide:
 - a. 100% safety shut-off
 - b. A 15 second minimum pre-purge period prior to trial for ignition
 - c. High energy direct spark ignition of main burners
 - d. Electronic flame supervision incorporating a 0.8 second flame failure response time
 - e. Up to 2 additional ignition retries preceded by an inter purge period
 - f. A minimum 30 second post-purge
 - g. Automatic reset after one hour to initiate additional ignition trials if lockout occurs during heat call
 - h. An LED indicator light to provide a flash code to identify the operating condition of the control

2.04 MATERIALS

- A. Steel:
 1. ASTM A36/A36M for carbon structural steel.
 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 1. Manufacturer's standard grade for casing.
 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

- D. Aluminum: ASTM B 09.

2.05 SOURCE QUALITY CONTROL

- A. AHRI 430 Certification: Test, rate, and label air-handling units and their components in accordance with AHRI 430.
- B. AHRI 260 or AMCA 311 Sound Performance Rating Certification: Test, rate, and label in accordance with AHRI 260 or AMCA 311.
- C. Fan Energy Index (FEI): Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- D. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.
- E. Refrigerant Coils: Factory tested to minimum 450-psig internal pressure and to minimum 300-psig internal pressure while underwater, in accordance with AHRI 410 and ASHRAE 33.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine 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.
- C. Examine roughing-in for steam, hydronic, and condensate drainage piping systems and electrical services to verify actual locations of connections before installation.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION OF INDOOR, SEMI-CUSTOM AIR-HANDLING UNITS

- A. Equipment Mounting:
 - 1. Install air-handling units on cast-in-place concrete equipment bases. Coordinate sizes and locations of concrete bases with actual equipment provided. Comply with requirements for equipment bases and foundations specified in Sections 03 3000 "Cast-in-Place Concrete and 23 0500 COMMON WORK RESULTS FOR HVAC.
 - 2. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
- B. Arrange installation of units to provide access space around air-handling units for service and maintenance.
- C. 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.

- D. Install filter-gauge, static-pressure taps upstream and downstream of filters. Mount filter gauges on outside of filter housing or filter plenum in accessible position. Provide filter gauges on filter banks, installed with separate static-pressure taps upstream and downstream of filters.
- E. Connect duct to air-handling units with flexible connections. Comply with requirements in Section 23 3300 "Air Duct Accessories."

3.03 PIPING CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where installing piping adjacent to air-handling unit, allow for service and maintenance.
- C. Connect piping to air-handling units mounted on vibration isolators with flexible connectors.
- D. Connect condensate drain pans using NPS 1-1/4, ASTM B88, Type M copper tubing. Extend to nearest equipment or floor drain. Construct deep trap at connection to drain pan and install cleanouts at changes in direction.
- E. Refrigerant Piping: Comply with applicable requirements in Section 23 2300 "Refrigerant Piping." Install shutoff valve and union or flange at each supply and return connection.
- F. Gas Piping: Furnished and installed by plumbing contractor in accord with Section 22 1616 Facility Natural Gas Piping.

3.04 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 - 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."

3.05 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC.

3.06 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions.
 - 2. 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 zone dampers fully open and close for each zone.
 - 7. Verify that face-and-bypass dampers provide full face flow.
 - 8. Verify that outdoor- and return-air mixing dampers open and close, and maintain minimum outdoor-air setting.
 - 9. Comb coil fins for parallel orientation.
 - 10. Verify that proper thermal-overload protection is installed for electric coils.
 - 11. Install new, clean filters.
 - 12. Verify that manual and automatic volume control and fire and smoke dampers in connected duct systems are in fully open position.
- B. Starting procedures for air-handling 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.

3.07 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Comply with requirements in Section 23 0593 TESTING, ADJUSTING, AND BALANCING FOR HVAC for air-handling system testing, adjusting, and balancing.
- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.08 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling 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.

3.09 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Charge refrigerant coils with refrigerant and test for leaks.

2. Fan Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Air-handling unit or components will be considered defective if unit or components do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.10 DEMONSTRATION

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

END OF SECTION 23 7313.16

SECTION 23 7339 - INDOOR DIRECT FIRED HEATING AND VENTILATING UNITS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Indoor, direct-fired heating and ventilating units.

1.02 ACTION SUBMITTALS

- A. Product Data: For each indoor, direct, gas-fired heating and ventilating unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
 - 3. Include unit dimensions and weight.
 - 4. Include cabinet material, metal thickness, finishes, insulation, and accessories.
 - 5. Fans:
 - a. Include certified fan-performance curves with system operating conditions indicated.
 - b. Include certified fan-sound power ratings.
 - c. Include fan construction and accessories.
 - d. Include motor ratings, electrical characteristics, and motor accessories.
 - e. Include fan-speed controllers.
 - 6. Include filters with performance characteristics.
 - 7. Include direct, gas-fired burners with performance characteristics.
 - 8. Include dampers, including housings, linkages, and operators.
- B. Shop Drawings: For each indoor, direct, gas-fired heating and ventilating unit.
 - 1. Include plans, elevations, sections, and mounting details.
 - 2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 3. Detail fabrication and assembly of gas-fired heating and ventilating units, as well as procedures and diagrams.
 - 4. Include diagrams for power, signal, and control wiring.

1.03 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Floor plans and other details, or BIM model, drawn to scale, showing the items described in this Section, and coordinated with all building trades.
- B. Sample Warranty: For manufacturer's warranty.
- C. Startup service reports.
- D. Field quality-control reports.

1.04 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For direct, gas-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.05 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. Filters: One set(s) for each unit.

1.06 WARRANTY

- A. Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period for Entire Unit: Manufacturer's standard, but not less than one year(s) from date of Substantial Completion.
 - 2. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by an NRTL, and marked for intended location and application.
- B. NFPA Compliance: Comply with NFPA 90A for design, fabrication, and installation of units and components.
- C. ASHRAE 62.1 Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
- D. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

2.02 CAPACITIES AND CHARACTERISTICS

- A. Refer to schedules provided on drawings.

2.03 INDOOR, DIRECT-FIRED HEATING AND VENTILATING UNITS

- 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. FloAire
 - 2. Cambridge Engineering
 - 3. CaptiveAire

4. Modine

B. Unit Casings:

1. General Fabrication Requirements for Casings:
 - a. Forming: Form walls, roofs, and floors with at least two breaks at each joint.
 - b. Casing Joints: Sheet metal screws or pop rivets, factory sealed with water-resistant sealant.
 - c. Heating and Ventilating Unit Mounting Frame: Formed galvanized-steel channel or structural channel supports, designed for low deflection, welded with integral lifting lugs.
2. Configuration: Horizontal unit with horizontal discharge for suspended installation.
3. Double-Wall Construction:
 - a. Outside Casing Wall: Galvanized steel, minimum 20 gauge thick, with manufacturer's standard finish.
 - b. Inside Casing Wall:
 - 1) Inside Casing: Galvanized steel, solid, minimum 20-gauge thick steel.
 - c. Floor Plate: Galvanized steel, minimum 20 gauge thick.
 - d. Casing Insulation:
 - 1) Materials: Glass-fiber blanket or board insulation, Type II ASTM C1071.
 - 2) Insulation Thickness: 1 inch.
4. Inspection and Access Panels and Access Doors:
 - a. Panel and Door Fabrication: Formed and reinforced, single- or double-wall and insulated panels of same materials and thicknesses as casing.
 - b. Inspection and Access Panels:
 - 1) Fasteners: Two or more camlock type for panel lift-out operation. Arrangement is to allow panels to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: Large enough to allow inspection and maintenance of air-handling unit's internal components.
 - c. Access Doors:
 - 1) Hinges: A minimum of two ball-bearing hinges or stainless steel piano hinge and two wedge-lever-type latches, operable from inside and outside. Arrange doors to be opened against air-pressure differential.
 - 2) Gasket: Neoprene, applied around entire perimeters of panel frames.
 - 3) Size: At least 18 inches wide by full height of unit casing up to a maximum height of 60 inches.
 - d. Locations and Applications:
 - 1) Fan Section: Doors.
 - 2) Access Section: Doors.
 - 3) Gas-Fired Burner Section: Doors.
 - 4) Damper Section: Doors.
 - 5) Filter Section: Doors large enough to allow periodic removal and installation of filters.

C. Fan, Drive, And Motor:

1. Fan and Drive Assemblies: Statically and dynamically balanced and designed for continuous operation at maximum-rated fan speed and motor horsepower.
2. Fans: Centrifugal, rated in accordance with AMCA 210; galvanized steel; mounted on solid-steel shaft.
 - a. Shafts: With field-adjustable alignment.

- 1) Turned, ground, and polished hot-rolled steel with keyway.
 - b. Shaft Bearings: Heavy-duty, self-aligning, permanently lubricated ball bearings with an L50 rated life of 100,000 hours in accordance with ABMA 9.
 - c. Housings: Formed- and reinforced-steel panels to form curved scroll housings with shaped cutoff and spun-metal inlet bell.
 - d. Mounting: For internal vibration isolation. Factory-mount fans with manufacturer's standard vibration isolation mounting devices having a minimum static deflection of 1 inch.
 3. Drive: Direct drive with variable frequency controller or electronically commutated motor.
 4. Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, and efficiency requirements for motors specified in Section 23 0513 COMMON MOTOR REQUIREMENTS FOR HVAC EQUIPMENT.
 - b. Motor Sizes: Maximum sizes as indicated. If not indicated, large enough so driven load will not require motor to operate in service factor range above 1.0.
 - c. Enclosure Type: Totally enclosed, fan cooled Insert type.
- D. Air Filtration:
1. Particulate air filtration is specified in Section 23 4100 "Particulate Air Filtration."
 2. Side-Access Filter Mounting Frames:
 - a. Particulate Air Filter Frames: Match inner casing and outer casing material, and insulation thickness. Galvanized-steel track.
 - 1) Sealing: Incorporate positive-sealing device to ensure seal between gasketed material on channels to seal top and bottom of filter cartridge frames to prevent bypass of unfiltered air.
- E. Dampers:
1. Outdoor-Air Dampers: Low-leakage, double-skin, airfoil-blade, galvanized-steel dampers with compressible jamb seals and extruded-vinyl blade edge seals in parallel-blade arrangement with zinc-plated steel operating rods rotating in sintered bronze or nylon bearings mounted in a single galvanized-steel frame, and with operating rods connected with a common linkage. Leakage rate is not to exceed 4 cfm/sq. ft. at 1-inch wg and 8 cfm/sq. ft. at 4-inch wg, leakage Class 1.
 2. Damper Operators: Comply with requirements in Section 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC."
- F. Direct-Fired Gas Burner:
1. Description: Factory assembled, piped, and wired; complying with ANSI Z21.47 and NFPA 54
 2. CSA Approval: Designed and certified by and bearing label of CSA.
 3. Burners: Stainless steel.
 - a. Rated Minimum Turndown Ratio: 30 to 1.
 - b. Fuel: Natural gas.
 - c. Ignition: Electronically controlled electric spark with flame sensor.
 - d. Gas Control Valve: Modulating.
 - e. Gas Train: Regulated, redundant, 24-V ac gas valve assembly containing pilot solenoid valve, electronic-modulating temperature control valve, pilot filter, pressure regulator, pilot shutoff, and manual shutoff all in one body.
 4. Heat-Exchanger and Drain Pan: Stainless steel.

5. Safety Controls:

- a. Gas Manifold: Safety switches and controls complying with ANSI standards.
- b. Vent Flow Verification: Flame rollout switch.
- c. High Limit: Thermal switch or fuse to stop burner.
- d. Purge-period timer is to automatically delay burner ignition and bypass low-limit control.
- e. Automatic-Reset, High-Limit Control Device: Stops burner and closes main gas valve if high-limit temperature is exceeded.
- f. Safety Lockout Switch: Locks out ignition sequence if burner fails to light after three tries. Controls are reset manually by turning the unit off and on.
- g. Control Transformer: 24 V ac.

G. Unit Control Panel:

1. Factory-wired, fuse-protected control transformer, connection for power supply and field-wired unit to remote control panel.
2. Control Panel: Recessed, with trim ring, remote panel, with engraved plastic cover and the following lights and switches:
 - a. On-off-auto fan switch.
 - b. Heat-vent-off switch.
 - c. Supply-fan operation indicating light.
 - d. Heating operation indicating light.
 - e. Thermostat.
 - f. Damper position potentiometer.
 - g. Dirty-filter indicating light operated by unit-mounted differential pressure switch.
 - h. Safety-lockout indicating light.
 - i. Enclosure: NEMA 250, Type 1.

H. Controls:

1. Comply with requirements in Section 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC and Section 230993 Sequence of Operations for HVAC CONTROL" for control equipment and sequence of operation.
2. Control Devices:
 - a. Factory install all control devices necessary to modulate the burner flame to accurately maintain a space temperature set point via 0-10 vdc BAS control signal and compensate for fluctuations in entering air temperature, air volume and % of OA using heating PID controls
3. Interface with DDC System for HVAC: Factory-installed hardware and software to enable the DDC system for HVAC to monitor, control, and display status and alarms of heating and ventilating unit.
 - a. Hardwired Points:
 - 1) Room temperature.
 - 2) Discharge-air temperature.
 - 3) Burner operating.
 - b. ASHRAE 135.1 (BACnet) communication interface with the DDC system for HVAC is to enable the DDC system for HVAC operator to remotely control and monitor the heating and ventilating unit from an operator workstation. Control features and monitoring points displayed locally at heating and ventilating unit control panel are to be available through the DDC system for HVAC.

2.04 SOURCE QUALITY CONTROL

- A. AMCA Certification for Fan Sound Performance Rating: Test, rate, and label in accordance with AMCA 311.
- B. Fan Sound Performance Rating: Factory test and rate fan sound performance rating in accordance with AMCA 300/301.
- C. AMCA Certification for Fan Aerodynamic Performance Ratings: Test, rate, and label in accordance with AMCA 211.
- D. Fan Aerodynamic Performance Rating: Factory test and rate fan performance for airflow, pressure, power, air density, rotation speed, and efficiency in accordance with AMCA 210.
- E. Fan Energy Index: Test in accordance with AMCA 210 and rate in accordance with AMCA 99, AMCA 207, and AMCA 208.
- F. AMCA Certification for Fan Energy Index (FEI): Test, rate, and label in accordance with AMCA 211.
- G. Fan Operating Limits: Classify fans in accordance with AMCA 99, Section 14.

2.05 MATERIALS

- A. Steel:
 - 1. ASTM A36/A36M for carbon structural steel.
 - 2. ASTM A568/A568M for steel sheet.
- B. Stainless Steel:
 - 1. Manufacturer's standard grade for casing.
 - 2. Manufacturer's standard type, ASTM A240/A240M for bare steel exposed to airstream or moisture.
- C. Galvanized Steel: ASTM A653/A653M.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of indirect-fired heating and ventilating units.
- B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of connections before equipment installation.
- C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Equipment Mounting:

1. Suspended Units: Suspend units from structural-steel support frame using threaded steel rods and spring hangers. Coordinate sizes and locations of structural-steel support members with actual equipment provided. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC."
2. Install gas-fired units in accordance with NFPA 54, "National Fuel Gas Code."
3. Install controls and equipment shipped by manufacturer for field installation with direct, gas-fired heating and ventilating units.

3.03 PIPING CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Gas Piping: Furnished and installed by plumbing contractor in accord with Section 22 1616 "Facility Natural Gas Piping".
- C. Where installing piping adjacent to heating and ventilating units, allow space for service and maintenance.

3.04 DUCTWORK CONNECTIONS

- A. Connect supply and outdoor air intake ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 233300 "Air Duct Accessories" for flexible duct connectors.
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.05 ELECTRICAL CONNECTIONS

- A. Connect wiring in accordance with Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Ground equipment in accordance with Section 26 0526 "Grounding and Bonding for Electrical Systems."
- C. Install electrical devices furnished by manufacturer, but not factory mounted, in accordance with NFPA 70 and NECA 1.
- D. Install nameplate for each electrical connection, indicating electrical equipment designation and circuit number feeding connection.
 1. Nameplate is to be laminated acrylic or melamine plastic signs, as specified in Section 26 0553 "Identification for Electrical Systems."

3.06 CONTROL CONNECTIONS

- A. Install control and electrical power wiring to field-mounted control devices.
- B. Connect control wiring in accordance with Section 23 0900 AUTOMATIC TEMPERATURE CONTROL FOR HVAC.

3.07 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
 - 1. Complete installation and startup checks in accordance with manufacturer's written instructions and perform the following:
 - a. Inspect for visible damage to burner combustion chamber.
 - b. Inspect casing insulation for integrity, moisture content, and adhesion.
 - c. Verify that clearances have been provided for servicing.
 - d. Verify that controls are connected and operable.
 - e. Verify that filters are installed.
 - f. Purge gas line.
 - g. Inspect and adjust vibration isolators.
 - h. Verify bearing lubrication.
 - i. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.
 - j. Adjust fan belts to proper alignment and tension.
 - k. Start unit in accordance with manufacturer's written instructions.
 - 2. Complete startup sheets and attach copy with Contractor's startup report.
 - 3. Inspect and record performance of interlocks and protective devices; verify sequences.
 - 4. Operate unit for run-in period recommended by manufacturer.
 - 5. Perform the following operations for both minimum and maximum firing and adjust burner for peak efficiency:
 - a. Measure gas pressure at manifold.
 - b. Measure combustion-air temperature at inlet to combustion chamber.
 - c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.
 - 6. Calibrate thermostats.
 - 7. Adjust and inspect high-temperature limits.
 - 8. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
 - 9. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
 - 10. Measure and record airflow. Plot fan volumes on fan curve.
 - 11. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:
 - a. High-limit heat.
 - b. Alarms.
 - 12. After startup and performance testing, change filters, verify bearing lubrication, and adjust belt tension.
 - 13. Verify drain-pan performance.
 - 14. Verify outdoor-air damper operation.

3.08 ADJUSTING

- A. Adjust initial temperature set points.
- B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

- C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.09 CLEANING

- A. After completing system installation and testing, adjusting, and balancing air-handling unit and air-distribution systems and after completing startup service, clean air-handling 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.

3.10 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform tests and inspections with the assistance of a factory-authorized service representative.
 - 1. Fan 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.
- C. Units will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.11 DEMONSTRATION

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

END OF SECTION 23 7339

SECTION 23 8126 - SPLIT SYSTEM AIR CONDITIONERS

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. Section includes split system heat pump units consisting of separate evaporator fan and compressor condenser components.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

- A. Field quality control reports.
- B. Warranty: Sample of special warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For split system air conditioning units to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."
 - 2. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 4 - "Outdoor Air Quality," Section 5 - "Systems and Equipment," Section 6 - "Procedures," and Section 7 - "Construction and System Start-up."

- C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1.

1.07 COORDINATION

- A. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

1.08 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of split system air conditioning units that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period:
 - a. For Compressor: Five years from date of Substantial Completion.
 - b. For Parts: Five years from date of Substantial Completion.
 - c. For Labor: One year from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Daikin
 - 2. Trane
 - 3. Mitsubishi Electric & Electronics USA, Inc.; HVAC Advanced Products Division.
 - 4. Samsung
 - 5. Panasonic
 - 6. LGI
 - 7. Hitachi

2.02 INDOOR UNITS (5 TONS OR LESS)

- A. Concealed Evaporator Fan Components:
 - 1. Chassis: Galvanized steel with flanged edges, removable panels for servicing, and insulation on back of panel.
 - 2. Insulation: Faced, glass-fiber duct liner.
 - 3. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal-expansion valve. Comply with ARI 206/110.
 - 4. Fan: Forward-curved, double-width wheel of galvanized steel; directly connected to motor.
 - 5. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - b. Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
 - c. Wiring Terminations: Connect motor to chassis wiring with plug connection.
 - 6. Filters: Permanent, cleanable.

7. Condensate Drain Pans:

- a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Depth: A minimum of 2 inches deep.
- b. Double-wall, stainless-steel sheet with space between walls filled with foam insulation and moisture-tight seal.
- c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on [one end] [both ends] of pan.
 - 1) Minimum Connection Size: NPS 1.
- d. Units with stacked coils shall have an intermediate drain pan to collect condensate from top coil.

B. Wall Mounted, Evaporator Fan Components:

1. Cabinet: Enameled steel with removable panels on front and ends in color selected by Architect, and discharge drain pans with drain connection.
2. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and thermal expansion valve. Comply with ARI 206/110.
3. Fan: Direct drive, centrifugal.
4. Fan Motors:
 - a. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements specified in Section 23 0513 "Common Motor Requirements for HVAC Equipment."
 - b. Multi-tapped, multispeed with internal thermal protection and permanent lubrication.
 - c. NEMA Premium (TM) efficient motors as defined in NEMA MG 1.
 - d. Controllers, Electrical Devices, and Wiring: Comply with requirements for electrical devices and connections specified in electrical Sections.
 - e. Mount unit-mounted disconnect switches on interior of unit.
5. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.
6. Condensate Drain Pans:
 - a. Fabricated with one percent slope in at least two planes to collect condensate from cooling coils (including coil piping connections, coil headers, and return bends) and humidifiers, and to direct water toward drain connection.
 - 1) Length: Extend drain pan downstream from leaving face to comply with ASHRAE 62.
 - 2) Depth: A minimum of 1 inch deep.
 - b. Double wall, stainless steel sheet with space between walls filled with foam insulation and moisture-tight seal.
 - c. Drain Connection: Located at lowest point of pan and sized to prevent overflow. Terminate with threaded nipple on both ends of pan.
 - 1) Minimum Connection Size: NPS 1.
7. Air Filtration Section:
 - a. Titanium apatite photocatalytic air-purifying filter without frame.

2.03 OUTDOOR UNITS (5 TONS OR LESS)

A. Air cooled, Compressor condenser Components:

1. Casing: Steel, finished with baked enamel in color selected by Architect, with removable panels for access to controls, weep holes for water drainage, and mounting holes in base. Provide brass service valves, fittings, and gauge ports on exterior of casing.
2. Compressor: Hermetically sealed with crankcase heater and mounted on vibration isolation device. Compressor motor shall have thermal and current sensitive overload devices, start capacitor, relay, and contactor.
 - a. Compressor Type: Scroll.
 - b. Variable speed compressor motor with manual reset high pressure switch and automatic reset low pressure switch.
 - c. Refrigerant Charge: Manufacturer's standard.
 - d. Refrigerant Coil: Copper tube, with mechanically bonded aluminum fins and liquid sub-cooler. Comply with ARI 206/110.
3. Fan: Aluminum propeller type directly connected to motor.
4. Motor: Permanently lubricated, with integral thermal overload protection.
5. Low Ambient Kit: Permits operation down to 0°F.
6. Mounting Base: Roof Equipment Rails.

2.04 ACCESSORIES

- A. Thermostat - wireless infrared functioning to remotely control compressor and evaporator fan, with the following features:
1. Compressor time delay.
 2. 24-hour time control of system stop and start.
 3. Liquid-crystal display indicating temperature, setpoint temperature, time setting, operating mode, and fan speed.
 4. Fan-speed selection including auto setting.
- B. Automatic-reset timer to prevent rapid cycling of compressor.
- C. Refrigerant Line Kits: Soft-annealed copper suction and liquid lines factory cleaned, dried, pressurized, and sealed; factory-insulated suction line with flared fittings at both ends.
- D. Drain Hose: For condensate.
- E. Condensate Pump. Provide a packaged corrosion-resistant automatic condensate drain pump with plastic tank with cover, and automatic controls. Include factory or field installed check valve and a 72-inch minimum, electrical power cord with plug.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Install units' level and plumb.

- B. Install evaporator fan components using manufacturer's standard mounting devices securely fastened to building structure.
- C. Install roof-mounted, compressor condenser components on equipment supports specified in Section 07 7200 "Roof Accessories." Anchor units to supports with removable, cadmium-plated fasteners.
- D. Equipment Mounting:
 - 1. Comply with requirements for vibration isolation devices specified in Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."
- E. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.

3.03 FIELD QUALITY CONTROL

Perform tests and inspections.

- A. Tests and Inspections:
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
 - 2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- B. Remove and replace malfunctioning units and retest as specified above.
- C. Prepare test and inspection reports.

3.04 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup check according to manufacturer's written instructions.

3.05 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain units.

END OF SECTION 23 8126

SECTION 23 8239.13 - CABINET UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes cabinet unit heaters with centrifugal fans and electric-resistance heating coils.

1.03 SUBMITTALS

- A. Product Data: Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated. Also include plans, elevations, sections, and details. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. In addition, include details of anchorages and attachments to structure and to supported equipment.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- B. Samples: For each exposed product, provide color samples and texture samples for color and texture selection.
- C. Field quality control reports.
- D. Operation and Maintenance Data: Include installation, operation and maintenance data for cabinet unit heaters in emergency, operation, and maintenance manuals.

1.04 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit Heater Filters: Furnish one spare filter(s) for each filter installed.

PART 2 - PRODUCTS

2.01 ELECTRIC CABINET UNIT HEATERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Marley Engineered Products
 - 2. Modine

3. Ruffneck Heaters; a division of Lexa Corporation
4. Raywall
5. Trane

B. Description

1. Factory-assembled and -tested unit complying with AHRI 440.
2. 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.
3. Comply with UL 2021.

C. Coil Section Insulation

1. Flexible Elastomeric Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C534, Type II, except for density.
 - a. Thickness: Minimum 1/2-inch.
 - b. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75°F mean temperature.
 - c. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C411.
 - d. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.

D. Cabinet

1. Material: Heavy gauge steel.
2. Finish:
 - a. Baked-enamel finish in a custom color selected by Architect.
3. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch-thick galvanized sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
 - a. Base: Minimum 0.0528-inch-thick steel, finished to match cabinet, 4 inches high with leveling bolts.
4. Recessed Flanges: Steel, finished to match cabinet.
5. Control Access Door: Key operated.
6. Extended Piping Compartment: Minimum 8-inch-wide piping end pocket.

E. Filters

1. Minimum Arrestance: According to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
2. Filters shall be the pleated type, fabricated of glass fiber treated with adhesive. Filters shall have a 90 percent arrestance and MERV 7 rating.

F. Coil

1. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and hum, mounted in ceramic inserts in galvanized-steel housing; with fuses in terminal box for overcurrent protection and limit controls for high-temperature protection. Terminate elements in stainless-steel machine-staked terminals secured with stainless-steel hardware.

G. Fan and Motor

1. Fan: Forward curved, double width, centrifugal, directly connected to the motor; constructed of painted-steel wheels and aluminum, painted-steel, or galvanized-steel fan scrolls.
2. Motor: Permanently lubricated, multispeed; resiliently mounted on motor board. Comply with requirements in Section 23 0513 "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

- H. Controls
 - 1. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control devices that may be required.
 - 2. Refer to Division 23 Section 23 0993 "Sequence of Operations for HVAC Controls" for operating sequences and other additional controls that may be required.
- I. Electrical Connection: Factory-wired motors and controls for a single field connection.
- J. Capacities and Characteristics: Refer to the schedule on the Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive cabinet unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install cabinet unit heaters to comply with NFPA 90A.
- B. Suspend cabinet unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment." Spring hangers are specified in Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."
- C. Install wall-mounted temperature sensors in electrical outlet boxes at heights to match lighting controls. Verify exact location of thermostat(s) with Architect and Owner prior to rough-in installation work.
- D. Install new filters in each fan-coil unit within two weeks of Substantial Completion.

3.03 CONNECTIONS

- A. Comply with safety requirements in UL 1995.
- B. Ground equipment according to Division 26.
- C. Connect wiring according to Division 26.

3.04 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective and shall be removed and replaced if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.05 ADJUSTING

- A. Adjust initial temperature set points.

3.06 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain cabinet unit heaters. Refer to Division 01.
 - 1. Schedule training session with Owner a minimum of 14-days in advance.
 - 2. Record training session onto a DVD and deliver the DVD to the Owner.

END OF SECTION 23 8239.13

SECTION 23 8239.16 - PROPELLER UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes propeller unit heaters with electric-resistance heating coils.

1.03 SUBMITTALS

- A. Product Data: Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated. Also include plans, elevations, sections, and details. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. In addition, include details of anchorages and attachments to structure and to supported equipment.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- B. Field quality-control reports.
- C. Operation and Maintenance Data: Include installation, operation and maintenance data for propeller unit heaters in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.01 ELECTRIC PROPELLER UNIT HEATERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Marley Engineered Products
 - 2. Modine
 - 3. Ruffneck Heaters; a division of Lexa Corporation
 - 4. Raywall
 - 5. Trane
- B. Description
 - 1. Assembly including casing, coil, fan, and motor in horizontal discharge configuration with adjustable discharge louvers.
 - 2. 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.
 - 3. Comply with UL 2021.

- C. Housings
 - 1. Finish: Manufacturer's standard baked enamel applied to factory-assembled and -tested propeller unit heaters before shipping.
 - 2. Discharge Louver: Adjustable fin diffuser for horizontal units.
- D. Coils
 - 1. Electric-Resistance Heating Coil: Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in steel or corrosion-resistant metallic sheath with fins no closer than 0.16-inch. Element ends shall be enclosed in terminal box. Fin surface temperature shall not exceed 550°F at any point during normal operation.
 - a. Circuit Protection: One-time fuses in terminal box for overcurrent protection and limit controls for high-temperature protection of heaters.
 - b. Wiring Terminations: Stainless steel or corrosion-resistant material.
- E. Fan and Motor
 - 1. Fan: Propeller type with aluminum wheel directly mounted on motor shaft in the fan venturi.
 - 2. Motor: Permanently lubricated; comply with requirements in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
- F. Controls
 - 1. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control devices that may be required.
 - 2. Refer to Division 23 Section 23 0993 "Sequence of Operations for HVAC Controls" for operating sequences and other additional controls that may be required.
- G. Capacities and Characteristics: Refer to the schedule on the Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive propeller unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install propeller unit heaters to comply with NFPA 90A.
- B. Install propeller unit heaters level and plumb.
- C. Suspend propeller unit heaters from structure with all-thread hanger rods and spring hangers. Hanger rods and attachments to structure are specified in Division 23 Section 23 0529 "Hangers and Supports for HVAC Piping and Equipment." Spring hangers are specified in Division 23 Section 23 0548.13 "Vibration Controls for HVAC Piping and Equipment."

- D. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify exact location of thermostat(s) with Architect and Owner prior to rough-in installation work.

3.03 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties. Requirements for piping fittings, and specialties along with their installation requirements are specified in other Division 23 Sections.
- B. Install piping adjacent to unit heater to allow service and maintenance. Connect piping to unit heater in accordance with the manufacturer's installation instructions and recommendations.
- C. Comply with safety requirements in UL 1995.
- D. Ground equipment according to Division 26.
- E. Connect wiring according to Division 26.

3.04 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Operate electric heating elements through each stage to verify proper operation and electrical connections.
 - 3. Test and adjust controls and safety devices. Replace damaged and malfunctioning controls and equipment.
- B. Units will be considered defective and shall be removed and replaced if they do not pass tests and inspections.
- C. Prepare test and inspection reports.

3.05 ADJUSTING

- A. Adjust initial temperature set points.

3.06 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain propeller unit heaters. Refer to Division 01.
 - 1. Schedule training session with Owner a minimum of 14-days in advance.
 - 2. Record training session onto a DVD and deliver the DVD to the Owner.

END OF SECTION 23 8239.16

SECTION 23 8239.19 - WALL AND CEILING UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. All Division 23 Specification Sections also apply to this Section.

1.02 SUMMARY

- A. Section includes wall and ceiling heaters with propeller fans and electric-resistance heating coils.

1.03 SUBMITTALS

- A. Product Data: Include equipment schedules to indicate rated capacities, operating characteristics, furnished specialties, and accessories for each product indicated. Also include plans, elevations, sections, and details. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection. In addition, include details of anchorages and attachments to structure and to supported equipment.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- B. Samples: For each exposed product, provide color samples and texture samples for color and texture selection.
- C. Operation and Maintenance Data: For electric wall and ceiling heaters to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.01 ELECTRIC WALL AND CEILING HEATERS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 - 1. Berko Electric Heating; a division of Marley Engineered Products
 - 2. Chromalox, Inc.; a division of Emerson Electric Company
 - 3. Indeeco
 - 4. Markel Products; a division of TPI Corporation
 - 5. Marley Electric Heating; a division of Marley Engineered Products
 - 6. QMark Electric Heating; a division of Marley Engineered Products
 - 7. Trane
 - 8. Raywall
- B. Description
 - 1. Assembly including chassis, electric heating coil, fan, motor, and controls. Comply with UL 2021.

2. 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. Cabinet
1. Front Panel: Stamped-steel louver, with removable panels fastened with tamperproof fasteners.
 2. Finish:
 - a. Baked enamel over baked-on primer in manufacturer's standard color as selected by Architect, applied to factory-assembled and -tested wall and ceiling heaters before shipping.
 3. Enclosure: Steel back-box with finish to match cabinet.
 - a. Recessed-Mounting: Provide the manufacturer's standard recess mounting kit.
- D. Electric-Resistance Heating Coil
1. Nickel-chromium heating wire, free from expansion noise and 60-Hz hum, embedded in magnesium oxide refractory and sealed in corrosion-resistant metallic sheath. Terminate elements in stainless-steel, machine-staked terminals secured with stainless-steel hardware, and limit controls for high-temperature protection.
- E. Fan and Motor
1. Fan: Aluminum propeller directly connected to motor.
 2. Motor: Permanently lubricated; comply with requirements in Division 23 Section 23 0513 "Common Motor Requirements for HVAC Equipment."
- F. Electrical Connection
1. Factory wire motors and controls for a single field connection with disconnect switch.
- G. Controls
1. Provide a unit-mounted (integral) thermostat with the heater.
- H. Capacities and Characteristics: Refer to the schedule on the Drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas to receive wall and ceiling unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.
- B. Examine roughing-in for electrical connections to verify actual locations before unit-heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install wall and ceiling unit heaters to comply with NFPA 90A.
- B. Install wall and ceiling unit heaters level and plumb.

- C. Install wall-mounted thermostats and switch controls in electrical outlet boxes at heights to match lighting controls. Verify exact location of thermostat(s) with Architect and Owner prior to rough-in installation work.
- D. Ground equipment according to Division 26.
- E. Connect wiring according to Division 26.

3.03 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain **wall and ceiling** unit heaters.

END OF SECTION 23 8239.19

SECTION 23 8323 - RADIANT HEATING ELECTRIC PANELS

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. Section includes prefabricated radiant-heating electric panels.

1.03 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Include rated capacities, operating characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For electric heating panels.
 - 1. Include plans, sections, details, and attachments to other work.
 - 2. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Ceiling suspension assembly members.
 - 2. Method of attaching hangers to building structure.
 - 3. Structural members to which heating panels and suspension systems will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Items installed in finished ceiling, including the following:
 - a. Lighting fixtures.
 - b. Air outlets and inlets.
 - c. Speakers.
 - d. Sprinklers.
 - e. Access panels.
 - f. Perimeter moldings.
- B. Field quality-control reports.
- C. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For electric heating panels to include in operation and maintenance manuals.

1.06 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace electric heating panels that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR RADIANT-HEATING ELECTRIC PANELS

- 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.

2.02 PREFABRICATED RADIANT-HEATING ELECTRIC PANELS

- A. Description: Sheet-metal-enclosed panel with heating element suitable for lay-in installation flush with T-bar ceiling grid. Comply with UL 2021.
 - 1. Panel: Minimum 0.0276-inch thick, galvanized sheet steel back panel riveted to minimum 0.0396-inch-thick, galvanized sheet steel front panel with fused-on crystalline surface.
 - 2. Heating Element: Encapsulated casted element that assures uniform temperatures across surface.
 - 3. Electrical Connections: Non-heating, high-temperature, insulated-copper leads, factory connected to heating element.
 - 4. Exposed-Side Panel Finish: Baked-enamel finish in manufacturer's custom paint color as selected by Architect.
- B. Controls
 - 1. Refer to Division 23 Section 23 0900 "Automatic Temperature Control for HVAC" for additional control devices that may be required.
 - 2. Refer to Division 23 Section 23 0993 "Sequence of Operations for HVAC Controls" for operating sequences and other additional controls that may be required.
- C. Capacities and Characteristics: Refer to schedules provided on drawings.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine surfaces and substrates to receive electric heating panels for compliance with requirements for installation tolerances and other conditions affecting performance.
 - 1. Ensure surfaces in contact with electric heating panels are free of burrs and sharp protrusions.
 - 2. Ensure surfaces and substrates are level and plumb.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install radiant-heating panels level and plumb.
- B. Support for Radiant-Heating Panels in or on Grid-Type Suspended Ceilings: Use grid as a support element.
 - 1. Install a minimum of four ceiling-support-system rods or wires for each panel. Locate not more than 6 inches from panel corners.
 - 2. Support Clips: Fasten to panel and to ceiling grid members at or near each panel corner with clips designed for the application.
 - 3. Panels of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support panels independently with at least two 3/4-inch metal channels spanning and secured to ceiling tees.

3.03 CONNECTIONS

- A. Ground equipment according to Section 26 0526 "Grounding and Bonding for Electrical Systems."
- B. Connect wiring according to Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections:
 - 1. Operate electric-heating elements through each stage to verify proper operation and electrical connections.
 - 2. Test and adjust controls and safeties.
- C. Radiant-heating electric panels will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.05 PROTECTION

- A. Protect installed radiant-heating electric panels from damage during construction.
- B. Remove and replace damaged radiant-heating electric panels.

END OF SECTION 23 8323

SECTION 26 0100 - BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 09 FINISHES Sections.
- D. Division 31 EARTHWORK Sections.

1.02 SUMMARY

- A. This Section includes general administrative, procedural requirements, construction materials and construction methods for electrical installations. The following requirements are included in this Section to expand the requirements specified in Division 01 - reference individual sections for further expansion of these requirements:
 - 1. Abbreviations and Acronyms
 - 2. Definitions
 - 3. Permits, Codes, and Inspections
 - 4. Visiting Premises
 - 5. Project Drawings and Specifications
 - 6. Nameplate Data
 - 7. Soil Materials
 - 8. Coordination
 - 9. Substitutions
 - 10. Excavation, Backfill and Restoration
 - 11. Submittals
 - 12. Quality Assurance and Testing
 - 13. Temporary
 - 14. Delivery, Storage, and Handling
 - 15. Cutting and Patching
 - 16. Installations
 - 17. Final Cleaning
 - 18. Warranties
 - 19. Maintenance Manuals
 - 20. Record Documents
 - 21. Demonstration and Training

1.03 ABBREVIATIONS AND ACRONYMS

- A. Industry Organizations: Where abbreviations and acronyms are used in Specifications or other Contract Documents, they shall mean the recognized name of the entities in the following list. This information is subject to change and is believed to be accurate as of the date of the Contract Documents.
 - 1. AAMA - American Architectural Manufacturers Association; www.aamanet.org.

2. AASHTO - American Association of State Highway and Transportation Officials; www.transportation.org.
3. ACI - American Concrete Institute; (Formerly: ACI International); www.concrete.org.
4. AEIC - Association of Edison Illuminating Companies, Inc. (The); www.aeic.org.
5. AIA - American Institute of Architects (The); www.aia.org.
6. AISC - American Institute of Steel Construction; www.aisc.org.
7. AISI - American Iron and Steel Institute; www.steel.org.
8. ANSI - American National Standards Institute; www.ansi.org.
9. APA - Architectural Precast Association; www.archprecast.org.
10. ASHRAE - American Society of Heating, Refrigerating and Air-Conditioning Engineers; www.ashrae.org.
11. ASME - ASME International; (American Society of Mechanical Engineers); www.asme.org.
12. ASSE - American Society of Safety Engineers (The); www.asse.org.
13. ASTM - ASTM International; www.astm.org.
14. ATIS - Alliance for Telecommunications Industry Solutions; www.atis.org.
15. AWEA - American Wind Energy Association; www.awea.org.
16. BICSI - BICSI, Inc.; www.bicsi.org.
17. CDA - Copper Development Association; www.copper.org.
18. CEA - Consumer Electronics Association; www.ce.org.
19. CRSI - Concrete Reinforcing Steel Institute; www.crsi.org.
20. CSA - CSA Group; www.csa.ca.
21. CSA - CSA International; (Formerly: IAS - International Approval Services); www.csa-international.org.
22. CSI - Construction Specifications Institute (The); www.csinet.org.
23. CPSC - Consumer Product Safety Commission; www.cpsc.gov.
24. DASMA - Door and Access Systems Manufacturers Association; www.dasma.com.
25. DHI - Door and Hardware Institute; www.dhi.org.
26. DOE - Department of Energy; www.energy.gov.
27. ECA - Electronic Components Association; (See ECIA).
28. ECAMA - Electronic Components Assemblies & Materials Association; (See ECIA).
29. ECIA - Electronic Components Industry Association; www.eciaonline.org.
30. EIA - Electronic Industries Alliance; (See TIA).
31. EJMA - Expansion Joint Manufacturers Association, Inc.; www.ejma.org.
32. EPA - Environmental Protection Agency; www.epa.gov.
33. ESD - ESD Association; (Electrostatic Discharge Association); www.esda.org.
34. ESTA - Entertainment Services and Technology Association; (See PLASA).
35. ETL - Intertek (See Intertek); www.intertek.com.
36. FAA - Federal Aviation Administration; www.faa.gov.
37. FM Approvals - FM Approvals LLC; www.fmglobal.com.
38. FM Global - FM Global; (Formerly: FMG - FM Global); www.fmglobal.com.
39. GSA - General Services Administration; www.gsa.gov.
40. HMMA - Hollow Metal Manufacturers Association; (See NAAMM).
41. HUD - Department of Housing and Urban Development; www.hud.gov.
42. IAPSC - International Association of Professional Security Consultants; www.iapsc.org.
43. ICBO - International Conference of Building Officials; (See ICC).
44. ICC - International Code Council; www.iccsafe.org.
45. ICEA - Insulated Cable Engineers Association, Inc.; www.icea.net.
46. ICRI - International Concrete Repair Institute, Inc.; www.icri.org.
47. IEEE - Institute of Electrical and Electronics Engineers, Inc. (The); www.ieee.org.
48. IES - Illuminating Engineering Society; (Formerly: Illuminating Engineering Society of North America); www.ies.org.
49. IESNA - Illuminating Engineering Society of North America; (See IES).
50. Intertek - Intertek Group; (Formerly: ETL SEMCO; Intertek Testing Service NA); www.intertek.com.
51. ISO - International Organization for Standardization; www.iso.org.
52. ITU - International Telecommunication Union; www.itu.int/home.

53. LPI - Lightning Protection Institute; www.lightning.org.
54. MCA - Metal Construction Association; www.metalconstruction.org.
55. MFMA - Metal Framing Manufacturers Association, Inc.; www.metalframingmfg.org.
56. MHIA - Material Handling Industry of America; www.mhia.org.
57. MPI - Master Painters Institute; www.paintinfo.com.
58. NAAMM - National Association of Architectural Metal Manufacturers; www.naamm.org.
59. NBI - New Buildings Institute; www.newbuildings.org.
60. NCAA - National Collegiate Athletic Association (The); www.ncaa.org.
61. NCMA - National Concrete Masonry Association; www.ncma.org.
62. NECA - National Electrical Contractors Association; www.necanet.org.
63. NEMA - National Electrical Manufacturers Association; www.nema.org.
64. NETA - InterNational Electrical Testing Association; www.netaworld.org.
65. NFHS - National Federation of State High School Associations; www.nfhs.org.
66. NFPA - National Fire Protection Association; www.nfpa.org.
67. NICET - National Institute for Certification in Engineering Technologies.
68. NRMCA - National Ready Mixed Concrete Association; www.nrmca.org.
69. NSPE - National Society of Professional Engineers; www.nspe.org.
70. NSSGA - National Stone, Sand & Gravel Association; www.nssga.org.
71. OSHA - Occupational Safety & Health Administration; www.osha.gov.
72. PCI - Precast/Prestressed Concrete Institute; www.pci.org.
73. PLASA - PLASA; (Formerly: ESTA - Entertainment Services and Technology Association); www.plasa.org.
74. RoHS - Restriction of Hazardous Substances
75. SCTE - Society of Cable Telecommunications Engineers; www.scte.org.
76. SIA - Security Industry Association; www.siaonline.org.
77. SMPTE - Society of Motion Picture and Television Engineers; www.smpte.org.
78. SPIB - Southern Pine Inspection Bureau; www.spib.org.
79. SRCC - Solar Rating & Certification Corporation; www.solar-rating.org.
80. SSINA - Specialty Steel Industry of North America; www.ssina.com.
81. SSPC - SSPC: The Society for Protective Coatings; www.sspc.org.
82. STI - Steel Tank Institute; www.steeltank.com.
83. TIA - Telecommunications Industry Association (The); (Formerly: TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance); www.tiaonline.org.
84. TIA/EIA - Telecommunications Industry Association/Electronic Industries Alliance; (See TIA).
85. UL - Underwriters Laboratories Inc.; www.ul.com.
86. UNI - Uni-Bell PVC Pipe Association; www.uni-bell.org.
87. USGBC - U.S. Green Building Council; www.usgbc.org.
88. USITT - United States Institute for Theatre Technology, Inc.; www.usitt.org.
89. WASTEC - Waste Equipment Technology Association; www.wastec.org.

1.04 DEFINITIONS

A. Basic Contract definitions are included in the Conditions of the Contract.

1. Approved: When used to convey Architect's action on Contractor's submittals, applications, and requests, 'approved' is limited to Architect's duties and responsibilities as stated in the Conditions of the Contract.
2. Backfill and Fill Materials: Materials complying with ASTM D2487 soil classification groups GW, GP, GM, SM, SW, and SP; free of clay, rock, or gravel larger than 2 inches in any dimension; debris; waste; frozen materials; and vegetable and other deleterious matter.
3. Concealed: Embedded in masonry or other construction, installed behind wall furring or within double partitions or installed within hung ceilings.
4. Conduit: The inclusion of all fittings, hangers, supports, sleeves, etc.
5. Contractor: As stated herein shall mean Electrical Contractor.

6. Directed: A command or instruction by Architect. Other terms including 'requested,' 'authorized,' 'selected,' 'required,' and 'permitted' have the same meaning as 'directed.'
7. Equal: Equivalent as approved by the Architect or their representative.
8. Furnish: Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
9. Indicated: Requirements expressed by graphic representations or in written form on Drawings, in Specifications, and in other Contract Documents. Other terms including 'shown,' 'noted,' 'scheduled,' and 'specified' have the same meaning as 'indicated.'
10. Install: Unload, temporarily store, unpack, assemble, erect, place, anchor, apply, work to dimension, finish, cure, protect, clean, and similar operations at Project site.
11. Project Site: Space available for performing construction activities. The extent of Project site is shown on Drawings and may or may not be identical with the description of the land on which Project is to be built.
12. Provide: Furnish and install, complete and ready for the intended use.
13. Regulations: Laws, ordinances, statutes, and lawful orders issued by authorities having jurisdiction, and rules, conventions, and agreements within the construction industry that control performance of the Work.
14. Sub-base Material: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, crushed slag, or natural or crushed sand.
15. Subgrade: Compacted soil immediately below the slab or pavement system.
16. Wiring: The inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such work.

1.05 PERMITS, CODES, AND INSPECTIONS

- A. Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. The electrical installation shall comply fully with
 1. All local, county and state laws, ordinances and regulations having jurisdiction and as applicable to the electrical installations.
 2. All requirements of electric, telephone, and CATV utility companies.
 3. All approved published instructions set forth by equipment manufacturers.
- C. The Electrical installation and all components shall be in compliance with the code and/or standard requirements of the latest revision or state-adopted edition of:
 1. American Society for Testing and Materials (ASTM)
 2. Americans with Disabilities Act (ADA)
 3. FM Global (Factory Mutual) Approval Guide
 4. Institution of Electrical and Electronic Engineers (IEEE)
 5. International Building Code (IBC)
 6. International Fire Code (IFC)
 7. International Energy Conservation Code (IECC)
 8. Legislative Act 235 (1965) - Handicapped
 9. Legislative Act 287 (1974) - Excavation
 10. National Electric Code (NEC)
 11. National Electrical Contractor's Association (NECA)
 12. National Electrical Manufacturer's Association (NEMA)
 13. National Electrical Safety Code (NESC)
 14. National Fire Protection Association (NFPA)
 15. National Safety Code
 16. Occupational Safety and Health Act (OSHA)
 17. Underwriter's Laboratories, Inc. (UL)

- D. Submit certificates issued by approved authorized agencies to indicate conformance of all work with the above requirements, as well as any additional certificates as may be required for the performance of this contract work.
- E. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect prior to execution of the work. The work shall be carried out according to the requirements of such code in accordance with the instruction of the Architect and at no additional cost to the Owner.
- F. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from the municipality-approved inspection agency and deliver it to the Architect before final payment is made.

1.06 VISITING PREMISES

- A. The Bidder shall visit the project site before submitting his bid, in order to familiarize himself with existing conditions that may affect his work. It is the Contractor's responsibility to analyze existing conditions. Sufficient allowances shall be provided in the Contractor's bid to cover work, due to existing conditions, that will be required to complete this contract work.
- B. By submission of a bid, the Contractor is attesting that responsible personnel did in fact visit the site during the bidding period and verified all existing pertinent conditions.
- C. Contractor shall verify all measurements and dimensions at the site prior to submitting a bid.

1.07 PROJECT DRAWINGS AND SPECIFICATIONS

- A. Contractor shall carefully examine the Drawings and Specifications of all trades and report all discrepancies to the Architect in writing to obtain corrective action. No departures from the Contract Documents will be made without prior written approval from the Architect.
- B. Questions or disputes regarding the intent or meaning of Contract Documents shall be resolved by the interpretation of the Architect. The Architect's interpretation is final and binding.
- C. The Drawings and Specifications are not intended to define all details, finish materials, and special construction that may be required or necessary. The Contractor shall provide all installations complete and adequate as implied by the project documents.
- D. Drawings are diagrammatic only and do not show exact routes and locations of equipment and associated wiring. The Contractor shall verify the work of all other trades and shall arrange his work to avoid conflicts. In the event of a conflict, the Contractor shall obtain corrective action from the Architect.
- E. All work shall be considered new, unless noted otherwise.
- F. Prior to the submitting of bids, the Contractor shall familiarize himself with all conditions affecting the proposed installation of equipment by all trades that will require electrical connections and shall make provisions as to the cost thereof. Failure to comply with the intent of this paragraph shall in no way relieve the Contractor of performing all necessary work required for final electrical connections and equipment.

PART 2 - PRODUCTS

2.01 GENERAL

- A. All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.
- B. When two or more items of same material or equipment are required, they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, wire, conduit, fittings, sheet metal, steel bar stock, welding rods, solder, fasteners, and similar items used in work, except as otherwise indicated.
- C. Provide products that are compatible within systems and other connected items.
- D. In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.
- E. All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units and shall be furnished as such.
- F. In certain instances specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, sound level and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.
- G. Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.
- H. Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Architect.
- I. All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.
- J. All material and equipment to be furnished under this contract shall be new and shall conform to the grade, quality and standards specified herein. Items of equipment shall be the latest standard product as advertised in printed catalogues by reputable manufacturers for the purpose intended and shall have replacement parts available.

2.02 NAMEPLATE DATA

- A. Provide factory-installed, permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data.

2.03 SOIL MATERIALS

- A. Provide in accordance with Division 31 EARTHWORK Sections.

PART 3 - EXECUTION

3.01 GENERAL

- A. All construction under this contract shall be completed in a neat and craftsman-like manner. Work that, in the judgement of the Architect, is not satisfactorily installed shall be removed and replaced to the Architect's satisfaction, at the Contractor's expense.
- B. Throughout construction, all work areas and storage areas shall be kept clean. The Contractor shall keep all items clean of dirt, rust, dust and fingerprints.
- C. The Contractor shall furnish, set, erect, and maintain all scaffolding, aerial equipment and ladders required in the installation of this Contract work.
- D. Install temporary platforms so as to be supported only by the existing steel truss framework.
- E. Painting: Provide in accordance with Division 09 FINISHES Sections and as stated below.
 - 1. Except in Mechanical Rooms, Electrical Rooms, attics, and chase spaces all exposed items provided or installed under this Contract shall be painted.
 - 2. Unless painting is provided by others as elsewhere specified, all painting for items furnished or installed under this Contract shall be the responsibility of this Contractor.
 - 3. Factory-painted equipment cabinets and trim shall not be field-painted except for touching up scratches or damage where necessary to achieve like-new finish. Touching up shall be done after equipment is in its final location.
 - 4. Paint for metal surfaces shall be Rust-o-leum or as approved, one prime coat and two finish coats of color selected by Architect.
 - 5. Items to be painted shall be cleaned and degreased and shall be free of dirt, rust and corrosion prior to application of paint. All paint shall be applied in accordance with all the manufacturer's recommendations (i.e. temperature, dew point, ventilation).
 - 6. All patchwork performed under this Contract shall be painted. Color shall match the color of adjacent walls, ceilings and floors in which patchwork occurs. Area to be painted shall extend a minimum of 24" all around patchwork; however, final limit shall be set by the Architect. Blend new paint work with existing painted surfaces. Where existing finish is stained or varnished woodwork, all damaged or patched surfaces shall be restored to match the existing adjacent surface, as approved. Paint, stain, varnish and method of application shall be as set out in the specifications for General Construction, or as otherwise approved. Except where painting of patchwork is provided by others, as elsewhere specified, all painting of patchwork required under this Contract shall be the responsibility of this Contractor.

3.02 COORDINATION

- A. Sequence of Work
 - 1. Provide in accordance with Division 01 Section SUMMARY.
- B. Utility
 - 1. The Contractor shall cooperate fully with local utility companies with respect to their services.
 - 2. The Contractor shall be responsible for all coordination and scheduling of construction with all utility companies as necessary for the performance of this Contract work.
 - 3. The actual amount of the charges will be determined by the electric utility company at the time of the installation, and shall be paid directly by the Owner.
 - 4. Coordinate the shut-off and disconnection of electrical service with the Owner and the utility company.

C. New Work

1. Coordinate electrical equipment installation with other building components.
2. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the work.
3. Arrange for chases, slots, and openings in building structure during progress of construction to allow for electrical installations.
4. Coordinate the installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
5. Coordinate installation of large equipment requiring positioning prior to closing in the building.
6. Coordinate connection of electrical services with equipment provided under other sections of the specifications.
7. Coordinate requirements for access panels and doors where electrical items requiring access are concealed behind finished surfaces. Verify all dimensions by field measurements.
8. Coordinate connection of electrical systems with exterior underground and overhead utilities and services. Comply with requirements of governing regulations, franchised service companies, and controlling agencies. Provide required connection for each service.
9. Coordinate the cutting and patching of building components to accommodate installation of electrical equipment and materials.
10. Coordinate the installation of electrical materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.

D. Cooperation and Coordination With Other Trades

1. This Electrical Contractor must cooperate completely and coordinate work with the contractors of other trades providing equipment under this division and other divisions of the specifications. This is particularly important in connection with Divisions 21, 22, and 23 - Mechanical.
2. Interference drawings shall be prepared as a combined effort of all trades. The Electrical Contractor shall prepare floor plans, reflected ceiling plans, elevations, sections, and details to conclusively coordinate and integrate all installations on mylar backgrounds prepared by the Mechanical Contractor. The Mechanical Contractor shall start their drawings immediately upon award of contract. Drawings shall be at 1/4" = 1'0" scale based on sheet size and plan location and orientation as shown on the architectural drawings. All interference drawings shall be capable of being overlaid to coordinate interferences and for printing. All congested areas and mechanical room plans shall be drawn at 3/8" = 1'0" scale.
3. After the Mechanical Contractor has finished, electronic files will be forwarded to the Plumbing trade who will show and coordinate the plumbing work with the other trades. After the Plumbing trade has finished, electronic files will be forwarded to the Electrical trade who will show and coordinate their work on the combined plans.
4. Interference plans and elevations shall show in detail the location of the following items that require coordination because of size and proximity to other equipment and systems. Drawings shall show in order of installation priority within the allotted space the items prioritized in the following paragraph entitled "Space Priority".
 - a. In addition, show electrical work in equipment rooms.
 - b. On the interference drawings, show all electrical conduits that are 1-1/2" and larger.
 - c. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the work.
 - d. Proposed locations of major systems, equipment and material.
 - e. Work in pipe spaces, chases, and trenches.
 - f. Exterior wall penetrations.
 - g. Fire-rated wall and floor penetrations.
 - h. Ceilings that contain piping, ductwork, or equipment in congested arrangement.
 - i. Equipment connections and support details.
 - j. Exterior underground lines in common excavation.
 - k. Sizes and location of required concrete pads and bases.
 - l. Indicate scheduling, sequencing, movement, and positioning of large equipment into the building during construction.

- m. Prepare floor plans, elevations, and details to indicate penetrations in floors, walls, and ceilings and their relationship to other penetrations and installations.
 - n. Prepare reflected ceiling plans to coordinate and integrate installations, air outlets and inlets, light fixtures, communications systems components, sprinklers, and other ceiling-mounted devices.
 - o. Clearances for servicing equipment, including space for equipment disassembly required for periodic maintenance.
 - 5. Electronic files of the finished interference drawings shall be submitted to the Architect for record before actual installation work begins. Each trade shall make completed interference drawings available to their craft for installation of the work.
 - 6. Individual trade interference drawings may be used as shop drawings and/or as record drawings at the completion of the project.
 - 7. The coordination drawings shall be reviewed and approved by the Owner and Architect, and shall be signed by both the Owner and the Architect.
- E. Cooperation and Coordination With Subcontractors
- 1. The Electrical Contractor shall give their subcontractors the option to attend construction and coordination meetings to aid in overall electrical construction coordination.
- F. Space Priority
- 1. Ensure equitable use of available space for materials and equipment installed above ceilings. Allocate space in the order of priority as listed below. Items are listed in the order of priority, with items of equal importance listed under a single priority number.
 - a. Gravity flow piping systems
 - b. Vent piping systems
 - c. Ceiling recessed lighting fixtures
 - d. Concealed air terminal units, fans
 - e. Air duct systems
 - f. Sprinkler systems piping
 - g. Forced flow piping systems
 - h. Electrical conduit, wiring, control wiring
 - 2. Order of priority does not dictate installation sequence. Installation sequence shall be as mutually agreed by all affected trades.
 - 3. Change in order of priority is permissible by mutual agreement of all affected trades.
 - 4. The work of a particular trade shall not infringe upon the allocated space of another trade without permission of the contractor for the affected trade.
 - 5. The work of a particular trade shall not obstruct access for installation, operation and maintenance of the Work, materials and equipment of another trade.

3.03 SUBSTITUTIONS

- A. Provide in accordance with Division 01 Section SUBSTITUTION PROCEDURES and as stated below.
- B. Where the contractor proposes substitute equipment, contractor to submit complete product data indicating compliance with all requirements of the documents, including performance rating, size and resistance to wear and deterioration equivalent to the specified item at least ten (10) days prior to the bid date. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.

3.04 EXCAVATION, BACKFILL, AND RESTORATION

- A. Provide in accordance with Division 31 EARTHWORK Sections and as follows.
- B. Conditions Affecting Excavations: The following project conditions apply:
 - 1. Subsurface conditions were investigated during the design of the Project. Reports of these investigations are available for information only; data in the reports are not intended as representations or warranties of accuracy or continuity of conditions. The Owner will not be responsible for interpretations or conclusions drawn from this information. Contact specific utility company immediately for instructions regarding uncharted or incorrectly charted utilities.
 - 2. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by excavation operations.
 - 3. Locate existing underground utilities in excavation areas. If utilities are indicated to remain, support and protect services during excavation operations.
 - 4. Maintain and protect existing building services that transit the area affected by excavation.
 - 5. Remove existing underground utilities indicated to be removed.
 - 6. Use of explosives is not permitted.
 - 7. Where excavation has reached required subgrade elevations, if unsuitable bearing materials are encountered, continue excavation until suitable bearing materials are reached. The Contract Sum may be adjusted by an appropriate Contract Modification.
 - 8. Where surface excavation cannot be used, provide directional boring or horizontal directional drilling for routing conduit below grade. Provide auger type boring machine for soil removal during boring process.

3.05 SUBMITTALS

- A. Provide in accordance with Division 01 Section SUBMITTAL PROCEDURES and as stated below.
- B. Submit for approval a complete Material Source of Supply and Subcontractor list for all electrical work required under this project. Shop drawing submittals will not be reviewed until a complete Material Source of Supply and Subcontractor list is received. Submit this listing as a part of the submittal requirement specified in Division 01.
- C. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect will not be processed.
- D. Prepare and submit detailed shop drawings for materials, systems and equipment as listed herein, including locations and sizes of all openings in floor decks, walls and floors.
- E. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.
- F. All shop drawings shall be stamped by the Contractor, indicating approval, and space shall be provided for the Engineer's stamp and the Architect's stamp.
- G. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and resubmittal as may be required. All submittals shall be complete and contain all required and detailed information.
- H. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing all items of proper dimensions, weight, capacities, sizes, quantity and quality as intended by the Contract. Such acceptance shall not relieve Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.

- I. Each shop drawing shall contain job title and reference to the applicable drawing and specification article, including the contractor's drawings, specifications and verification of compatibility with the systems involved.
- J. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be return without review.
- K. All nameplate data shall be complete at time of equipment submittals - refer to other sections for identification requirements.
- L. For each room or area of the building containing switchboards, panelboards, transformers, and/or emergency generators, coordination drawings are required to be submitted for review and acceptance at the time of the equipment submittal.
- M. Equipment shall not be ordered or purchased until the shop drawing approval is received.
- N. Shop Drawings shall show conformance with specified electrical characteristics, or Contractor shall assume responsibility for all deviations including all additional costs involved for the deviations.
- O. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
 - 1. Low Voltage Electrical Power Cables
 - 2. Grounding and Bonding Equipment
 - 3. Hangers and Supports
 - 4. Raceways and Boxes
 - 5. Lighting Controls
 - 6. Fire Alarm System
 - 7. Panelboards
 - 8. Wiring Devices
 - 9. Fuses
 - 10. Enclosed Switches and Circuit Breakers
 - 11. Emergency Generator
 - 12. Transfer Switches
 - 13. Lightning Protection
 - 14. Light Fixtures
- P. Product Options:
 - 1. The product manufacturers listed in each section are either the product the design is based on or a product that the Engineer feels would be an acceptable substitution if that product can meet the intent of the written specifications and the scheduled capacities. The Electrical Contractor is responsible for ensuring that the substituted product complies with the intent of the specifications, the scheduled capacities and the drawings. Substitutions of manufacturers not listed are not permitted unless prior approval is obtained from the Engineer as required by Part 3.3, SUBSTITUTIONS, of this specification section.
 - 2. It will be the responsibility of the Electrical Contractor to pay any and all costs associated with any approved substitutions that impact the architectural layout, structure, electrical system(s), mechanical systems, and/or the plumbing systems, due to an increase in physical dimensions, weight, electrical requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.

3.06 QUALITY ASSURANCE AND TESTING

- A. Provide in accordance with Division 01 Section QUALITY REQUIREMENTS.
- B. Provide products that are listed and labeled by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Refer to all Division 26 specification sections for additional testing requirements.

3.07 TEMPORARY

- A. Provide in accordance with Division 01 Section TEMPORARY FACILITIES AND CONTROLS and as stated below.
- B. The Electrical Contractor shall provide temporary electric services to the construction areas at locations acceptable to the General Contractor. The service to be provided shall be from the existing electrical system and shall be 3 phase, 4 wire, 208Y/120V, 100 ampere minimum with the necessary distributing facilities. The service shall be installed within fifteen (15) days after written request has been made to the Electrical Contractor, with copies to the Architect and Owner by any contractor requiring such service.
- C. The Electrical Contractor shall provide temporary electric services to the construction trailers at locations acceptable to the General Contractor. The service to be provided shall be from the existing electrical system and shall be 3 phase, 4 wire, 208Y/120V, 100 ampere minimum with the necessary distributing facilities. The service shall be installed within fifteen (15) days after written request has been made to the Electrical Contractor, with copies to the Architect and Owner, by any contractor requiring such service.
- D. Power consumption shall not disrupt Owner's need for continuous service.
- E. The Contractor shall provide power outlets for construction operations, branch wiring, distribution boxes. Each individual contractor will provide flexible power cords as required.
- F. Power required for tools and operating equipment used for the installation of equipment, that exceeds the power available, shall be temporarily installed and removed by the Contractor requiring it.
- G. Provide wiring and connections for temporary heating equipment required for construction purposes and to prevent building freeze up.
- H. Distribution wiring and equipment/devices used for temporary services shall not be installed as part of the permanent building distribution system.
- I. Permanent distribution wiring and equipment/devices shall not be used for temporary services.
- J. The Contractor shall provide temporary lights and all associated wiring as required by the individual prime contractors.
- K. Contractor to remove all temporary wiring and temporary lighting.

3.08 DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 01 Section PRODUCT REQUIREMENTS and as stated below.
- B. Receive, inspect, handle, and store products in accordance with manufacturer's instructions.

- C. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage and handling.
- D. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- E. Coordinate deliveries of electrical materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

3.09 CUTTING AND PATCHING

- A. Provide in accordance with Division 01 Section EXECUTION.

3.10 INSTALLATIONS

- A. Provide in accordance with Division 01 Section EXECUTION and as stated below.
- B. Verify all dimensions by field measurements.
- C. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- D. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
- E. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible.
- F. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
- G. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
- H. Install electrical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.
- I. Install access panel or doors where units are concealed behind finished surfaces.
- J. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
- K. Obtain written approval of locations of all electrical devices from the Owner and Architect prior to rough-in. The owner reserves the right to move any or all electrical devices prior to rough-in, at no additional cost.
- L. Verify final locations for rough-ins with field measurements and with the requirements of the actual equipment to be connected.

- M. Obtain approval from the Architect before drilling or cutting structural members.
- N. Holes cut into reinforced concrete beams or in concrete shall not cut reinforcing bars. If the Contractor cuts into any reinforcing bars, stop work and notify the Architect immediately.
- O. Refer to equipment specifications in Divisions 02 through 33 for rough-in requirements for equipment furnished under other contracts.
- P. Door swings may vary from plans. Make note of actual door swings at time of rough-in. Do not install switches or other items behind the swing of any door.
- Q. The installation shall be subject to such revisions as may be necessary to overcome building obstructions.
- R. Provide connections to all electrically operated equipment furnished under other sections and/or divisions of this project specification. Verify all power connections with submitted manufacturer's written recommendations prior to installation and prior to energizing circuit.
- S. Inspect areas and conditions under which electrical connections for equipment that will be installed and notify the Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in a manner acceptable to the Contractor.
- T. Verify that equipment is ready for electrical connection, wiring, and energization.
- U. Install all in-line power control, protection, and disconnection devices furnished by others that are not an integral part of the equipment. These devices shall be located in accordance with the Contractor furnishing the devices and the requirements of the NEC.
- V. Provide for proper rotation of all three phase motors.
- W. Work improperly placed because of Contractor's failure to obtain the above information shall be relocated and reinstalled as directed, without additional costs to the Contract. No charges shall be made in location of equipment without prior written approval.

3.11 FINAL CLEANING

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES.

3.12 WARRANTIES

- A. Provide in accordance with Division 01 Section CLOSEOUT PROCEDURES and as stated below.
- B. Refer to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- C. Compile and assemble the warranties specified in Division 26 into a separated set of vinyl covered, three ring binders, tabulated and indexed for easy reference.
- D. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.

- E. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner and Architect. Obtain similar warranties from subcontractors, manufacturers, suppliers and sub-trade specialists.
- F. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or that are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

3.13 MAINTENANCE MANUALS

- A. Provide in accordance with Division 01 Section OPERATION AND MAINTENANCE DATA and as stated below.
- B. Include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, performance curves, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's printed operating procedures to include start-up, break-in, and routine and normal operating instructions; regulation, control, stopping, shutdown, and emergency instructions; and summer and winter operating instructions.
 - 3. Maintenance procedures for routine preventative maintenance and troubleshooting; disassembly, repair, and reassembly; aligning and adjusting instructions.
 - 4. Servicing instructions and lubrication charts and schedules.
 - 5. Provide a cover sheet for each manual including the project name, Architect's name and contact information, Engineer's name and contact information, and Division 26 contractor's name and contact information.
 - 6. Alphabetical list of all system components, with the name, address, and 24-hour phone number of the company responsible for servicing each item during the first year of operation.
 - 7. Manufacturer's data of each piece of equipment including:
 - a. Installation instructions.
 - b. Drawings and Specifications.
 - c. Parts list, including recommended items to be stocked.
 - d. Complete wiring diagrams.
 - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
 - f. Test and inspection certificates.

3.14 RECORD DOCUMENTS

- A. Provide in accordance with Division 01 Section PROJECT RECORD DOCUMENTS and as stated below.
- B. Indicate installed conditions for the following:
 - 1. Raceway systems, size and location, for both exterior and interior.
 - 2. Locations of control devices.
 - 3. Distribution and branch electrical circuitry.
 - 4. Fuse and circuit breaker size and arrangements.
 - 5. Equipment locations (exposed and concealed), dimensioned from prominent building lines.
 - 6. Approved substitutions, Contract Modifications, and actual equipment and materials installed.
 - 7. Engage the services of a Land Surveyor or Professional Engineer registered in the state in which the project is located as specified in Division 01 to record the locations and invert elevations of underground installations.

3.15 DEMONSTRATION AND TRAINING

- A. Provide in accordance with Division 01 Section DEMONSTRATION AND TRAINING and as stated below.
- B. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.
- C. The following is a list systems that require Demonstration and Training, refer to the individual specification sections for additional training requirements:
 - 1. Lighting Controls
 - 2. Fire Alarm System
 - 3. Panelboards
 - 4. Enclosed Switches and Circuit Breakers
 - 5. Emergency Generator
 - 6. Transfer Switches

END OF SECTION 26 0100

SECTION 26 0519 - LOW VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Copper building wire rated 600 V or less.
 - 2. Metal clad cable, Type MC, rated 600 V or less.
 - 3. Connectors, splices, and terminations rated 600 V and less.

1.03 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
 - 1. Product Data: Submit manufacturer's data for electrical wires, cables and connectors.

PART 2 - PRODUCTS

2.01 COPPER BUILDING WIRE

- A. Description: Flexible, insulated, drawn copper current-carrying conductor with an overall insulation layer and jacket, rated 600 V or less.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Cerro Wire
 - 1. Colonial Wire and Cable Company
 - 2. Encore Wire Corporation
 - 3. General Cable Corporation
 - 4. Nehring Electrical Works Company
 - 5. Okonite Company
 - 6. Service Wire Company
 - 7. Southwire Company
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. RoHS compliant.

- 3. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Conductors: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors.
- E. Conductor Insulation:
 - 1. Type THHN/THWN-2: Comply with UL 83.

2.02 METAL CLAD CABLE, TYPE MC

- A. Description: A factory assembly of one or more current-carrying insulated conductors in an overall metallic sheath.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. AFC Cable Systems
 - 2. Encore Wire Corporation
 - 3. Okonite Company
 - 4. Service Wire Company
 - 5. Southwire Company
- C. Standards:
 - 1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
 - 2. Comply with UL 1569.
 - 3. RoHS compliant.
 - 4. Conductor and Cable Marking: Comply with wire and cable marking according to UL's "Wire and Cable Marking and Application Guide."
- D. Circuits: Single circuit and multi-circuit with color-coded conductors as required.
- E. Conductors for branch circuits, #8AWG and smaller: Copper, complying with ASTM B 3 for bare annealed copper and with ASTM B 8 for stranded conductors
- F. Ground Conductor: Insulated.
- G. Conductor Insulation: Type THHN/THWN-2: Comply with UL 83.
- H. Armor: Steel, interlocked.
- I. Jacket: PVC applied over armor.

2.03 SO MULTICONDUCTOR FLEXIBLE CORD

- A. Cord Construction: Oil-resistant thermoset insulated type with identified equipment ground conductor, suitable for (extra) hard usage in damp locations.
- B. Cord Size: Suitable for connected load of equipment and rating of branch circuit overcurrent protection.

2.04 CONNECTORS AND SPLICES

- A. Description: Factory-fabricated connectors, splices, and lugs of size, ampacity rating, material, type, and class for application and service indicated; listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use. Use connectors with temperature ratings equal to or greater than those of the wires upon that are used.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. 3M Electrical Products
 - 2. AFC Cable Systems
 - 3. Burndy
 - 4. Hubbell Power Systems
 - 5. Ideal Industries
 - 6. ILSCO
 - 7. NSi Industries
 - 8. O-Z/Gedney
 - 9. TE Connectivity
 - 10. Thomas and Betts Corporation
- C. Jacketed Cable Connectors: For steel jacketed cables, zinc die-cast with set screws, designed to connect conductors specified in this Section.
- D. Lugs: One piece, seamless, designed to terminate conductors specified in this Section.
 - 1. Material: Match conductor material.
 - 2. Termination: Compression.

2.05 COLOR CODING

- A. Color Coding of Conductors - factory applied the entire length of conductors, provide the following:
 - 1. 208/120V through 240V Conductors:
 - a. Phase A: Black
 - b. Phase B: Red
 - c. Phase C: Blue
 - d. Neutral: White

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE AND HANDLING

- A. Each length, bundle, or reel of wire and cable delivered to job site shall bear manufacturer's name, catalog number and trademark, UL label, type letters, size, length and manufacturing date.
- B. Deliver wire and cable properly packaged in factory fabricated type containers, or wound on NEMA specified type wire and cable reels.
- C. Store wire and cable in clean dry space in original containers. Protect products from weather, damaging fumes, construction debris, and traffic.

- D. Handle wire and cable carefully to avoid abrading, puncturing and tearing wire and cable insulation and sheathing. Ensure that dielectric resistance integrity of wires/cables is maintained.

3.02 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper, stranded.
- B. Branch Circuits: Copper. Solid or stranded.

3.03 CONDUCTOR INSULATION AND MULTI-CONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Feeders:
 - 1. Exposed Feeders: Type THHN/THWN-2, single conductors in raceway.
 - 2. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN/THWN-2, single conductors in raceway.
 - 3. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- B. Branch Circuits:
 - 1. Exposed Branch Circuits, Including in Crawlspace: Type THHN/THWN-2, single conductors in raceway.
 - 2. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN/THWN-2, single conductors in raceway and /or Metal clad cable, Type MC. Provide Type MC cable only for concealed branch circuit wiring in drywall partitions and above accessible ceilings. MC cable shall terminate in a junction box above the finished ceiling of space served by circuiting. All homeruns from branch panelboards shall be routed to space served in EMT conduit, unless otherwise specified. MC cable will not be used as the homerun from space served to panelboard of origin, unless otherwise specified.
 - 3. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN/THWN-2, single conductors in raceway.
- C. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

3.04 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.
- B. Provide wire and cable suitable for temperature, conditions and location; and install in compliance with the NEC.
- C. Minimum wire size shall be #12 AWG for all wiring, with the following exceptions:
 - 1. If the distance between the panelboard and the first circuit load is greater than 100 feet, the minimum wire size shall be #10 AWG.
 - 2. All emergency lighting circuit wiring shall be #10 AWG or larger.
 - 3. Conductors and cables for communications and signal systems shall be as described in respective specification sections and as recommended and approved by manufacturer.
- D. Provide dedicated neutrals for all single-phase branch circuits.

- E. Complete raceway installation between conductor and cable termination points according to Section 26 0533 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.
- F. Use manufacturer-approved pulling compound or lubricant where necessary; compound used must not deteriorate conductor or insulation. Do not exceed manufacturer's recommended maximum pulling tensions and sidewall pressure values.
- G. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.
- H. Pull conductors simultaneously where more than one is being installed in same raceway.
- I. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- J. Support cables according to Section 26 0529 "Hangers and Supports for Electrical Systems."
- K. MC cable shall be neatly trained and supported clear of ceiling tile and ceiling grid by means of metallic straps or clips. The use of nylon tie wraps to support MC cable from the structure is prohibited. Supports for MC cable shall be independent from supports for other systems (i.e., light fixtures, ceiling grid, mechanical systems) and the supports for the MC cable shall be directly connected to the structure.
- L. Provide adequate length of conductors within electrical enclosures and train the conductors to terminal points with no excess. Bundle multiple conductors, with conductors larger than #10 AWG cabled in individual circuits. Make terminations so there is no bare conductor at the terminal.
- M. Conductor/cable supports for vertical runs shall be provided in top cabinet or pull box of all feeders in accordance with NEC requirements.

3.05 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.
- B. Splices:
 - 1. Keep conductor splices to minimum.
 - 2. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
 - 3. Splicing of #10 wires and smaller shall be made with Scotchlok or as approved.
 - 4. Splicing of #8 wire and larger shall be made by means of compression type connectors and installed with a proper tool and then insulated to same dielectric value as the original insulation with plastic tape.
 - 5. Splices are not permitted in conductors larger than #10, except where specifically called for.
 - 6. All splicing shall be made in outlet boxes or junction boxes.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.06 IDENTIFICATION

- A. Identify and color-code conductors and cables according to Section 26 0553 "Identification for Electrical Systems."

3.07 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".

3.08 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Section 26 0544 "Sleeves and Seals for Electrical Systems".

3.09 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.
- B. Perform each of the following visual and electrical tests:
 - 1. Inspect exposed sections of conductor and cable for physical damage and correct connection according to the single-line diagram.
 - 2. Test bolted connections for high resistance using one of the following:
 - a. A low-resistance ohmmeter.
 - b. Calibrated torque wrench.
 - c. Thermographic survey.
 - 3. Inspect compression-applied connectors for correct cable match and indentation.
 - 4. Inspect for correct identification.
 - 5. Inspect cable jacket and condition.
 - 6. Insulation-resistance test on each conductor for ground and adjacent conductors. Apply a potential of 500-V dc for 300-V rated cable and 1000-V dc for 600-V rated cable for a one-minute duration.
 - 7. Continuity test on each conductor and cable.
 - 8. Uniform resistance of parallel conductors.
- C. Cables will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports to record the following:
 - 1. Procedures used.
 - 2. Results that comply with requirements.
 - 3. Results that do not comply with requirements, and corrective action taken to achieve compliance with requirements.

END OF SECTION 26 0519

SECTION 26 0526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes solid grounding of electrical systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.

1.03 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
 - 1. Product data for ground rods, connectors and connection materials, and grounding fittings.
 - 2. Qualification Data: For testing agency and testing agency's field supervisor.
 - 3. Field quality control reports.

1.04 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.
- C. Materials: Copper with 98% conductivity.

2.02 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. B-Line Systems Inc.
 - 2. Burndy Corporation
 - 3. Erico International

4. ILSCO
5. O-Z/Gedney
6. Thomas and Betts Corporation

2.03 CONDUCTORS

- A. Comply with Division 26 Section 26 0519 " Low Voltage Electrical Power Conductors and Cables."
- B. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction, green insulation.
- C. Bare Copper Conductors: Stranded Conductors: ASTM B 8.
- D. Copper Bonding Conductors:
 1. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch in diameter.
 2. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 3. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; 1-5/8 inches wide and 1/16 inch thick.
- E. Grounding Bus: Pre-drilled rectangular bars of annealed copper, 24 inch long, 1/4 inch by 4 inches in cross section, with 9/32-inch holes spaced 1-1/8 inches apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.04 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors:
 1. Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
 2. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - a. nVent ERICO Cadweld
 - b. Hubbell Continental Industries thermOweld
- C. Bus-Bar Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar or compression type, copper or copper alloy, with two wire terminals.
- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Bonding Strap: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.
- H. Flexible Jumper Strap: Flexible flat conductor, 480 strands of 30-gauge bare copper wire; 3/4" wide, 9-1/2" long. Protect braid with copper bolt hole ends with holes sized for 3/8" diameter bolts.

- I. Water Pipe Clamps: Mechanical type, die-cast zinc alloy, two pieces with stainless-steel bolts.

2.05 GROUNDING ELECTRODES

- A. Ground Rods: 13-mil copper-bonded steel, 3/4 inch by 8 feet.

2.06 ACCESSORIES

- A. Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type services indicated.

PART 3 - EXECUTION

3.01 APPLICATIONS

- A. Equipment Grounding
 - 1. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - a. Feeders and branch circuits.
 - b. Lighting circuits.
 - c. Receptacle circuits.
 - d. Single-phase motor and appliance branch circuits.
 - e. Three-phase motor and appliance branch circuits.
 - f. Flexible raceway runs.
 - g. Metal-clad cable runs.
 - 2. Air Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping. Install bonding jumper to bond across flexible duct connections to achieve continuity.
 - 3. Poles Supporting Outdoor Lighting Fixtures: In addition to grounding conductor installed with branch circuit conductors, install a grounding electrode at each pole connected to ground lug in pole handhole.
- B. Grounding and Bonding for Gas Piping: Bond each above-ground portion of gas piping system downstream from equipment shutoff valve.
- C. Telecommunications Grounding
 - 1. Install ground bus in rooms housing service equipment and elsewhere as indicated on drawings. Install horizontally, on insulated spacers 2 inches minimum from wall, 6 inches above finished floor unless otherwise indicated.
 - 2. Provide a #3/0 AWG green insulated copper conductor, unless noted otherwise, from the grounding electrode system to each ground bus location.
- D. Fence Grounding
 - 1. Metallic Fences: Comply with requirements of IEEE C2.
 - 2. Fence Grounding: Install at maximum intervals of 300 feet except as follows:
 - a. Fences within 100 Feet of Buildings, Structures, Walkways, and Roadways: Ground at maximum intervals of 100 feet.

3. Gates and Other Fence Openings: Ground fence on each side of opening.
 - a. Bond across openings, with and without gates, except at openings indicated as intentional fence discontinuities. Use No. 2 AWG wire and bury it at least 18 inches below finished grade.
 - b. Connect flexible bonding jumper between gate post and gate frame.
4. Grounding Method: At each grounding location, drive a grounding rod vertically until the top is 6 inches below finished grade. Connect rod to fence with No. 6 AWG conductor. Connect conductor to each fence component at grounding location.
5. Bonding to Lightning-Protection System: If fence terminates at lightning-protected building or structure, ground the fence and bond the fence grounding conductor to lightning-protection down conductor or lightning-protection grounding conductor, complying with NFPA 780.

E. Service Grounding

1. Connect equipment grounding conductors and grounding electrode conductors to the ground bus.
2. Install a main bonding jumper between the neutral and ground buses.
3. Metallic Water Service Pipe:
 - a. Provide insulated copper ground conductors, sized as indicated, from the building main service equipment, or the ground bus, to main metallic water service entrances to the building. Connect ground conductors to the main metallic water service pipes by means of ground clamps. Where a dielectric main water fitting is installed, connect the ground conductor to the street side of the fitting. Do not install a grounding jumper around dielectric fittings.
 - b. Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
4. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; use a minimum of 20 feet of bare copper conductor, No. 3/0 AWG, unless noted otherwise.
 - a. If concrete foundation is less than 20 feet long, coil excess conductor within base of foundation.
 - b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
5. Grounding Triad: Install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
6. Ground Ring:
 - a. Ground the steel framework of the building with a driven ground rod at the base of every corner column and at intermediate exterior columns at distances not more than 60 feet apart. Provide a grounding conductor (counterpoise), electrically connected to each ground rod and to each steel column, extending around the perimeter of the building.
 - b. Install tinned-copper conductor, No. 3/0 AWG unless noted otherwise, for ground ring and for taps to building steel.
 - c. Bury ground ring not less than 24 inches from building's foundation.
7. Test Wells: Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.

F. Grounding Separately Derived Systems

1. Install grounding electrode(s) at the generator location. The electrode shall be connected to the equipment grounding conductor and to the frame of the generator.

G. Grounding Underground Distribution System Components

1. Comply with IEEE C2 grounding requirements.
2. Grounding practices of the local utility company may differ from requirements in "Grounding Manholes and Handholes," "Grounding Connections to Manhole Components," and "Pad-Mounted Transformers and Switches" paragraphs below. Although grounding specified in this article is not for the utility company's use and does not have to comply with its standards, it is possible that the utility company may be requested to repair or maintain the line in the future. For this reason, it may be desirable to design some grounding features according to the utility company's standards. Utility companies, for economic reasons, often design to a standard lower than what is appropriate for Project requirements. Alternatively, because of their experience with conditions in their service area, utility companies may design to a higher standard than is required by Code. In addition to Project requirements, evaluate the local utility company's practices and revise paragraphs accordingly. This evaluation is particularly important if Project's underground lines connect with utility lines. Coordinate with Drawings and with Section 260543 "Underground Ducts and Raceways for Electrical Systems."
3. Grounding Handholes: Install a driven ground rod through handhole floor, close to wall, and set rod depth so 4 inches will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches above to 6 inches below concrete. Seal floor opening with waterproof, non-shrink grout.

- H. Ground Bonding Common with Lightning Protection System: Comply with NFPA 780 and UL 96 when interconnecting with lightning protection system. Bond electrical power system ground directly to lightning protection system grounding conductor at closest point to electrical service grounding electrode. Use bonding conductor sized same as system grounding electrode conductor, and install in conduit.

3.02 INSTALLATION

- A. Grounding Conductors: Route along shortest and straightest paths possible unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage. Terminate insulated equipment grounding conductors with pressure-type grounding lugs.
- B. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment. Use braided type bonding jumpers for flexible bonding and grounding connections.
 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.
- C. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.
1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
 2. Make connections with clean, bare metal at points of contact.
 3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
 4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
 5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

6. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.
 7. Exothermic Welded Connections:
 - a. Comply with manufacturer's written recommendations.
 - b. Use for connections to structural steel and for underground connections.
 - c. Install at connections to ground rods.
 - d. Comply with AWS Code for procedures, appearance, and quality of welds; and methods used in correcting welding work.
 - e. Welds that are puffed up or that show convex surfaces indicating improper cleaning are not acceptable.
 8. Provide connections as follows:
 - a. Equipment Grounding Conductor Terminations: Bolted connectors.
 - b. Pipe Grounding Conductor Terminations: Bolted connectors.
 - c. Underground Connections: Welded connectors.
 - d. Connections to Structural Steel: Welded connectors.
 - e. Connections to Ground Rods at Test Wells: Bolted connectors.
- D. Ground Rods: Drive rods until tops are 2 inches below finished floor or final grade unless otherwise indicated.
1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 2. Use exothermic welds for all below-grade connections.
- E. Underground Grounding Conductors: Install bare copper conductor, No. 3/0 AWG, unless noted otherwise. Bury at least 24 inches below grade.

3.03 FIELD QUALITY CONTROL

- A. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.
- B. Tests and Inspections:
1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.
 3. Test completed grounding system at service disconnect enclosure grounding terminal at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 - c. Prepare test and inspection reports.
 - d. Excessive Ground Resistance: If resistance to ground exceeds 5 ohms, notify Engineer promptly and include recommendations to reduce ground resistance.
 - e. Provide approved method to reduce ground resistance and retest.
- C. Grounding system will be considered defective if it does not pass tests and inspections.

END OF SECTION 26 0526

SECTION 26 0529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Steel slotted support systems.
 - 2. Aluminum slotted support systems.
 - 3. Nonmetallic slotted support systems.
 - 4. Conduit and cable support devices.
 - 5. Structural steel for fabricated supports and restraints.
 - 6. Mounting, anchoring, and attachment components, including powder-actuated fasteners, mechanical expansion anchors, concrete inserts, clamps, through bolts, toggle bolts, and hanger rods.
 - 7. Fabricated metal equipment support assemblies.

1.03 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
 - 1. Product Data: Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Preformed steel channels and angles with minimum 13/32-inch diameter holes at a maximum of 8 inches o.c. in at least one surface.
 - 1. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - a. B-Line/Eaton
 - b. Caddy/Pentair
 - c. Flex-Strut, Inc.
 - d. G-Strut/Gregory Industries, Inc.
 - e. Haydon Corporation
 - f. Jet Stream International
 - g. Madison Electric Products
 - h. Minerallac Company
 - i. Power-Strut/Atkore

- j. Superstrut/Thomas & Betts
 - k. Unistrut/Aatkore
 - l. Westrut/Wesanco
 - 2. Standard: Comply with MFMA-4 factory fabricated components for field assembly.
 - 3. Material for Channel, Fittings, and Accessories: Steel.
 - 4. Channel Width: Selected for applicable load criteria.
 - 5. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 6. Connect with machine bolts to form rigid supports.
 - 7. Protect finishes on exposed surfaces from damage by applying a strippable, temporary protective covering before shipping.
- B. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- C. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M steel plates, shapes, and bars; black and galvanized.
- D. Mounting, Anchoring, and Attachment Components - items for fastening electrical items or their supports to building surfaces include the following:
- 1. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - a. B-Line/Eaton
 - b. Empire Industries
 - c. Hilti, Inc.
 - d. MKT Anchoring Systems
 - e. Ramset/ITW
 - f. Rawlplug
 - g. Red Head/ITW
 - h. Simpson Strong-Tie Company
 - 2. Powder Actuated Fasteners: Threaded-steel stud, for use in hardened portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 3. Mechanical Expansion Anchors: Insert-wedge-type, stainless steel, for use in hardened portland cement concrete, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - 4. Concrete Inserts: Steel or malleable-iron, slotted support system units are similar to MSS Type 18 units and comply with MFMA-4 or MSS SP-58.
 - 5. Clamps for Attachment to Steel Structural Elements: MSS SP-58 units are suitable for attached structural element.
 - 6. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM F 3125/F 3125M, Grade A325 (Grade A325M).
 - 7. Toggle Bolts: Stainless steel springhead type.
 - 8. Hanger Rods: Threaded steel.

PART 3 - EXECUTION

3.01 APPLICATION

- A. Maximum Support Spacing and Minimum Hanger Rod Size for Raceways: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings that are less than those stated in NFPA 70. Minimum rod size shall be 1/4 inch in diameter.

- B. Boxes, Enclosures and Cabinets:
 - 1. Install surface mounted cabinets with minimum of four anchors.
 - 2. In wet and damp location use steel channel supports to stand cabinets one inch off wall.
 - 3. Use sheet metal channel to bridge studs above and below cabinets recessed in hollow partitions.
- C. Metal Items for Use Outdoors or in Damp Locations: Hot-dip galvanized steel.
- D. Use vibration and shock resistant fasteners for attachments to concrete slabs.
- E. Provide vibration and shock resistant fasteners for all moving equipment where the energy of the vibration is of sufficient magnitude to produce perceptible vibration or structure transmitted noise in occupied areas. Isolation equipment shall be selected, installed and adjusted in accordance with manufacturer's recommendations. All equipment and material shall be installed so as to operate without objectionable noise or vibration as determined by Architect and Owner. Should such objectionable noise or vibration be produced and transmitted to occupied portions of the building by apparatus, piping or other parts of this work, any necessary changes as approved shall be made by the Contractor.

3.02 SUPPORT INSTALLATION

- A. Unless otherwise indicated, fasten all electrical items and their supporting hardware securely to the building structure.
- B. Coordinate with the building structural system and other electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- C. Raceway Support Methods:
 - 1. In addition to methods described in NECA 1, conduit may be supported by openings through structure members, according to NFPA 70.
 - 2. Strength of each support shall be adequate to carry present and future load multiplied by a safety factor of at least four. Where this determination results in a safety allowance of less than 200 pounds, provide additional strength until there is a minimum of 200 pounds safety allowance in the strength of each support.
 - 3. Support individual horizontal raceways by separate pipe hangers.
 - 4. Support parallel runs of horizontal raceways together on trapeze-type hangers.
 - 5. Install individual and multiple (trapeze) raceway hangers and riser clamps as necessary to support raceways.
 - 6. Provide U-bolts, clamps, attachments, and other hardware necessary for hanger assembly and for securing hanger rods and conduits.
 - 7. Secure raceways to steel slotted supports with spring nuts using spring friction action for retention in support channel.
 - 8. Spring steel fasteners may be used only for 3/4" raceways above suspended ceilings. For hanger rods with spring steel fasteners, use 1/4 inch diameter or larger threaded steel. Use spring steel fasteners that are specifically designed for supporting single conduits or tubing.
 - 9. In vertical runs, arrange support so the load produced by the weight of the raceway and the enclosed conductors is carried entirely by the conduit supports with no weight load on raceway terminals. Install simultaneously with installation of conductors.
- D. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 pounds.

- E. Mounting and Anchorage of Surface Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
 - 1. To Wood: Fasten with lag screws or through bolts.
 - 2. To New Concrete: Bolt to concrete inserts.
 - 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 - 4. Instead of expansion anchors, powder actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches thick.
 - 5. To Steel: Beam clamps (MSS SP-58, Type 19, 21, 23, 25, or 27), complying with MSS SP-69.
 - 6. To Light Steel: Sheet metal screws.
 - 7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- F. Install hangers, supports, clamps and attachments to support raceways, boxes, enclosures and cabinets properly from building structure.
- G. Install supports with spacings indicated and in compliance with NEC requirements.
- H. Drill holes for expansion anchors in concrete at locations and to depths that avoid the need for reinforcing bars.
- I. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
- J. Do not weld conduit, pipe straps, or items other than threaded studs to steel structures.
- K. The use of clips or clip-on type supports is not acceptable.

3.03 CONCRETE BASES

- A. Unless otherwise indicated, construction of all concrete equipment foundations required for equipment furnished under Division 26 of specifications shall be this Contractor's responsibility. Foundations shall be sufficient size to suit equipment furnished, as approved.
- B. Construct concrete bases of dimensions indicated, but not less than 4 inches larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- C. Use 3000-psi, 28-day compressive-strength concrete.
- D. All exposed surfaces, except those that have steel protection, shall be finished with cement mortar, troweled smooth, with chamfered corners.
- E. Anchor equipment to concrete base as follows:
 - 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 - 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.04 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils.
- B. Touchup: Comply with requirements in Section 09 9113 "Exterior Painting", Section 09 9123 "Interior Painting" and/or Section 099600 "High-Performance Coatings for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing repair paint to comply with ASTM A 780.

END OF SECTION 26 0529

SECTION 26 0533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 08 Section "OPENINGS" for Access Doors.

1.02 SUMMARY

- A. This Section includes raceways for electrical wiring. Types of raceways in this section include the following:
 - 1. Conduits and fittings
 - 2. Boxes, enclosures, and cabinets
 - 3. Handholes and boxes for underground cabling
 - 4. Access doors

1.03 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections:
 - 1. Product Data - submit manufacturer's data for the following:
 - a. Conduits and fittings
 - b. Boxes, enclosures, and cabinets
 - c. Handholes
 - d. Access doors

PART 2 - PRODUCTS

2.01 METAL CONDUITS AND FITTINGS

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. AFC Cable Systems/Konkore
 - 2. Allied Tube & Conduit
 - 3. Anamet Electrical, Inc.
 - 4. Arlington
 - 5. Bridgeport
 - 6. Calconduit
 - 7. Crouse-Hinds/Eaton
 - 8. Electri-Flex
 - 9. Flexotek
 - 10. KonKore

11. Korkap
12. NEC, Inc.
13. O-Z/Gedney
14. Nucor (Republic Conduit)
15. Patriot Aluminum Products
16. Perma-Cote
17. Phoenix
18. Picoma Industries, Inc.
19. Plasti-Bond
20. RACO/Hubbell
21. Southwire Company
22. Teddico Electrical Products
23. Thomas & Betts/ABB
24. Topaz Electric
25. Western Tube
26. Wheatland Tube

- B. Metallic Conduit: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
1. Electrical Metallic Tubing (EMT): Comply with ANSI C80.3 and UL 797.
 2. Flexible Metal Conduit (FMC): Comply with UL 1; zinc-coated steel.
 3. Liquid-tight Flexible Metal Conduit (LFMC): Flexible steel conduit with PVC jacket and complying with UL 360.
 4. Rigid Metal Conduit (RMC): Comply with ANSI C80.1 and UL 6.
- C. Metal Fittings: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application. Comply with NEMA FB 1 and UL 514B.
1. Fittings for EMT: Steel, compression type.
 2. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.
 3. Fittings for FMC:
 - a. Straight Terminal Connectors: One piece body, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.
 - b. 45° or 90° Terminal Angle Connectors: Two-piece body construction with removable upper section, female end with clamp and deep slotted machine screw for securing conduit, and male threaded end provided with locknut.
 4. Fittings for LFMC: Cadmium plated, steel fittings with compression type steel ferrule and neoprene gasket sealing rings, with insulated, or non-insulated throat.
 5. Fittings for RMC: Threaded.
 6. Joint Compound for RMC: Approved, as defined in NFPA 70, by authorities having jurisdiction for use in conduit assemblies, and compounded for use to lubricate and protect threaded conduit joints from corrosion and to enhance their conductivity.

2.02 NONMETALLIC CONDUITS AND FITTINGS

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
1. AFC Cable Systems
 2. Allied Tube & Conduit
 3. Anamet Electrical, Inc.
 4. Cantex, Inc.
 5. Electri-Flex

6. FRE Composites
 7. Heritage Plastics
 8. JM Eagle
 9. Kraloy
 10. National Pipe & Plastics
 11. RACO/Hubbell
 12. Southern Pipe, Inc.
 13. Teddico Electrical Products
 14. Thomas & Betts, Corporation
 15. Topaz Electric
 16. United Fiberglass
- B. Nonmetallic Conduit: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
1. Rigid Nonmetallic Conduit (RNC): Type EPC-40-PV or EPC-80-PV, complying with NEMA TC 2 and UL 651 unless otherwise indicated.
 2. Liquidtight Flexible Nonmetallic Conduit (LFNC): Comply with UL 1660.
- C. Nonmetallic Fittings: Listed and labeled for type of conduit, location, and use.
1. Fittings for RNC: Comply with NEMA TC 3; match to conduit or tubing type and material.
 2. Solvents and Adhesives: Provide product and installation as recommended by conduit manufacturer.

2.03 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
1. Adalet
 2. Appleton Electric/Emerson
 3. Cope
 4. Crouse-Hinds/Eaton
 5. FSR Inc.
 6. Hoffman/Pentair
 7. Kraloy
 8. Milbank Manufacturing
 9. OZ/Gedney
 10. RACO/Hubbell
 11. Spring City Electrical Manufacturing
 12. Steel City/Thomas & Betts Company
 13. Topaz Electric
 14. Wiegmann/Hubbell
- B. Device Boxes
1. Provide size as required by drawings, minimum 2-1/8 inches deep. Boxes shall be one-piece type, gangable boxes are prohibited.
 2. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
 3. Cast Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
 4. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing 50 pounds. Outlet boxes designed for attachment of luminaires weighing more than 50 pounds shall be listed and marked for the maximum allowable weight.
 5. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

- C. Pull and Junction Boxes
 - 1. Sheet Metal Pull and Junction Boxes: NEMA OS 1.
 - 2. Cast Metal Pull and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
 - 3. Boxes shall have screwed or bolted on covers of material same as box and shall be of size and shape to suit application.
- D. Cabinets and Hinged Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1, Type 3R, or Type 4 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: 14-gauge steel minimum, finished inside and out with manufacturer's standard enamel.
 - 2. Nonmetallic Enclosures: Fiberglass.
 - 3. Metal barriers to separate wiring of different systems and voltage.
 - 4. Key latch to match panelboards.
 - 5. Accessory feet where required for freestanding equipment.
 - 6. Provide painted removable internal mounting panel for component installation.
- E. Accessories
 - 1. Provide accessories as required for each installation.
 - 2. Provide box supports, mounting ears and brackets, box extension rings, fixture studs, cable clamps and metal straps for supporting boxes, that are compatible with boxes being used to fulfill installation requirements for individual wiring situations.
 - 3. Provide corrosion-resistant box knockout closures, conduit locknuts and malleable iron conduit bushings, offset connectors, of types and sizes to suit respective installation requirements and applications.
 - 4. Provide stainless steel screws and hardware unless noted otherwise.

2.04 HANDHOLES AND BOXES FOR UNDERGROUND WIRING

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Armormat
 - 2. Martin Enterprises
 - 3. NewBasis
 - 4. Oldcastle Enclosure Solutions
 - 5. Quazite/Hubbell
- B. General Requirements for Handholes and Boxes:
 - 1. Boxes and handholes for use in underground systems shall be designed and identified as defined in NFPA 70, for intended location and application.
 - 2. Boxes installed in wet areas shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Polymer-Concrete Handholes and Boxes with Polymer-Concrete Cover:
 - 1. Material: Molded of sand and aggregate, bound together with polymer resin, and reinforced with steel, fiberglass, or a combination of the two.
 - 2. Standard: Comply with SCTE 77.
 - a. For installations in parking lots, roadways, etc., provide Tier 15 enclosure
 - b. For all other installations, provide Tier 5 enclosure.
 - 3. Configuration: Designed for flush burial with open bottom unless otherwise indicated.

4. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure and handhole location.
5. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
6. Cover Legend: Molded lettering, refer to drawings for labeling.
7. Conduit Entrance Provisions: Conduit-terminating fittings shall mate with entering ducts for secure, fixed installation in enclosure wall.
8. Dimension: Minimum 11 inches wide by 18 inches long x 24 inches deep, unless noted otherwise on the drawings.

2.05 ACCESS DOORS

- A. Manufacturers - subject to compliance with requirements, provide products by one of the following:
 1. Babcock-Davis
 2. JL Industries, Inc.
 3. Karp Associates, Inc.
 4. Milcor
 5. Nystrom, Inc.
- B. General:
 1. Provide access door and frame assemblies manufactured as integral units ready for installation.
 2. Provide factory fabricated and assembled units, complete with attachment devices and fasteners ready for installation. Joints and seams shall be continuously welded steel, with welds ground smooth and flush with adjacent surfaces.
 3. Refer to Section 08 3113 'Access Doors and Frames' for additional requirements.
- C. Materials:
 1. Face of door flush with frame, with exposed flange and concealed hinge.
 2. Uncoated Steel Sheet for Door: Nominal 0.060 inch, 16 gauge, factory finished.
 3. Frame Material: Same material and thickness as door.
 4. Latch and Lock: Cam latch, screwdriver operated
 5. Fire Rated Units:
 - a. Insulated flush panel doors, with continuous piano hinge and self-closing mechanism.
 - b. Fire-Resistance Rating: Not less than that of adjacent construction.
 - c. Provide with UL label.

PART 3 - EXECUTION

3.01 APPLICATION

- A. Raceways
 1. Minimum Raceway Size: 3/4-inch trade size.
 2. Indoor Installations: Apply raceway products as specified below unless otherwise indicated:
 - a. Exposed: EMT.
 - b. Concealed in Ceilings and Interior Walls and Partitions: EMT or MC cable. Provide Type MC cable only for concealed branch circuit wiring in drywall partitions and above accessible ceilings. MC cable shall terminate in a junction box above the finished ceiling of space served by circuiting. All homeruns from branch panelboards shall be routed to space served in EMT conduit, unless otherwise specified.

MC cable will not be used as the homerun from space served to panelboard of origin, unless otherwise specified.

- c. Concealed in masonry walls: PVC. Transition PVC conduit to metal conduit prior to exiting masonry wall using female adapter on PVC conduit for connection to male adapter on metal conduit. This shall provide one continuous raceway into masonry wall.
 - d. Final connection to recessed and semi-recessed lighting fixtures, not to exceed 72": FMC.
 - e. Damp or Wet Locations: RMC.
 - f. Corrosive Environments: LFMC.
 - g. Connection to Vibrating Equipment (Including Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
3. Outdoor Installations - apply raceway products as specified below unless otherwise indicated:
- a. Exposed Conduit: RMC.
 - b. Concealed Conduit, Aboveground: RMC.
 - c. Underground Conduit: RNC, Type EPC-40-PVC, direct buried or concrete encased.
 - d. Connection to Vibrating Equipment (Including Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Raceway Fittings: Compatible with raceways and suitable for use and location.
- a. EMT: Use compression, steel fittings. Comply with NEMA FB 2.10.
 - b. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.
 - c. Rigid Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - d. Damp or Wet Locations: Watertight fittings.

B. Boxes, Enclosures, and Cabinets

1. Provide boxes, enclosures and cabinets and associated covers and fittings of materials and NEMA types suitable for each location and in conformance with the following requirements, unless drawings indicate a more stringent requirement:
 - a. Interior Dry Locations: Sheet steel, NEMA type 1.
 - b. Locations Exposed to Weather or Dampness: Cast metal, NEMA type 3R, with threaded hub(s) and gasketed weatherproof cover.

C. Access Doors

1. Where installed in a fire-rated wall or ceiling, provide access door assembly with panel door, frame, hinge, and latch from manufacturer listed in the UL "Building Materials Directory" for rating shown.

3.02 INSTALLATION

A. General

1. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems".
2. Complete installation of raceways, boxes, enclosures, and cabinets before starting conductor installation.
3. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to 1-1/4-inch trade size and insulated throat metal bushings on 1-1/2-inch trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
4. Support conduit within 12 inches of boxes, enclosures or cabinets to which attached and within 12 inches of change of direction.
5. Do not install aluminum boxes or fittings in contact with concrete or earth.

6. Install raceways square to boxes, enclosures and cabinets and terminate with locknuts. Install locknuts hand tight plus 1/4 turn more.
7. Do not rely on locknuts to penetrate nonconductive coatings on boxes, enclosures and cabinets. Remove coatings in the locknut area prior to assembling conduit to ensure a continuous ground path.
8. Prevent foreign matter from entering raceways, boxes, enclosures and cabinets by using temporary closure protection.
9. Upon completion of installation of raceways, boxes, enclosures and cabinets, inspect interiors and clear all blockages and remove burrs, dirt, and construction debris.

B. Raceways

1. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed.
2. Make bends in raceway using either large-radius preformed elbows or field bending. Use only equipment specifically designed for material and size involved. Make bends and offsets so the inside diameter is not effectively reduced.
3. Run parallel raceways together.
4. Cut conduit perpendicular to the length. For conduits 2-inch trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
5. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-pound tensile strength. Leave at least 12 inches of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
6. Do not run raceways exposed on floors.
7. Do not run raceways exposed on roofs.
8. Where raceways terminate at locations subject to moisture, provide insulating bushings to protect conductors.
9. Where terminations are subject to vibration, use bonding bushings or wedges to ensure electrical continuity.
10. Indoor Raceways:
 - a. Conceal conduit within finished walls, ceilings, and floors except in equipment rooms and attics/crawl spaces, unless otherwise indicated.
 - b. Do not fasten conduits onto the bottom side of a metal deck roof.
 - c. Keep raceways at least 6 inches away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
 - d. Install conduits parallel or perpendicular to building lines.
 - e. Where a ceiling is scheduled to be exposed to structure, all conduit shall be secure to structure to provide a clean, organized appearance. Where routed between structural elements, install conduit as high as practical.
 - f. Where conduit is installed concealed in masonry walls, transition PVC conduit within masonry wall to otherwise-specified interior or exterior raceway.
 - g. Terminations:
 - 1) Where raceways are terminated with locknuts and bushings, align the raceway to enter squarely and install the locknuts with dished part against the box.
 - 2) Where terminations cannot be made secure with one locknut, use two locknuts, one inside and one outside the box.
 - 3) Where terminating in threaded hubs, screw the raceway or fitting tight into the hub so the end bears against the wire protection shoulder.
 - 4) Where chase nipples are used, align the raceway so the coupling is square to the box, and tighten the chase nipple so no threads are exposed.
 - h. Stub-Ups to Above Recessed Ceilings:
 - 1) Use EMT for raceways.
 - 2) Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.

- i. Expansion Joint Fittings:
 - 1) Install in each run of EMT conduit that is located where environmental temperature change may exceed 100°F and that has straight-run length that exceeds 100 feet.
 - 2) Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a) Indoor Spaces Connected with Outdoors without Physical Separation: 125°F temperature change.
 - b) Attics: 135°F temperature change.
 - 3) Install fitting(s) that provide expansion and contraction for at least 0.000078 inch per foot of length of straight run per degree F of temperature change for metal conduits.
 - 4) Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 - 5) Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
 - j. Raceways embedded in slabs (on metal deck) shall not be permitted.
11. Underground Raceways (including conduits under concrete floor slab):
- a. Install at a minimum depth of 3'-0" below finished grade to top of raceway unless noted otherwise.
 - b. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Section 31 2000 "Earth Moving" for pipe less than 6 inches in nominal diameter.
 - c. Provide conduit rack in trench prior to concrete pour or backfill.
 - d. Where indicated on the drawings, provide a minimum 3" concrete encasement for PVC conduit for underground raceways. Provide concrete encasement reinforced with a minimum of four No. 4 reinforcing steel rods spaced 2" in from each corner under roadways or any area subject to vehicular traffic. Reinforcing rods shall extend continuously throughout the width of the raceway in order to avoid raceway shear.
 - e. After installing conduit, backfill and compact. Start at tie-in point, and work toward end of conduit run, leaving conduit at end of run free to move with expansion and contraction as temperature changes during this process. Firmly hand tamp backfill around conduit to provide maximum supporting strength. After placing controlled backfill to within 12 inches of finished grade, make final conduit connection at end of run and complete backfilling with normal compaction as specified in Section 31 2000 "Earth Moving."
 - f. Where underground raceways end in a 90-degree bend and a vertical riser conduit, the 90-degree bend and riser conduit shall be PVC. PVC conduit shall rise to 6" above finished floor or finished grade then transition to specified exposed raceway. Arrange stub-ups so curved portions of bends are not visible above finished slab.
 - g. Provide watertight connections.
 - h. Provide underground warning tape in accordance with Section 26 0553 "Identification for Electrical Systems."
12. Raceway Sealants:
- a. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
 - b. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
 - 1) Where an underground service raceway enters a building or structure.
 - 2) Conduit extending from interior to exterior of building.

- 3) Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 - 4) Where otherwise required by NFPA 70.
13. Threaded Conduit Joints, Exposed to Wet, Damp, Corrosive, or Outdoor Conditions: Apply listed compound to threads of raceway and fittings before making up joints. Follow compound manufacturer's written instructions.
 14. Coat field-cut threads on PVC-coated raceway with a corrosion-preventing conductive compound prior to assembly.

C. Boxes, Enclosures and Cabinets

1. Locations shown on Contract Drawings are approximate unless dimensioned.
2. Mount at heights indicated on Drawings. If mounting heights are not individually indicated, give priority to ADA requirements. Install with height measured to top of box unless otherwise indicated.
3. Provide support of junction and pull boxes from building structure. Do not support boxes by conduits.
4. Position recessed boxes, enclosures and cabinets to allow for surface finish thickness.
5. Mount boxes, enclosures and cabinets with fronts straight and plumb.
6. Install surface-mounted cabinets with minimum of four anchors.
7. Locate and install to allow access. Where installation is otherwise inaccessible, coordinate locations and sizes and provide required access doors.
8. Coordinate masonry cutting to achieve neat openings.
9. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.
10. Locate so that cover or plate will not span different building finishes.
11. Do not install boxes back-to-back in walls. Provide minimum 6-inch separation. Provide minimum 24-inch separation in acoustic-rated walls.
12. Coordinate mounting heights and locations of wall outlets mounted where counters, benches, and backsplashes are to be installed. Install outlets 6" above tops of counters and benches.
13. Coordinate mounting heights and locations of wall outlets where wall-mounted heating units are to be installed.
14. Cap unused knockout holes where blanks have been removed and plug unused conduit hubs.
15. Mount outlet boxes for switches and receptacles with the long axis vertical unless noted otherwise. Three or more gang boxes shall be mounted with the long axis horizontal.
16. Electrically ground metallic boxes, enclosures and cabinets.
17. Where wiring to an item that includes a grounding conductor, provide a grounding terminal in the interior of the box, enclosure or cabinet.

D. Installation of Underground Handholes and Boxes:

1. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting conduits to minimize bends and deflections required for proper entrances.
2. Unless otherwise indicated, support units on a 6" deep level bed of crushed stone or gravel, graded from 1/2-inch sieve to No. 4 sieve and compacted to same density as adjacent undisturbed earth.
3. Elevation: In paved areas, set so cover surface will be flush with finished grade. Set covers of other enclosures 1 inch above finished grade.
4. Field-cut openings for conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.

E. Installation of Access Doors

1. Set frames accurately in position and securely attached to supports, with face panels plumb and level in relation to adjacent finish surfaces.
2. Adjust hardware and panels after installation for proper operation.

F. Sleeve and Sleeve Seal Installation for Electrical Penetrations

1. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".
2. Install firestopping at penetrations of fire rated floor and wall assemblies. Comply with requirements in Section 26 0544 "Sleeves and Seals for Electrical Systems".

3.03 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to painted finishes using matching corrosion inhibiting touch-up coating recommended by the manufacturer.

END OF SECTION 26 0533

SECTION 26 0544 - SLEEVES AND SEALS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 07 THERMAL AND MOISTURE PROTECTION Sections.

1.02 SUMMARY

- A. Section Includes:
 - 1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors
 - 2. Sleeve seal systems and fittings
 - 3. Grout
 - 4. Sealants
 - 5. Firestopping
 - 6. Cable Management Pathway

1.03 SUBMITTALS

- A. Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
 - 1. Product data for the following products:
 - a. Sealants
 - b. Firestopping
 - c. Cable Management Pathway

PART 2 - PRODUCTS

2.01 SLEEVES

- A. Wall Sleeves:
 - 1. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, plain ends.
 - 2. Cast iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral water stop unless otherwise indicated.
- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw fastening the sleeve to the board.

2.02 SLEEVE SEAL SYSTEMS AND FITTINGS

- A. Description: Provide modular mechanical type seals, consisting of interlocking synthetic rubber links shaped to continuously fill annular space between pipe and sleeve, connected with bolts and pressure plates that cause rubber sealing elements to expand when tightened, providing watertight seal and electrical insulation.
- B. Material:
 - 1. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
 - 2. Pressure Plates: Stainless steel.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements.
- C. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Advance Products and Systems Inc.
 - 2. Calpico
 - 3. GPT Industries
 - 4. MetraFlex
 - 5. Proco Products, Inc.

2.03 GROUT

- A. Description: Non-shrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi, 28-day compressive strength.
- D. Packaging: Premixed and factory packaged.

2.04 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
 - 1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 - 2. Color: As selected by the Architect from manufacturer's standard colors.
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.
- C. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. 3M
 - 2. Adfast
 - 3. Dow Corning Corporation
 - 4. GE Construction Sealants
 - 5. Pecora Corporation
 - 6. Rectorseal
 - 7. Sika Corporation
 - 8. Soudal USA
 - 9. Tremco, Inc.

2.05 FIRESTOPPING

A. General:

1. Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
2. Equipment used shall be in accordance with the firestop manufacturer's written installation instructions.
3. Color: Red.

B. Performance Requirements

1. Fire Test Response Characteristics:
 - a. Perform penetration firestopping system tests by a qualified testing agency acceptable to authorities having jurisdiction.
 - b. Test per testing standards referenced in "Penetration Firestopping Systems" article. Provide rated systems complying with the following requirements:
 - c. Penetration firestopping systems shall bear classification marking of a qualified testing agency.
 - 1) UL in its "Fire Resistance Directory."
 - 2) FM Global in its "Building Materials Approval Guide."

C. Penetration Firestopping Systems

1. Penetration Firestopping Systems: Systems that resist spread of fire, passage of smoke and other gases, and maintain original fire-resistance rating of construction penetrated. Penetration firestopping systems shall be compatible with one another, with the substrates forming openings, and with penetrating items if any.
2. Penetrations in Fire-Resistance-Rated Walls: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
 - a. F-Rating: Not less than the fire-resistance rating of constructions penetrated.
3. Penetrations in Horizontal Assemblies: Penetration firestopping systems with ratings determined per ASTM E 814 or UL 1479, based on testing at a positive pressure differential of 0.01-inch wg.
 - a. F-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated.
 - b. T-Rating: At least one hour, but not less than the fire-resistance rating of constructions penetrated except for floor penetrations within the cavity of a wall.
 - c. W-Rating: Provide penetration firestopping systems showing no evidence of water leakage when tested according to UL 1479.
4. Penetrations in Smoke Barriers: Penetration firestopping systems with ratings determined per UL 1479, based on testing at a positive pressure differential of 0.30-inch wg.
 - a. L-Rating: Not exceeding 5.0 cfm/sq. ft. of penetration opening at and no more than 50-cfm cumulative total for any 100 sq. ft. at both ambient and elevated temperatures.
5. Exposed Penetration Firestopping Systems: Flame-spread and smoke-developed indexes of less than 25 and 450, respectively, per ASTM E 84.
6. Accessories: Provide components for each penetration firestopping system that are needed to install fill materials and to maintain ratings required. Use only those components specified by penetration firestopping system manufacturer and approved by qualified testing and inspecting agency for conditions indicated.
 - a. Permanent forming/damming/backing materials.
 - b. Substrate primers.
 - c. Collars.
 - d. Steel sleeves.

D. Fill Materials

1. Cast-in-Place Firestop Devices: Factory assembled devices for use in cast-in-place concrete floors and consisting of an outer sleeve lined with an intumescent strip, a flange attached to one end of the sleeve for fastening to concrete formwork, and a neoprene gasket.
2. Latex Sealants: Single-component latex formulations that do not re-emulsify after cure during exposure to moisture.
3. Firestop Devices: Factory assembled collars formed from galvanized steel and lined with intumescent material sized to fit specific diameter of penetrant.
4. Intumescent Composite Sheets: Rigid panels consisting of aluminum foil faced intumescent elastomeric sheet bonded to galvanized steel sheet.
5. Intumescent Putties: Non-hardening, water-resistant, intumescent putties containing no solvents or inorganic fibers.
6. Intumescent Wrap Strips: Single-component intumescent elastomeric sheets with aluminum foil on one side.
7. Mortars: Prepackaged dry mixes consisting of a blend of inorganic binders, hydraulic cement, fillers and lightweight aggregate formulated for mixing with water at Project site to form a non-shrinking, homogeneous mortar.
8. Pillows/Bags: Reusable heat expanding pillows/bags consisting of glass fiber cloth cases filled with a combination of mineral fiber, water insoluble expansion agents, and fire-retardant additives. Where exposed, cover openings with steel reinforcing wire mesh to protect pillows/bags from being easily removed.
9. Silicone Foams: Multicomponent, silicone based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, non-shrinking foam.
10. Silicone Sealants: Single-component, silicone based, neutral curing elastomeric sealants.

E. Mixing

1. Penetration Firestopping Materials: For those products requiring mixing before application, comply with penetration firestopping system manufacturer's written instructions for accurate proportioning of materials, water (if required), type of mixing equipment, selection of mixer speeds, mixing containers, mixing time, and other items or procedures needed to produce products of uniform quality with optimum performance characteristics for application indicated.

F. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. 3M
2. A/D Fire Protection Systems
3. Emerson/Nelson
4. Hilti
5. Nuco Inc.
6. PFP Partners
7. RectorSeal
8. Specified Technologies Inc.
9. Tremco, Inc.

2.06 CABLE MANAGEMENT PATHWAY

A. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. Specified Technologies Inc.

PART 3 - EXECUTION

3.01 GENERAL

- A. Contractor shall provide sleeves where raceways pass through walls, floors, and ceilings.
- B. Where piping or raceways pass through waterproofed floors or walls, design of sleeves shall be such that waterproofing can be flashed into and around the sleeves.
- C. Where items pass through roofs, coordinate the installation with the roofing installer and provide an approved penetration to maintain the roof warranty.

3.02 SLEEVE INSTALLATION

- A. Sleeves for Conduits Penetrating Above-Grade Concrete and Masonry Unit Floors and Walls:
 - 1. Interior Penetrations of Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint.
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall/floor so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 - 2. Size pipe sleeves to provide 1/4-inch annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed.
 - 3. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during construction of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 - 4. Install sleeves for floor penetrations. Extend sleeves installed in floors 6 inches above finished floor level. Install sleeves during construction of floors.
- B. Sleeves for Conduits Penetrating Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- C. Roof Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- D. Aboveground, Exterior Wall Penetrations: Seal penetrations using stainless steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- E. Underground, Exterior Wall and Floor Penetrations: Install cast iron pipe sleeves. Size sleeves to allow for 1-inch annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.03 SLEEVE SEAL SYSTEMS AND FITTINGS INSTALLATION

- A. Provide sleeve seal system for below-grade sleeves through exterior walls.
- B. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.

- C. Install sleeve-seal fittings in new walls and slabs as they are constructed.
- D. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates in accordance with manufacturer's recommended values to ensure that sealing grommets expand to make watertight seal.
- E. Assemble fitting components of length to be flush with both surfaces of concrete slabs and walls. Position water stop flange to be centered in concrete slab or wall.
- F. Secure nailing flanges to concrete forms.
- G. Using grout, seal the space around outside of sleeve seal fittings.

3.04 SEALANTS

- A. General:
 - 1. Comply with joint sealant manufacturer's written installation instructions for products and applications indicated, unless more stringent requirements apply.
 - 2. Comply with recommendations in ASTM C 1193 for use of joint sealants as applicable to materials, applications, and conditions indicated.
- B. Preparation:
 - 1. Surface Cleaning of Joints: Clean out joints immediately before installing joint sealants to comply with joint-sealant manufacturer's written instructions and the following requirements:
 - a. Remove all foreign material from joint substrates that could interfere with adhesion of joint sealant, including dust, paints (except for permanent, protective coatings tested and approved for sealant adhesion and compatibility by sealant manufacturer), old joint sealants, oil, grease, waterproofing, water repellents, water, surface dirt, and frost.
 - b. Clean porous joint substrate surfaces by brushing, grinding, mechanical abrading, or a combination of these methods to produce a clean, sound substrate capable of developing optimum bond with joint sealants. Remove loose particles remaining after cleaning operations above by vacuuming or blowing out joints with oil-free compressed air.
 - c. Remove laitance and form-release agents from concrete.
 - d. Clean nonporous joint substrate surfaces with chemical cleaners or other means that do not stain, harm substrates, or leave residues capable of interfering with adhesion of joint sealants.
 - 2. Joint Priming: Prime joint substrates where recommended by joint-sealant manufacturer or as indicated by preconstruction joint-sealant-substrate tests or prior experience. Apply primer to comply with joint-sealant manufacturer's written instructions. Confine primers to areas of joint-sealant bond; do not allow spillage or migration onto adjoining surfaces.
 - 3. Masking Tape: Use masking tape where required to prevent contact of sealant or primer with adjoining surfaces that otherwise would be permanently stained or damaged by such contact or by cleaning methods required to remove sealant smears. Remove tape immediately after tooling without disturbing joint seal.
- C. Install sealant backings of kind 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 sealant backings.
 - 2. Do not stretch, twist, puncture, or tear sealant backings.

3. Remove absorbent sealant backings that have become wet before sealant application, and replace them with dry materials.
- D. Install bond-breaker tape behind sealants where sealant backings are not used between sealants and backs of joints.
- E. 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 in each joint configuration.
 3. Produce uniform, cross-sectional shapes and depths relative to joint widths that allow optimum sealant movement capability.
- F. Tooling of Non-sag Sealants: Immediately after sealant application and before skinning or curing begins, tool sealants according to requirements specified in subparagraphs 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 sealant from surfaces adjacent to joints.
 2. Use tooling agents that are approved in writing by sealant manufacturer and that do not discolor sealants or adjacent surfaces.
- G. Clean off excess sealant or sealant smears adjacent to joints as the Work progresses by methods and with cleaning materials approved in writing by manufacturers of joint sealants and of products in which joints occur.
- H. 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, remove, and repair damaged or deteriorated joint sealants immediately so installations with repaired areas are indistinguishable from original work.

3.05 FIRESTOPPING

- A. General:
 1. Where conduits, conduit sleeves, wireways and other electrical raceways or cables pass through fire partitions, fire walls, fire floors, or smoke walls, provide a fire or smoke stopping that provides an effective barrier against the spread of fire, smoke or gases.
 2. Provide firestopping with fire-resistance ratings indicated for floor or wall assembly in which penetration occurs.
 3. Install materials in accordance with printed instructions of the UL Fire Resistance Directory and per manufacturer's published instructions.
 4. All cables that are installed in conduit sleeves or in wireways through fire or smoke floors or partitions shall be provided with an equally rated re-enterable UL listed fire and smoke rated silicone RTV foam in the opening.
 5. Keep areas of work accessible until inspection by applicable code authorities.
- B. Preparation:
 1. Surface Cleaning: Before installing penetration firestopping systems, clean out openings immediately to comply with manufacturer's written instructions and with the following requirements:
 - a. Remove from surfaces of opening substrates and from penetrating items foreign materials that could interfere with adhesion of penetration firestopping materials.
 - b. Clean opening substrates and penetrating items to produce clean, sound surfaces capable of developing optimum bond with penetration firestopping materials. Remove loose particles remaining from cleaning operation.
 - c. Remove laitance and form-release agents from concrete.

- C. Install penetration firestopping systems to comply with manufacturer's written installation instructions and published drawings for products and applications.
- D. Install forming materials and other accessories of types required to support fill materials during their application and in the position needed to produce cross-sectional shapes and depths required to achieve fire ratings.
 - 1. After installing fill materials and allowing them to fully cure, remove combustible forming materials and other accessories not forming permanent components of firestopping.
- E. Install fill materials by proven techniques to produce the following results:
 - 1. Fill voids and cavities formed by openings, forming materials, accessories and penetrating items to achieve required fire-resistance ratings.
 - 2. Apply materials so they contact and adhere to substrates formed by openings and penetrating items.
 - 3. For fill materials that will remain exposed after completing the Work, finish to produce smooth, uniform surfaces that are flush with adjoining finishes.
- F. Clean off excess fill materials adjacent to openings as the Work progresses by methods and with cleaning materials that are approved in writing by penetration firestopping system manufacturers and that do not damage materials in which openings occur.
- G. Provide final protection and maintain conditions during and after installation that ensure that penetration firestopping systems are without damage or deterioration at time of Substantial Completion. If, despite such protection, damage or deterioration occurs, immediately cut out and remove damaged or deteriorated penetration firestopping material and install new materials to produce systems complying with specified requirements.

3.06 CABLE MANAGEMENT PATHWAY:

- A. Application:
 - 1. Where located in fire rated partitions, provide STI EZ-Path Fire Rated Pathway with radius control module or equal.
 - 2. Where located in non-fire rated partitions, provide STI EZ-Path Smoke and Acoustical Pathway or equal.
 - 3. Where installed between floors, provide STI EZ-Path Fire Rated Pathway or equal.
- B. Provide pathway with appropriate rating in the following locations:
 - 1. Minimum of one per classroom, located above door.
 - 2. Minimum of one per large group instruction space, located above door.
 - 3. Minimum of one per conference room, located above door.
 - 4. Minimum of one per private office, located above door.
 - 5. Locations indicated on drawings

END OF SECTION 26 0544

SECTION 26 0553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Cable/Conductor Identification Bands
 - 2. Laminated Acrylic or Melamine Plastic Labels
 - 3. Self-Adhesive Labels
 - 4. Underground Line Warning Tape

1.03 SUBMITTALS

- A. Product Data for each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for electrical identification products.
- B. Samples: For each type of label and sign to illustrate composition, size, colors, lettering style, mounting provisions, and graphic features of identification products.
- C. Identification Schedule: For each piece of electrical equipment and electrical system components to be an index of nomenclature for electrical equipment and system components used in identification signs and labels. Use same designations indicated on Drawings.

PART 2 - PRODUCTS

2.01 ELECTRICAL IDENTIFICATION PRODUCTS

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Brady Corporation
 - 2. Champion America
 - 3. Emedco
 - 4. Grafoplast
 - 5. Hellerman Tyton
 - 6. Ideal Industries
 - 7. LEM Products, Inc.
 - 8. Marketing Services, Inc.
 - 9. Panduit

- B. General: Coordinate names, abbreviations and other designations used in electrical identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the electrical systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.
- C. Cable/Conductor Identification Bands: Provide manufacturer's standard aluminum wrap-around cable/conductor markers, of size required for proper application with stamped or embossed legend, and numbered to show circuit identification.
- D. Laminated Acrylic or Melamine Plastic Labels:
 - 1. Engraved with black letters on white face, unless noted otherwise.
 - 2. Thickness:
 - a. For signs up to 20 sq. in. minimum 1/16 inch thick.
 - b. For signs larger than 20 sq. inch, 1/8 inch thick.
 - 3. Fasteners for Laminated Acrylic or Melamine Plastic Labels:
 - a. Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers. Where screws cannot or should not penetrate substrate, provide contact type permanent adhesive.
- E. Self-Adhesive Labels:
 - 1. Vinyl, thermal, transfer-printed, 3-mil-thick, multicolor, weather- and UV-resistant, pressure-sensitive adhesive labels, configured for intended use and location.
 - 2. Marker for Labels: Machine-printed, permanent, waterproof, black ink recommended by printer manufacturer.
- F. Underground Line Warning Tape: Permanent, bright-colored, continuous-printed, vinyl tape.
 - 1. Not less than 6 inches wide by 4 mils thick.
 - 2. Compounded for permanent direct-burial service.
 - 3. Embedded continuous metallic strip or core.
 - 4. Printed legend indicating type of underground line.

PART 3 - EXECUTION

3.01 GENERAL

- A. Install identifying devices before installing acoustical ceilings and similar concealment.
- B. Verify identity of each item before installing identification products.
- C. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and operation and maintenance manual.
- D. Apply identification devices to surfaces that require finish after completing finish work.
- E. Install signs with approved legend to facilitate proper identification, operation, and maintenance of electrical systems and connected items.

3.02 APPLICATION AND INSTALLATION

- A. Accessible Fittings for Raceways: Using permanent marker, identify the covers of each junction and pull box with the panelboard and circuit number(s) of installed conductors.
- B. Receptacle Faceplates: Using self-adhesive labels applied to back of coverplate, identify panelboard and circuit number feeding device. Label shall be clear with black lettering.
- C. Cable/Conductor Identification Bands: Apply cable/conductor identification bands indicating circuit number on each cable/conductor in each panelboard.
- D. Labels
 - 1. General
 - a. Attach labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.
 - b. Before applying self-adhesive electrical identification products, clean substrates of substances that could impair bond, using materials and methods recommended by manufacturer of identification product.
 - c. Apply labels to exterior of door or cover. In finished areas, install labels to inside face of doors.
 - d. Provide labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.
 - e. Unless otherwise indicated, provide a single line of text with 1/2-inch-high letters on minimum 1-1/2-inch-high sign; where two lines of text are required, use signs minimum 2 inches high.
 - 2. Warning labels - provide the following:
 - a. Workspace Clearance Warning at all panelboard locations: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES."
 - b. Multiple Power Source Warning at all transfer switches: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 3. Emergency Operating Labels: Provide laminated acrylic or melamine plastic labels with white letters on red background with minimum 3/8-inch high lettering for emergency instructions on power transfer, load shedding, or other emergency operations.
 - 4. Equipment Identification Labels: Provide laminated acrylic or melamine plastic equipment identification labels for each device in the following categories of electrical equipment. Text shall match terminology and numbering of the Contract Documents and shop drawings.
 - a. Automatic transfer switches
 - b. Disconnect switches
 - c. Emergency generator
 - d. Panelboards
- E. Underground Line Warning Tape: During trench backfilling, for exterior underground power, control, signal, and communication lines, install continuous underground plastic line marker located directly above line at 6 to 8 inches below finished grade. Where width of multiple lines installed a common trench or concrete envelope does not exceed 16 inches overall, use a single line marker. Install underground-line warning tape for direct-buried cables and cables in raceways.

END OF SECTION 26 0553

SECTION 26 0573 - OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes provisions for electrical distribution coordination, short circuit analysis, and shock and flash hazard studies.
- B. Study shall be provided for all new equipment and elsewhere as noted on drawings. Contractor shall provide all required information on existing upstream installations as required to complete the study.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
 - 1. Eight bound copies or coordination, short circuit, and shock and flash hazard studies.
 - 2. Electronic copy of studies on CD (8 copies).
 - 3. All flash hazard labels for use on equipment associated with the study (3 copies).
 - 4. Complete SKM database for study on CD for future Owner use (2 copies).

1.04 QUALITY ASSURANCE

- A. Qualifications: Firm engaged in performing studies of this type for at least 5 years.

1.05 SEQUENCE AND SCHEDULING

- A. Contractor shall submit three (3) copies of preliminary coordination and short circuit study prior to submitting distribution equipment submittals. No submittals for switchgear, switchboards, panelboards, transformers, etc., will be approved without prior submittal of coordination and short circuit study.
- B. If preliminary study indicates issues with equipment that will be submitted, preliminary study shall be rerun using alternate equipment with ratings and settings appropriate for the system being installed.
- C. After approval of preliminary coordination study, contractor shall submit distribution equipment submittals for approval, including any necessary revisions indicated by preliminary coordination and short circuit study.
- D. Provide final bound coordination, short circuit, and shock and flash hazard study. Provide PPE labels for all equipment being provided, and for existing equipment included in study. Provide CD with each copy of study containing all study files and input files.

PART 2 - PRODUCTS

2.01 STUDIES

- A. Provide, in accordance with industry standards, the electrical studies listed in this section.
- B. All studies shall incorporate the actual equipment being provided, and actual cable lengths, conduit types, and wire sizes of feeders being installed. Provide all field survey work necessary to obtain all required information from existing equipment that will be connected to as part of this project, in order to include existing equipment in study. This includes, but is not limited to, nameplate information, catalog numbers, trip unit settings, and relay settings.
- C. All studies shall be performed using analysis software as manufactured by SKM Systems Analysis, Inc.

2.02 ELECTRICAL DISTRIBUTION COORDINATION STUDY

- A. Provide a complete electrical distribution coordination study, based on the equipment being submitted. Submit complete documentation of the coordination of all circuit breakers and fused switches. The study shall provide recommendations for the settings of all adjustable devices (i.e. ground fault, adjustable breakers) to provide maximum coordination and selectivity. This report shall include a composite drawing for each segment of the distribution system showing the time-current curves of all devices, with the devices set as recommended. This shall include the complete characteristic curves for all circuit protection devices.

2.03 SHORT CIRCUIT ANALYSIS

- A. Provide a complete short circuit analysis, based on the actual equipment and conductor lengths provided by the Contractor. Analysis shall include all new equipment on project, and any and all existing equipment to which new equipment or feeders are being connected to.

2.04 EQUIPMENT EVALUATION ANALYSIS

- A. Provide a complete equipment evaluation analysis, based on the actual equipment and conductor lengths provided by the Contractor. Analysis shall include all new equipment on project, and any and all existing equipment to which new equipment or feeders are being connected to. Provide a list of any equipment that is not rated for the available fault current at its location.

2.05 COORINATION STUDY

- A. Provide a complete coordination study, based on the actual equipment provided by the Contractor. Coordination study shall include all relays, adjustable trip circuit breakers, fuses, and all thermal magnetic breakers in distribution equipment down to and including enclosed circuit breakers, and branch circuit breakers in panelboards.
- B. Adjust settings and fuses to obtain the highest level of coordination while maintaining a PPE level of 2 or less at each piece of equipment. Where level 2 PPE cannot be attained, settings shall be adjusted to obtain the lowest arc flash energy level possible.
- C. Provide color TCC curve plots for all equipment in coordination study. TCC's shall include device names and setting for each device on the TCC plot.

- D. Provide a list of recommended settings for use by the Contractor in programming and setting all breakers and fuses.

2.06 SHOCK HAZARD AND FLASH HAZARD ANALYSIS

- A. Provide a complete shock hazard and flash hazard analysis, based on the actual equipment and conductor lengths provided by the Contractor. Provide for all warning signs and classification signage on all distribution equipment as required by NFPA 70E, 2009 Edition.

PART 3 - EXECUTION

3.01 GENERAL

- A. Provide for adjustment and setting of all trip units and relays according to coordination study recommendations.
- B. Install all PPE labels on equipment.

END OF SECTION 26 0573

SECTION 26 0923 - LIGHTING CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. Section includes a networked lighting control system comprised of the following components:
 - 1. Occupancy/Vacancy Sensors
 - 2. Digital Daylight Harvesting Dimming Control
 - 3. Relay-Based Lighting Control
 - a. System Software Interfaces
 - b. System Backbone and Integration Equipment
 - c. Wired Control Devices
 - d. Wireless Control Devices
- B. The lighting control system shall meet all of the characteristics and performance requirements specified herein.
- C. The contractor shall provide, install and verify proper operation of all equipment as specified herein and as shown on applicable drawings.

1.03 DEFINITIONS

- A. BACnet: A networking communication protocol that complies with ASHRAE 135.
- B. BAS: Building automation system.
- C. BMS: Building management system.
- D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote control, signaling and power-limited circuits.
- E. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.

1.04 SUBMITTALS

- A. Submittal shall be provided including the following items.
 - 1. Bill of Materials necessary to install the networked lighting control system.
 - 2. Product Data Sheets indicating general device descriptions, dimensions, electrical specifications, wiring details, and nomenclature.

3. Riser Diagrams showing device wiring connections of system backbone and typical per room/area type.
4. Information Technology (IT) connection information pertaining to interconnection with facility IT networking equipment and third-party systems.
5. Other Diagrams and Operational Descriptions - as needed to indicate system operation or interaction with other system(s).
6. Example Contractor Startup/Commissioning Worksheet (must be completed prior to factory start-up).
7. Service Specification Sheets indicating general service descriptions, including startup, training, post-startup support, and service contract terms.
8. Hardware and Software Operation Manuals.

1.05 QUALITY ASSURANCE

- A. Product Qualifications
 1. All components and the manufacturing facility where product was manufactured must be RoHS compliant.
 2. In high humidity or cold environments, the sensors shall be conformably coated and rated for condensing humidity and -40°F operation.
 3. All applicable products must be UL Listed or other acceptable national testing organization.

1.06 WARRANTY

- A. All lighting control components shall have a five year warranty.
- B. Provide software support for two years, including software updates. Software updates shall include operating system and new or revised licenses for use of the software.

1.07 EXTRA MATERIALS

- A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels clearly describing contents. Deliver replacement stock directed to Owner's storage space.
 1. Relay-Based Lighting Controls (Relays, Low Voltage Switches, Occupancy Sensors, Ambient Light Sensors): 1 component for every 20 of each type installed.
 2. Stand-Alone Lighting Controls (Sensor Power Packs, Occupancy Sensors, Timer Switches): 1 component for every 20 of each type installed.

PART 2 - PRODUCTS

2.01 GENERAL

- A. Coordinate lighting control components to form an integrated interconnection of compatible components for optimum performance of lighting control functions.
- B. Communication and low voltage power shall be delivered to each device via standard low voltage cabling as recommended by the system manufacturer.

2.02 MANUFACTURERS

A. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. Base Bid: Cooper ILC, through Knight Sound & Communication
2. Alternate Bid E1a: Legrand/Wattstopper DLM
3. Alternate Bid E1b: Acuity Brands/nLight
4. Alternate Bid E1c: Hubbell NX

2.03 OCCUPANCY/VACANCY SENSORS

A. General Requirements for Sensors:

1. Wall or ceiling-mounted, suitable for mounting in any position on a standard outlet box.
2. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
3. Unless otherwise indicated, sensor shall be programmed to turn lights on when coverage area is occupied and turn them off when unoccupied, or to turn off lights that have been manually turned on; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes; and adjustable sensitivity.
4. All sensors shall have an LED to indicate occupant detection.
5. In case of device failure, sensor shall fail to the 'on' position.
6. All sensors shall operate with all LED lamp and driver combinations.

B. PIR Type: Detect occupants in coverage area by their heat and movement.

1. Use only for high ceiling applications of over 15'.
2. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in.
3. Detection Coverage: Within a 15' horizontal radius of sensor.

C. Dual-Technology Type: Detect occupants in coverage area using ultrasonic/microphonic and PIR detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.

1. Ceiling mounted:

- a. Sensitivity Adjustment: Separate for each sensing technology.
- b. Detector Sensitivity: Detect occurrences of 6-inch minimum movement of any portion of a human body that presents a target of not less than 36 sq. in., and detect a person of average size and weight moving not less than 12 inches in either a horizontal or a vertical manner at an approximate speed of 12 inches/sec.
- c. Detection Coverage: Detect occupancy anywhere within a circular area of 1000 sq. ft. when mounted on an 8' high ceiling.

2. Wall box mounted:

- a. Sensor shall have a minimum 170 degree radial spread pattern with a minimum of 20 feet axial sensor coverage.
- b. Sensor shall incorporate temperature compensated dual element sensor and multi element Fresnel lens.
- c. Sensor shall have a daylight filter to ensure the sensor is insensitive to short-wavelengths emitted by the sun.
- d. Device shall be completely self-contained to replace standard toggle switches.
- e. Device shall be user adjustable for normal operation.
- f. Device shall control lighting using momentary switch operation.

2.04 RELAY-BASED LIGHTING CONTROL

A. Summary

1. The lighting control system specified in this section shall provide time-based, sensor-based (both occupancy and daylight), and manual lighting control.
2. The system shall be capable of turning lighting loads on/off as well as dimming lights (if lighting load is capable of being dimmed).
3. All system devices shall be networked together enabling digital communication and shall be individually addressable.
4. The system architecture shall be capable of enabling stand-alone groups (rooms) of devices to function in some default capacity even if network connectivity to the greater system is lost.
5. The system architecture shall allow for remote operation via a computer connection.
6. The system shall not require any centrally hardwired switching equipment.
7. The system shall be capable of wireless, wired, or hybrid wireless/wired architectures.

B. System Performance Requirements

1. System Architecture

- a. System shall have an architecture that is based upon three main concepts: (1) networkable intelligent lighting control devices, (2) standalone lighting control zones using distributed intelligence, (3) system backbone for remote, time based and global operation between control zones.
- b. Intelligent lighting control devices shall have individually addressable network communication capability and consist of one or more basic lighting control components: occupancy sensor, photocell sensor, relay, dimming output, contact closure input, analog 0-10V input, and manual wall station capable of indicating switching, dimming, and/or scene control. Combining one or more of these components into a single device enclosure shall be permissible so as to minimize overall device count of system.
- c. System must be capable of interfacing directly with networked luminaires such that either low voltage network cabling or wireless RF communication is used to interconnect networked luminaires with control components such as sensors, switches and system backbone.
- d. Lighting control zones consisting of one or more networked luminaires and intelligent lighting control devices and shall be capable of providing automatic control from sensors (occupancy and/or photocell) and manual control from local wall stations without requiring connection to a higher-level system backbone; this capability is referred to as "distributed intelligence."
- e. Networked luminaires and intelligent lighting control devices shall support individual (unique) configuration of device settings and properties, with such configuration residing within the networked luminaires and intelligent control devices.
- f. Networked luminaires and intelligent lighting control devices shall have distributed intelligence programming stored in non-volatile memory, such that following any loss of power the lighting control zones shall operate according to their defined default settings and sequence of operations.
- g. Lighting control zones shall be capable of being networked with a higher-level system backbone to provide time based control, remote control from inputs and/or systems external to the control zone, and remote configuration and monitoring through a software interface.
- h. The system may include one or more system controllers that provide time-based control and global system control across multiple control zones and backbone network segments. The system controller also provides a means of connecting the lighting control system to a system software interface and building management systems via BACnet/IP or BACnet MS/TP protocol.
- i. The system may include "communication bridge" devices that route communication from lighting control zones (wired or wireless) to and from the system controller, for purposes of decreasing system wiring requirements.
- j. All system devices shall support remote firmware update, such that physical access to each device is not necessary, for purposes of upgrading functionality at a later date.

2. Wireless Networked Control Zone Characteristics

- a. No wired control connections between wireless networked devices shall be required.
- b. Wireless networked devices shall communicate via radio frequency of 2.4 GHz using a standards-based wireless networking protocol.
- c. Wireless network shall be self-healing, such that optimum routing paths between devices are automatically established or restored if any nodes are respectively added to or removed from the wireless network.
- d. Wireless network communication shall support uniform and instant response such that all luminaires in a lighting control zone respond immediately and synchronously in response to a sensor or wall station signal.
- e. To support the system architecture requirement for distributed intelligence, wireless network communication shall support communication of control signals from sensors and wall stations to networked luminaires and wireless load control devices, without requiring any communication, interpretation, or translation of information through a backbone device such as a wireless access point, communication bridge or gateway.
- f. All wireless communication shall be encrypted using the 128-bit Advanced Encryption Standard (AES).
- g. Accounting for typical environmental conditions and building construction materials encountered within parking garage environments or within high-bay applications in industrial, warehouse and gymnasium environments, wireless networked devices shall be capable of communicating to at least 30' spacing between luminaires with embedded wireless transceivers, and shall be capable of communicating to at least 60' spacing between wireless networked devices installed external to luminaire housings or other enclosures.
 - 1) Wireless networked devices shall have a line-of-sight communication range of at least 1000' under ideal environmental conditions.

3. System Integration Capabilities

- a. The system shall interface with third party building management systems (BMS) to support two-way communication using the industry standard BACnet/IP or BACnet MS/TP protocols. The following system integration capabilities shall be available via BACnet/IP and BACnet MS/TP protocols:
 - 1) The system shall support control of individual devices, including, but not limited to, control of relay and dimming output.
 - 2) The system shall support reading of individual device status information. The available status will depend on the individual device type and capabilities, which may include but not be limited to, relay state, dimming output, power measurement, occupancy sensor status, and photocell sensor states or readings. All system devices shall be available for polling for devices status.
 - 3) The system shall support activation of pre-defined system Global Profiles.
- b. The system shall support activation of Profiles (local or global) and Preset Scenes from third party systems by receiving dry contact closure output signals or digital commands via RS-232/RS-485.
- c. The system shall support activation of demand response levels from Demand Response Automation Servers (DRAS) via the OpenADR 2.0a protocol.

4. Supported Sequence of Operations

- a. Characteristics and performance requirements herein shall be supported by the networked lighting control system.
- b. Control Zones
 - 1) Networked luminaires and intelligent lighting control devices installed in an area (also referred to as a group of devices) shall be capable of transmitting and tracking occupancy sensor, photocell sensor, and manual switch information within control zones to support different and reconfigurable sequences of operation within the area. These shall also be referred to as 'local control zones'.

- 2) Networked luminaires and intelligent lighting control devices located in different areas shall be able to transmit and track information within system-wide control zones to support required sequences of operation that may span across multiple areas. Occupancy and photocell commands shall be available across a single controller, and switch commands shall be available across single or multiple controllers. These shall also be referred to as 'global control zones'.

c. Wall Station Capabilities

- 1) Wall stations shall be provided to support the following capabilities:
 - a) On/Off of a local control zone and global control zone simultaneously, as required.
 - b) Continuous dimming control of light level of a local control zone and global control zone simultaneously, as required.
 - c) Preset Scenes that can activate a specific combination of light levels across multiple local and global channels, as required.
 - d) Profile Scenes that can modify the sequence of operation for the devices in the area (group) in response to a button press. This capability is defined as supporting "Local Profiles" and is used to dynamically optimize the occupant experience and lighting energy usage. Wall stations shall be able to manually start and stop Local Profiles, or the local profile shall be capable of ending after a specific duration of time between 5 minutes and 12 hours. Parameters that shall be configurable and assigned to a Local Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.
- 2) Multiple wall stations shall be capable of controlling the same local and global control zones, so as to support "multi-way" switching, dimming, preset scene, and profile scene control.

d. Occupancy Sensing Capabilities

- 1) Occupancy sensors shall be configurable to control a local and global zone simultaneously, as required.
- 2) Multiple occupancy sensors shall be capable of controlling the same local and global control zones. This capability combines occupancy sensing coverage from multiple sensors without consuming multiple control zones.
- 3) System shall support the following types of occupancy sensing sequence of operations:
 - a) On/Off Occupancy Sensing
 - b) Partial-On Occupancy Sensing
 - c) Partial-Off Occupancy Sensing
 - d) Vacancy Sensing (Manual-On / Automatic-Off)
- 4) On/Off, Partial-On, and Partial-Off Occupancy Sensing modes shall function according to the following sequence of operation:
 - a) Occupancy sensors shall automatically turn lights on to a designated level when occupancy is detected.
 - b) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected.
 - c) Photocell readings, if enabled in the Occupancy Sensing control zone, shall be capable of automatically adjusting the light level during occupied or unoccupied conditions as necessary to further reduce energy usage.
 - d) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.

- 5) Vacancy Sensing mode (also referred to as Manual-On / Automatic-Off) shall function according to the following sequence of operation:
 - a) The use of a wall station is required to turn lights on. The system shall be capable of programming the zone to turn on to either to a designated light level or the previous user light level. Initially occupying the space without using a wall station shall not result in lights turning on.
 - b) Occupancy sensors shall automatically turn lights off or to a dimmed state (Partial-Off) when vacancy occurs or if sufficient daylight is detected.
 - c) To minimize occupant impact in case the area or zone is still physically occupied following dimming or shutoff of the lights due to detection of vacancy, the system shall support an "automatic grace period" immediately following detection of vacancy, during which time any detected occupancy shall result in the lights reverting to the previous level. After the grace period has expired, the use of a wall station is required to turn lights on.
 - d) At any time, the use of a wall station shall change the dimming level or turn lights off as selected by the occupant. The lights shall optionally remain in this manually-specified light level until the zone becomes vacant; upon vacancy the normal sequence of operation, as defined above, shall proceed.
 - 6) To accommodate different types of environments, occupancy time delays before dimming or shutting off lights shall be specifiable for control zones between 15 seconds to 2 hours.
- e. Schedule and Global Profile Capabilities
- 1) The system shall be capable of automatically modifying the sequence of operation for selected devices in response to any of the following: a time-of-day schedule, contact closure input state, manually triggered wall station input, RS-232/RS-485 command, and BACnet input command. This capability is defined as supporting "Global Profiles" and is used to dynamically optimize the occupant experience and lighting energy usage.
 - 2) Global profiles may be scheduled with the following capabilities:
 - a) Global Profiles shall be stored within and executed from the system controller (via internal timeclock) such that a dedicated software host or server is not required to be online to support automatic scheduling and/or operation of Global Profiles.
 - b) Global Profile time of day schedules shall be capable of being given the following recurrence settings: daily, specific days of week, every "n" number of days, weekly, monthly, and yearly. Lighting control profile schedules shall support definition of start date, end date, end after "n" recurrences, or never ending. Daylight savings time adjustments shall be capable of being performed automatically, if desired.
 - c) Global Profile Holiday Schedules should follow recurrent settings for specific US holiday dates regardless if they always occur on a specific date or are determined by the day/week of the month.
 - d) Global Profiles shall be capable of being scheduled to run according to timed offsets relative to sunrise or sunset. Sunrise/sunset times shall be automatically derived from location information using an astronomical clock.
 - e) System shall support blink warning and timed extension capabilities. At the end of a scheduled period, the system shall be capable of providing a visible "blink warning" 5 minutes prior to the end of the schedule. Wall stations may be programmed to provide timed overrides that turn the lights on for an additional period of time. Timed override duration shall be programmable for each individual device, zone of devices, or customized group of devices, ranging from 5 minutes to 12 hours.
 - f) Software management interface shall be capable of displaying a graphic calendar view of profile schedules for each control zone.

- 3) System Global Profiles shall have the following additional capabilities:
 - a) Global Profiles shall be capable of being manually activated directly from the system controller, specially programmed input devices, scene capable wall stations, and the software management interface.
 - b) Global Profiles shall be selectable to apply to a single device, zone of devices, or customized group of devices.
 - c) Parameters that shall be configurable and assigned to a Global Profile shall include, but not be limited to, fixture light level, occupancy time delay, response to occupancy sensors (including enabling/disabling response), response to daylight sensors (including enabling/disabling response), and enabling/disabling of wall stations.
- 4) A backup of Local and Global Profiles shall be stored on the software's host server such that the Profile backup can be applied to a replacement system controller or wall station.
- f. System shall support automated demand response capabilities with automatic reduction of light level to at least three levels of demand response.

C. System Software Interfaces

1. Management Interface

- a. System shall provide a web-based management interface that provides remote system control, live status monitoring, and configuration capabilities of lighting control settings and schedules.
- b. Management interface must be compatible with industry-standard web browser clients.
- c. Management interface shall require all users to login with a User Name and Password.
- d. Management interface shall support at least three permission levels for users: read-only, read & change settings, and full administrative system access.
- e. Management interface shall be capable of restricting access for user accounts to specific devices within the system.
- f. All system devices shall be capable of being given user-defined names.
- g. The following device identification information shall be displayed in the Management interface: model number, model description, serial number, manufacturing date code, custom label(s), and parent network device.
- h. Management interface shall be able to read the live status of a networked luminaire or intelligent control device and shall be capable of displaying luminaire on/off status, dim level, power measurement, device temperature, PIR occupancy sensor status, microphonic occupancy sensor status, remaining occupancy time delay, photocell reading, and active Scenes or Profiles.
- i. Management interface shall be able to read the current active settings of a networked luminaire or intelligent control device and shall be capable of displaying dimming trim levels, occupancy sensor and photocell enable/disable, occupancy sensor time delay and light level settings, occupancy sensor response (normal or vacancy), and photocell setpoints and transition time delays.
- j. Management interface shall be able to change the current active settings and default settings for an individual networked luminaire or intelligent control device.
- k. Management interface shall be capable of applying settings changes for a zone of devices or a group of selected devices using a single "save" action that does not require the user to save settings changes for each individual device.
- l. A printable network inventory report shall be available via the management interface.
- m. A printable report detailing all system profiles shall be available via the management interface.
- n. All sensitive information stored by the software shall be encrypted.
- o. All system software updates must be available for automatic download and installation via the internet.

2. Historical Database and Analytics Interface

- a. System shall provide a historical database that stores device operational history and calculates energy usage for all networked luminaires and intelligent control devices.

3. Visualization and Programming Interfaces

- a. System shall provide a web-based visualization interface that displays graphical floorplan.
- b. Graphical floorplan shall offer the following types of system visualization:
 - 1) Full Device Option - A master graphic of the entire building, by floor, showing each control device installed in the project with zones outlined. This shall include, but not be limited to, the following:
 - a) Controls embedded light fixtures
 - b) Controls devices not embedded in light fixtures
 - c) Daylight Sensors
 - d) Occupancy Sensors
 - e) Wall Switches and Dimmers
 - f) Scene Controllers
 - g) Networked Relays
 - h) Bridges
 - i) System Controllers
 - j) Panels
 - k) Zone outlines
 - 2) Zone Only Option - A master graphic of the entire building, by floor, showing only control zones outlined.
 - 3) Allow for pan and zoom commands so smaller areas can be displayed on a larger scale simply by panning and zooming each floor's master graphic.
 - 4) Selection of any control device shall display the following information:
 - a) The device name and custom label.
 - b) Device diagnostic information.
 - c) Information about the device status or current configuration.

4. Personal Control Applications

- a. Software interface shall support personal control software applications that provide user-specific control of individual luminaires/control devices, control zones, global scene presets, and scene selector virtual button presses.
- b. The system administrator shall be capable of defining personal control permissions for each user account.

D. System Backbone And System Integration Equipment

1. System Controller

- a. System Controller shall be multi-tasking, real-time digital control processor consisting of modular hardware with plug-in enclosed processors, communication controllers, and power supplies.
- b. System Controller shall have 32-bit microprocessor operating at a minimum of 1 GHz.
- c. System Controller shall have minimum of 512MB memory, with a minimum of 4GB non-volatile flash, to support its own operating system and databases.
- d. System Controller shall perform the following functions:
 - 1) Time-based control of downstream wired and wireless network devices.
 - 2) Facilitation of global network switch communication between different system controllers.
 - 3) Linking into an Ethernet network.
 - 4) Integration with Building Management Systems (BMS) and Heating, Ventilation and Air Conditioning (HVAC) equipment.
 - 5) Connection to various software interfaces, including management interface, historical database and analytics interface, visualization interface, and personal control applications.

- e. System Controller shall have an integral web server to support configuration, diagnostics and hosting of software interfaces.
- f. Device shall have option for a graphical touch screen to support configuration and diagnostics.
- g. Device shall be capable of communicating with wireless network bridges and software interfaces via LAN connection.
- h. Device shall automatically detect all networked devices connected to it, including those connected to wired and wireless communication bridges.
- i. Device shall have a standard and astronomical internal time clock.
- j. Device shall have 2 switched RJ-45 10/100 BaseT Ethernet ports for local area network (LAN) connection.
 - 1) Ethernet connection shall support daisy chain wiring to other lighting control system LAN devices, such as other system controllers and wireless networked communication bridges.
 - 2) Ethernet connection shall support IPv4 and shall be capable of using a dedicated static or DHCP assigned IP address.
- k. System Controller shall support BACnet/IP and BACnet MS/TP protocols to directly interface with BMS and HVAC equipment without the need for additional protocol translation gateways.
- l. System controller shall be available within a NEMA 1 enclosure with Class 1 and Class 2 separation
- m. Enclosure shall support power input power of 120-277VAC.

E. Wired Networked Devices

1. Wall Switches, Dimmers, Scene Controllers

- a. Devices shall recess into single-gang switch box and fit a standard GFI opening.
- b. Devices with mechanical push-buttons shall provide tactile and LED user feedback.
- c. Devices with mechanical push-buttons shall be furnished with custom button labeling.
- d. Supply faceplates per specification Section 26 2726 "Wiring Devices".

2. Graphic Wall Stations (Touchscreen Low-Voltage Switch)

- a. Device shall have a minimum 3.5" full color touch screen.
- b. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply.
- c. Device shall enable user supplied screen saver image to be uploaded within one of the following formats: jpg, png, gif, bmp, tif.
- d. Device shall enable configuration of all switches, dimmers, and lighting preset scenes via password protected setup screens.
- e. Graphic wall stations shall support the following device options:
 - 1) Number of control zones: Up to 16
 - 2) Number of scenes: Up to 16
 - 3) Profile type scene duration: User configurable from 5 minutes to 12 hours

3. Relay Packs

- a. Relay Packs shall accept 120 or 277 VAC and carry a plenum rating.
- b. Power Supplies shall provide system power only, but are not required to switch line voltage circuit.
- c. Auxiliary Relay Packs shall switch low voltage circuits only, capable of switching 1 amp at 40 VAC/VDC (resistive only).
- d. Relay Pack programming parameters shall be available and configurable remotely from the software and locally via the device push-button.
- e. Relay Pack shall securely mount through a threaded ½ inch chase nipple or be capable of being secured within a luminaire ballast/driver channel. Plastic clips into junction box shall not be accepted. All Class 1 wiring shall pass through chase nipple into adjacent junction box without any exposure of wire leads.

- f. Types of Relay Packs
 - 1) Standard Relay Pack: Capable of full 16-Amp switching of all normal power lighting load types.
 - 2) Dimming Relay Pack: Capable of full 16-Amp switching of all normal power lighting load types, and 0-10V dimming output capable of up to 100mA of sink current.
 - 3) Emergency Relay Pack: With UL924 listing for switching of full 16-Amp Emergency Power circuits, and 0-10V dimming output capable of up to 100mA of sink current.
 4. Network Bridge
 - a. Device shall surface mount to a standard 4" x 4" square junction box.
 - b. Device shall have 8 ports for connection to lighting control zones, additional network bridges, and System Controller.
 - c. Device shall be capable of aggregating communication from multiple lighting control zones for purposes of minimizing backbone wiring requirements back to System Controller.
 - d. Device shall be powered with Class 2 low voltage supplied locally via a directly wired power supply, or powered via low voltage network connections from powered lighting control devices (e.g. relay packs).
 - e. Network Bridge shall be capable of redistributing power from its local supply and connected lighting control zones with excess power to lighting control zones with insufficient local power. This architecture also enables loss of power to a particular area to be less impactful on network lighting control system.
 5. Outdoor Photocell
 - a. Relay-based lighting control system shall utilize an external photocell to continuously measure exterior light levels.
 - b. The photocell is to be mounted on roof.
 - c. The photocell shall be accurate to +/- 5%.
 - d. The photocell shall have a range of .2 to 2000 footcandles.
- F. Wireless Networked Devices
1. Sensor Interface
 - a. The wireless sensor interface shall integrate industry standard low voltage switching devices and contact closure outputs into the control network.
 - b. The device interface shall have a universal power supply that operates at 120, 208, 240 or 277 VAC.
 - c. The device shall be listed to the UL 916 standard to allow field installation.
 - d. The device shall be listed to the UL 2043 listing for mounting in a plenum.
 - e. The device interface shall provide low voltage input channels suitable for connecting to momentary contact wall switches and dry contact outputs from other systems.
 - f. The device shall be capable of broadcasting the following manual wall control commands: on, off, and adjust dim level.
 2. Light Controllers
 - a. The wireless light controller shall have a line voltage relay and 0-10V dimming output suitable for control of commercial and industrial lighting.
 - b. Device shall have an integrated non-removable antenna for wireless communication.
 - c. The wireless light controller shall have a universal power supply that operates at 120, 208, 240 or 277VAC.
 - d. The device shall be listed under the UL 916 standard to allow field installation.
 - e. The device shall have optional measurement capability of the amperage, voltage, wattage, and watt-hours of its controlled lighting.
 - 1) Amperage and current measurements shall be accurate to +/- 2%.
 - 2) Wattage measurement shall account for power factor of the load, so that real active power is reported by the system instead of apparent power.

- f. Wireless light controller options shall be available that support the following minimum relay specifications:
 - 1) Normal power, 5A relay
 - 2) Emergency power, 5A relay (UL924 listed)
 - 3) Emergency power, no relay (UL924 listed); still provides 0-10V dimming control and power measurement of the load while providing unswitched and "fail-on" operation of the lighting load.
- 3. Digital Sensors
 - a. Digital sensors provide integrated digital occupancy sensing and digital photocell sensor suitable for embedding into the enclosure of a luminaire.
 - b. Digital sensor shall have the following form factors and lens types:
 - 1) High-mounting height (15-45'), 360° PIR with minimum 15' detection radius, and photocell.
 - 2) Low-mounting height (up to 15'), extended range 360° PIR with up to 30' detection radius and photocell.
 - 3) Micro-sensor form factor, 360° PIR and photocell.
- 4. Sensor-Controllers
 - a. Sensor-Controllers shall integrate the following functions in to a single enclosure:
 - 1) Line voltage relay and 0-10V dimming control of a lighting load.
 - 2) Power measurement of lighting load (voltage, amperage, watts, and watt-hours).
 - 3) Digital PIR occupancy sensor.
 - 4) Digital photocell sensor.
 - 5) User button used to provide diagnostic and factory-default reset capabilities.
 - b. Sensor-Controllers shall mount to luminaires or junction boxes with a secured chase nipple suitable for ½" KO mounting holes.
- 5. Communication Bridge
 - a. A communication bridge device shall be provided that interfaces the System Controller with wireless networked devices.
 - b. To provide security, the wireless bridge shall be unresponsive to wired and wireless communication that do not conform to the specific protocols used by the networked lighting control system.

2.05 CABLING

- A. Provide all low voltage cabling as recommended by system manufacturer. Cable color shall be orange.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Inspection:
 - 1. Inspect each installed device for damage. Replace damaged devices and components.
 - 2. Review architectural drawings for ceiling construction where applicable and verify details with ceiling installer. Provide hardware and additional supporting devices as necessary to install devices in each area.
- B. Project Conditions:
 - 1. Only install equipment after the following site conditions are maintained:
 - a. Ambient Temperature: 14° to 105°F.

- b. Relative Humidity: less than 90% non-condensing
 - 2. Equipment shall not be subjected to dust, debris, moisture, or temperature and humidity conditions exceeding the requirements indicated above, at any point prior to installation.
 - 3. Only properly rated equipment and enclosures, installed per the manufacturer's instructions, may be subjected to dust and moisture following installation.
- C. General:
- 1. Install wiring in raceways except where installed above accessible ceilings.
 - 2. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power limited and non-power limited conductors according to conductor manufacturer's written instructions.
 - 3. Install and connect the networked lighting control system components according to the manufacturer's installation instructions, wiring diagrams, the project submittals and plans specifications.
 - 4. Mount each relay directly to junction box above the ceiling near the location of the associated low voltage switch (where applicable). Conduit shall terminate within 6" of relay. Provide bushing on end of conduit. Low voltage cable may be coiled, a maximum of 5' of length, between the conduit termination and the sensor.
 - 5. Where four or more relay packs are grouped together in one location, mount relays to a 6" x 6" x 4" deep junction box above accessible ceiling.

3.02 COORDINATION

- A. Review all required installation and pre-startup procedures with the manufacturer's representative through pre-construction meetings.
- B. Coordinate with the owner's representative all network infrastructure requirements of the networked lighting control system.

3.03 SYSTEM STARTUP

- A. Test all field-terminated low voltage control cable prior to system start-up. Pre-terminated cables to be tested at factory.
- B. Upon completion of installation, system startup shall be performed by qualified personnel approved or certified by the manufacturer.
- C. Verify operational communication to all system devices.
- D. Program the network devices into functional control zones to meet the required sequence of operation.
- E. Initial start-up and programming is to occur on-site. Additional programming may occur on-site or remotely over the Internet as necessary.
- F. Install and program software with initial settings of adjustable values.
- G. Provide current licenses for software.

3.04 FIELD QUALITY CONTROL

- A. Clean devices upon completion of installation. Use methods and materials recommended by manufacturer. Devices with dust, dirt, scratches, or fingerprints shall not be acceptable.

- B. The Contractor shall be responsible for final adjustment and testing of all devices.
- C. Manufacturer's Field Service: Engage a factory authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- D. Perform the following tests after devices have been installed, circuits energized, and system start-up is complete:
 - 1. Test for circuit continuity.
 - 2. Verify operation of local override controls.
 - 3. Test sensitivity of each device per manufacturer's recommendations.
 - 4. Verify that dimmers function without producing lamp flicker and without interference with audio and visual equipment.
- E. Replace or repair malfunctioning devices and components, then retest. Repeat procedure until all units operate properly.

3.05 DEMONSTRATION AND TRAINING

- A. Provide onsite meeting with owner, engineer, and qualified technician approved or certified by the manufacturer to verify all system programming preferences.
- B. Provide eight hours of onsite training for owner and designated personnel by qualified technician approved or certified by the manufacturer. Personnel to be trained to adjust, operate, and maintain lighting controls and software for PC-based control systems.

3.06 PROJECT CLOSE-OUT

- A. As-built Drawings: Document installed location of all networked devices, including networked luminaires.
- B. Provide the following additional documentation to the manufacturer's representative:
 - 1. As-Built floor plan drawings showing daisy-chain wired network control zones outlined, in addition to device address locations required above. All documentation shall remain legible when reproducing/scanning drawing files for electronic submission.
 - 2. As-Built electrical lighting drawings in PDF and CAD format. Architectural floor plans shall be based on as-built conditions.
- C. When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to four visits to site during other-than-normal occupancy hours for this purpose.
- D. Update software to latest version at Project completion. Software updates shall include operating system and new or revised licenses for use of the software.
- E. Provide owner with any hardware, software, computer interface equipment, and/or configuration tools necessary to update, adjust, or modify the system.
- F. Provide owner with updated as-built drawings and/or database file, including device/equipment addresses, locations, etc.

END OF SECTION 26 0923

SECTION 26 1900 - ADDRESSABLE FIRE ALARM SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.
- C. Division 08 Openings
- D. Division 21 Fire Suppression
- E. Division 23 Heating Ventilating and Air Conditioning Monitoring & Control (HVAC).

1.02 SUMMARY

- A. This specification describes an addressable fire detection and alarm signaling system.
- B. This Section includes system components including the following:
 - 1. Fire alarm control panel (FACP).
 - 2. Fire alarm annunciator panel (FAAP).
 - 3. Manual pull stations.
 - 4. System smoke detectors.
 - 5. Heat detectors.
 - 6. Notification appliances (visual and/or audible).
 - 7. Individual addressable modules and control modules.
 - 8. Digital alarm communicator transmitter.
 - 9. Emergency power supply.
- C. Provide complete fire alarm system including all required hardware, raceways, interconnecting wiring and software to accomplish the requirements of this specification and the contract drawings and in accordance with the manufacturer's instructions, whether or not specifically itemized herein.

1.03 ABBREVIATIONS

- A. NAC: Notification Appliance Circuit

1.04 DEFINITIONS

- A. Alarm Initiating Device: A manual station, smoke detector, heat detector, flame detector, or sprinkler water flow switch.
- B. Alarm Signal: Signifies a state of emergency requiring immediate action. Pertains to signals such as the operation of a manual station and the operation of a sprinkler system flow switch.

- C. Supervisory Signal: Indicates need for action regarding fire suppression or other protective system.
- D. Trouble Signal: Indicates that a fault, such as an open circuit or ground, has occurred in the system.

1.05 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections.
- B. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories. Complete manufacturer's catalog data including supervisory power usage, alarm power usage, physical dimensions, and finish and mounting requirements.
- C. Power calculations. Battery capacity calculations. Battery size shall be a minimum of 125% of the calculated requirement. Provide the following supporting information:
 - 1. Supervisory power requirements for all equipment.
 - 2. Alarm power requirements for all equipment.
 - 3. Power supply rating justification showing power requirements for each of the system power supplies. Power supplies shall be sized to furnish the total connected load in a worst-case condition plus 25% spare capacity.
 - 4. Voltage drop calculations for wiring runs demonstrating worst-case condition.
 - 5. NAC circuit design shall incorporate a 25% spare capacity.
 - 6. Addressable SLC circuit design shall incorporate 25% spare capacity.
 - 7. IDC circuit design shall allow only a single initiating device installed on each IDC so that it is uniquely identified on the system.
- D. Submit manufacturer's requirements for testing Signaling Line Circuits and device addresses prior to connecting to control panel. At a minimum the following tests shall be required; device address, the usage (Alarm, Supervisory etc.), environmental compensation, temperature ratings for thermal detectors and smoke detector sensitivities. This requirement shall need approval before any wiring is connected to the control panel.
- E. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
 - 3. Complete drawings covering the following shall be submitted by the contractor for the proposed system:
 - a. Floor plans in a CAD compatible format at a scale of 1/8"=1'-0" showing all equipment and raceways, marked for size, conductor count with type and size, showing the percentage of allowable National Electric Code fill used.
 - b. Provide a fire alarm system function matrix as referenced by NFPA 72. Matrix shall illustrate alarm input/out events in association with initiation devices. Matrix summary shall include system supervisory and trouble output functions. Include any and all departures, exceptions, variances or substitutions from these specifications and/or drawings at time of bid.
 - 4. Installation drawings shop drawings, and as-built drawings shall be prepared by an individual experienced with the work specified herein.
 - 5. Incomplete submittals shall be returned without review, unless with prior approval of the Engineer.
- F. Fire Alarm Permit Drawings: This electrical contractor shall also submit all documents, drawings, calculations, etc. identified in Section 907 of the IBC to the Local Authority Having Jurisdiction (AHJ) for "Approval" prior to commencing work. All costs for Permits and Inspections by the AHJ shall be by the Electrical Contractor.

- G. Qualification Data: For qualified Installer, Applicator, manufacturer, fabricator, professional engineer, testing agency, and factory-authorized service representative.

1.06 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 5 years.
- B. Installers
 - 1. Provide the services of a factory trained and certified representative or technician, experienced in the installation and operation of the type of system provided. The representative shall be licensed in the State if required by law.
 - 2. The technician shall supervise installation, software documentation, adjustment, preliminary testing, final testing and certification of the system. The technician shall provide the required instruction to the owner's personnel in the system operation and maintenance.
 - 3. The contractor shall employ on staff a minimum of one NICET level II technician or a professional engineer, registered in the State of the installation.
 - 4. Contractors unable to comply with the provisions of Qualification of Installers shall present proof of engaging the services of a subcontractor qualified to furnish the required services.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to project site in original, unopened packages with intact and legible manufacturers' labels identifying product and manufacturer, date of manufacture, and shelf life if applicable.
- B. Store materials inside, under cover, above ground, and kept dry and protected from physical damage until ready for use. Remove from site and discard wet or damaged materials.
- C. Do not deliver or install products or materials until spaces are enclosed and weather-tight, wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.08 WARRANTY

- A. Manufacturer's standard form in which manufacturer agrees to repair or replace fire alarm equipment that fail(s) in materials or workmanship within 1 year from date of Substantial Completion.

1.09 EXTRA MATERIALS

- A. Furnish extra materials matching products installed, as described below, packaged with protective covering for storage, and identified with labels clearly describing contents. Deliver replacement stock directed to Owner's storage space.
 - 1. Manual Stations, Visual Notification Appliances (Strobes), Combination Audible/Visual Appliances (Horn/Strobes), Audible Notification Appliances (Horns), Smoke Detectors, Heat Detectors, Detector Bases, Individual Addressable Modules, Monitoring Modules: Furnish quantity equal to 5 percent of the number of units installed, but not less than two (2).
 - 2. System Keys: Provide six (6) of each type.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Manufacturers - subject to compliance with requirements, provide products of one of the following:

1. Edwards, A United Technologies Company
2. Siemens
3. Simplex, a JCI company

2.02 GENERAL

A. All equipment furnished shall be new and the latest state of the art products of a single manufacturer.

B. All equipment shall be sourced from a single supplier for fire alarm equipment, engineering, programming, inspection and tests, and shall be capable of providing a "UL Listing Certificate" for the complete system.

C. System Description

1. Noncoded, UL-listed, FM Global-placarded addressable system, with multiplexed signal transmission and horn and/or strobe evacuation.
2. All components provided shall be listed for use with the selected system.
3. All electrical components, devices, and accessories shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
4. System shall provide an output port for monitoring purposes by external systems. Communications to an external system shall be RS-232 or RS-485 communications.
5. Fire alarm control panel shall provide status indicators and control switches for all of the following functions:
 - a. Audible and visible notification alarm circuit zone control.
 - b. Status indicators for sprinkler system water-flow and valve supervisory devices.
 - c. Any additional status or control functions as indicated on the drawings, including but not limited to; emergency generator functions, door unlocking and security with bypass capabilities.

D. Systems Operational Description

1. Fire alarm signal initiation shall be by one or more of the following devices or systems:
 - a. Manual stations.
 - b. Heat detectors.
 - c. Smoke detectors.
 - d. Automatic sprinkler system water flow.
2. Fire alarm signal shall initiate the following actions:
 - a. Continuously operate alarm notification appliances.
 - b. Identify alarm and specific initiating device at the following locations:
 - 1) Fire alarm control unit
 - 2) Remote annunciators.
 - c. Transmit an alarm signal to the remote alarm receiving station.
 - d. Unlock electric door locks in designated egress paths.
 - e. Release fire and smoke doors held open by magnetic door holders.
 - f. Switch heating, ventilating, and air conditioning equipment controls to fire alarm mode.
 - g. Record events in the system memory.

3. Supervisory signal initiation shall be by one or more of the following devices and actions:
 - a. Valve supervisory switch.
 - b. User disabling of zones or individual devices.
 - c. Loss of communication with any panel on the network.
4. System trouble signal initiation shall be by one or more of the following devices and actions:
 - a. Open circuits, shorts, and grounds in designated circuits.
 - b. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 - c. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
 - d. Loss of primary power at fire alarm control unit.
 - e. Ground or a single break in internal circuits of fire alarm control unit.
 - f. Abnormal ac voltage at fire alarm control unit.
 - g. Break in standby battery circuitry.
 - h. Failure of battery charging.
 - i. Abnormal position of any switch at fire alarm control unit or annunciator.

2.03 FIRE ALARM CONTROL UNIT

- A. General Requirements for Fire alarm Control Unit
 1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.
 - a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder and printer.
 - c. Provide communication between the FACP, NAC panels, and annunciators.
 - d. The FACP shall be listed for connection to a central-station signaling system service.
 - e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.
 2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.
 3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
 1. Annunciator and Display: Liquid-crystal type, two lines of 40 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands.
- C. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits
 1. Pathway Class Designations: NFPA 72, Class A for buildings with selective evacuation or relocation.
 2. Install no more than 256 addressable devices on each signaling-line circuit.
 3. Serial Interfaces:
 - a. One dedicated RS 485 port for remote station operation using point ID DACT.
 - b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
 - c. One USB or RS 232 port for PC configuration.

- D. Notification-Appliance Circuit
 - 1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
 - 2. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.
- E. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.
- F. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- G. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided as a special module that is part of fire alarm control unit.
 - 1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.
 - a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
 - b. Programmable tone and message sequence selection.
 - c. Standard digitally recorded messages for "Evacuation" and "All Clear."
 - d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire alarm control unit.
 - 2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
 - 3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.
- H. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 - 1. Alarm current draw of entire fire alarm system shall not exceed 80 percent of the power-supply module rating.
- I. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
 - 1. Batteries: Sealed lead calcium.

2.04 MANUAL FIRE ALARM BOXES

- A. General Requirements for Manual Fire alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.
 - 1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire alarm control unit.
 - 2. Station Reset: Key- or wrench-operated switch.

2.05 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors

1. Comply with UL 268 7th Edition; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
5. Integral Visual-Indicating Light: LED type, indicating detector is operational and power-on status.
6. Remote Control: Unless otherwise indicated, detectors shall be digital-addressable type, individually monitored at fire alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire alarm control unit.
 - a. Multiple levels of detection sensitivity for each sensor.
 - b. Sensitivity levels based on time of day.

B. Photoelectric Smoke Detectors

1. Detector address shall be accessible from fire alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

2.06 HEAT DETECTORS

A. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

B. Heat Detector, Combination Type: Actuated by either a fixed temperature of 135°F or a rate of rise that exceeds 15°F per minute unless otherwise indicated.

1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire alarm control unit.

2.07 NOTIFICATION APPLIANCES

A. General Requirements for Notification Appliances: Connected to notification-appliance signal circuits, zoned as indicated, equipped for mounting as indicated, and with screw terminals for system connections.

1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated, and with screw terminals for system connections.
2. Finish: Wall mounted devices shall be RED, ceiling mounted devices shall be WHITE.

B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured 10 feet from the horn, using the coded signal prescribed in UL 464 test protocol.

- C. Bells: 10" diameter, weather-proof, vibrating bell for use with fire alarm applications. Bell shall be under dome type with heavy duty mechanisms, constructed of heavy duty cast steel, and equipped with mounting plate for exterior use.
- D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- high letters on the lens.
 - 1. Rated Light Output: As indicated on drawings.
 - 2. Mounting: Wall mounted or ceiling mounted as shown on drawings unless otherwise indicated.
 - 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 - 4. Flashing shall be in a temporal pattern, synchronized with other units.
 - 5. Strobe Leads: Factory connected to screw terminals.
 - 6. Mounting Faceplate: Factory finished, red for wall mounted devices and white for ceiling mounted devices.

2.08 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire alarm control unit, including acknowledging, silencing, resetting, and testing.
 - 1. Mounting: Flush or surface cabinet as required, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.09 ADDRESSABLE INTERFACE DEVICE

- A. General
 - 1. Include address-setting means on the module.
 - 2. Store an internal identifying code for control panel use to identify the module type.
 - 3. Listed for controlling HVAC fan motor controllers.
- B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.
- C. Control Module: Operate notification devices.

2.10 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.
- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
1. Verification that both telephone lines are available.
 2. Programming device.
 3. LED display.
 4. Manual test report function and manual transmission clear indication.
 5. Communications failure with the central station or fire alarm control unit.
- D. Digital data transmission shall include the following:
1. Address of the alarm-initiating device.
 2. Address of the supervisory signal.
 3. Address of the trouble-initiating device.
 4. Loss of ac supply.
 5. Loss of power.
 6. Low battery.
 7. Abnormal test signal.
 8. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.
- G. Communications
1. **The fire alarm communicator shall offer three selectable reporting paths which include: Cellular only, IP only, or IP primary/cellular backup.** All signals shall delivered to the Network Control Center, which shall route highly encrypted Ethernet data packets via a customer provided internet connection or cellular network to the appropriate central station.
 2. The network control center shall be fully redundant and monitored 24/7 and route messages, providing true redundancy and multi-path message delivery.
 3. Alternative communication methods are critical in the marketplace due to VoIP (Voice over IP), migration from POTS (Plain Old Telephone Service) and growth of digital radio networks.
 4. The dialer's single path communications solution allows one technology to be used (either IP or cellular) to provide the appropriate connectivity to a central station. For added reliability, dual path solution allows both technologies (IP and cellular) to be used together for maximum survivability or for local jurisdiction requirements that specify a dual technology system providing:
 - a. Single or dual path communications- (can communicate to central station using cellular technology, internet, or both.
 - b. Connects directly to the primary and secondary telephone ports of a DACT.
 - c. Operates over the standard communication protocols.
 - d. Selectable reporting paths and supervision intervals to meet NFPA 72, chapter 26 requirements. (Compliant with NFPA 72 2010 and 2013 supervision requirements.).
 - e. Works over any type of customer provided Ethernet 10/100 based network connection (LAN or WAN), DSL modem or cable modem.
 - f. Data transmits over standard contact-ID protocol but is secured with the industry's advanced encryption standard (AES 256 bit).
 - g. Supports both dynamic (DHCP) or Public and Private Static IP addressing.
 - h. Built-In Power Supply module: On board charging circuit design accommodates backup battery. Includes primary power and battery supervision.
 - i. Diagnostic LEDs: Signal strength and status indicators.
 - j. Reliable connection: IP and GSM connection tested every day.
 - k. Hand-held programmer for easy setup.

- l. Designed to operate over the most common cellular networks, including 3G and HSPA+. The multi-GSM platform technology automatically chooses the best available cellular signal in the area based on signal strength and seamlessly self-adjusts to maintain critical life safety communication. It connects to any type of customer provided Ethernet 10/100 base network connection (LAN or WAN), DSL model or cable modem. The selectable reporting path feature allows the radio to be configured for a single or dual path solution as well as the appropriate supervision intervals based on NFPA 72 requirements.
5. Description: Manufacturer's standard commercial product; factory assembled, wired, and tested; ready for installation and operation.
 - a. Packaging: A single, modular, NEMA 250, Type 1 metal enclosure with a tamper-resistant flush tumbler lock.
 - b. Signal Transmission Mode and Frequency: VHF or UHF 2-W power output, coordinated with operating characteristics of the established remote alarm receiving station designated by Owner.
 - c. Normal Power Input: 120-V ac.
 - d. Secondary Power: Integral-sealed, rechargeable, 12-V battery and charger. Comply with NFPA 72 requirements for battery capacity; submit calculations.
 - e. Antenna: Omnidirectional, coaxial half-wave, dipole type with driving point impedance matched to transmitter and antenna cable output impedance.
 - f. Antenna Cable: Coaxial cable with impedance matched to the transmitter output impedance.
 - g. Alarm Interface Devices: Circuit boards, modules, and other auxiliary devices, integral to the transmitter, matching fire alarm and other system outputs to message-generating inputs of the transmitter that produce required message transmissions.
6. The digital alarm communicator transmitter (DACT) shall be able to communicate without the need of copper telephone lines. The Federal Communications Commission (FCC) has announced plans to discontinue the use of land line telephone systems (copper telephone lines).

2.11 SYSTEM RECORD CABINET

- A. Provide a wall cabinet for storage of the "System Record of Completion" and the "System Record of Inspection and Testing" documents as described in the Field Quality Control section.

2.12 FIRE ALARM WIRE AND CABLE

- A. Class A (style D & Z) Wiring: Circuits arranged and electrically supervised so a single break or single ground fault condition will be indicated by a trouble signal at the FACP and the circuit will continue to be capable of operation for its intended service in the faulted condition no matter where the break or ground fault condition occurs.
- B. The type and quantity of conductors shall be as required by the equipment manufacturer.
- C. Minimum wire size to be 18AWG or larger where required by system supplier.
- D. Where routed concealed above ceilings, provide plenum-rated Fire Alarm Cable with premium-grade red PVC jacket, type FPLR for riser application and type FPLP for general application.
- E. Where routed exposed, all cabling shall be routed in 3/4" EMT conduit, factory painted red.
- F. All splices shall be made using solderless connectors. All connectors shall be installed in conformance with the manufacturer's recommendations.
- G. Crimp-on type spade lugs shall be used for terminations of stranded conductors to binder screw or stud type terminals. Spade lugs shall have upset legs and insulation sleeves sized for the conductors.

PART 3 - EXECUTION

3.01 INSTALLATION

A. General

1. Inspect each device for damage prior to installation. Replace damaged devices.
2. Install system in accordance with NFPA guidelines.
3. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.
4. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.
5. Examine rough-ins for electrical connections to verify actual locations of connections before installation.
6. Proceed with installation only after unsatisfactory conditions have been corrected.
7. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Equipment

1. Cabinets: Install wall-mounted, with tops of cabinets not more than 78 inches above the finished floor.
2. Manual Pull Stations:
 - a. Unless otherwise indicated mount semi-flush in recessed back boxes.
 - b. Install manual pull station with operating handle 42 inches above floor.
 - c. Install pull station at locations shown on drawings within 5' of door frame.
 - d. Mount manual fire alarm box on a background of a contrasting color.
3. Detectors:
 - a. Install detectors indicated to be ceiling mounted not less than 4 inches from a side wall to the near edge.
 - b. On flat ceilings, install detectors not over 30 feet apart in any direction.
 - c. Install detectors no closer than 5 feet from air-supply diffuser or return-air opening.
 - d. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.
 - e. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.
4. Water Flow Detectors and Valve Supervisory Switches: Connect for each sprinkler valve station required to be supervised.
5. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.
6. Audible Notification Devices:
 - a. Install at locations shown on the drawings.
 - b. Install at 90" above the floor or 6" below finished ceiling, whichever is lower, measured to the top of the device.
 - c. Unless otherwise indicated, install on flush mounted back boxes with the device operating mechanism concealed behind a grille.
 - d. Install weather-proof bell on exterior of building at fire department connection (FDC) location. Location to be verified with AHJ. Mount bell 10'-0" above finished grade.

7. Visible and Combination Audible/Visible Notification Devices:
 - a. Install at locations shown on the drawings.
 - b. Install at 80" above the floor or 6" below finished ceiling, whichever is lower, measured to the top of the device.
 - c. Unless otherwise indicated, install on flush mounted back boxes.
8. Antenna for Radio Alarm Transmitter: Mount to building structure where indicated. Use mounting arrangement and substrate connection that resists 100-mph wind load with a gust factor of 1.3 without damage.

C. Wiring

1. Where routed concealed, provide plenum-rated fire alarm cable.
2. Where routed exposed, install wiring in metal raceway with factory applied red finish.
3. The exact wiring arrangement shall be in accordance with the fire alarm equipment manufacturer's requirements.
4. Wiring within Enclosures: Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved crimp-on terminal spade lugs, pressure type terminal blocks, or plug connectors. Wiring shall be arranged and routed to allow accessibility to equipment for adjustment and maintenance.
5. Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.
6. Mount end-of-line device box with last device or separate box adjacent to last device in circuit.

- D. Connections: Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Electronically locked doors and access gates.
2. Supervisory connections at valve supervisory switches.

- E. Install System Record Cabinet adjacent to main fire alarm control panel, unless noted otherwise.

3.02 IDENTIFICATION

- A. The Electrical Contractor shall provide a Label for each addressable device identifying the device's System Address (i.e.: 01-065).
- B. Color Coding: Color code all fire alarm conductors differently from the normal building power wiring. Provide one color code for alarm circuits wiring and a different color code for supervisory circuits. Provide a color code for audible alarm indicating circuits different from alarm initiating circuits. Use different colors for visual alarm indicating devices. Paint fire alarm system junction boxes and covers red.
- C. Each conductor shall be identified as shown on the drawings with wire markers at every splice and terminal point. Attach permanent wire markers within 2 inches of the wire termination. Marker legends shall be visible.
- D. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

3.03 GROUNDING

- A. Ground fire alarm control unit and associated circuits in accordance with the manufacturer's requirements.

3.04 PROGRAMMING

- A. The Contractor and Manufacturer's Representative shall meet with the Owner and review the requirements for device and location identifications prior to entering any script files. All script files shall be in accordance with the Owner's requirements.

3.05 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by the AHJ.
- B. Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- C. Pretesting: Upon completing installation of the system, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- D. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable. The letter shall include the names and titles of the witnesses to the preliminary tests.
- E. Final Test Notice: Provide 10 days' minimum notice in writing when the system is ready for final acceptance testing.
 - 1. Minimum System Test: Test the system in accordance with the procedures outlined in NFPA 72. Testing specified shall be performed by the installing contractor, the distributor's technician and the building inspector. Minimum required tests are as follows:
 - 2. Verify the absence of unwanted voltages between circuit conductors and ground.
 - 3. Megger test all conductors other than those intentionally and permanently grounded with electronic components disconnected. Test for resistance to ground. Report readings less than 1-megohm for evaluation.
 - 4. Test all conductors for short circuits utilizing an insulation testing device.
 - 5. 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 on the record drawings.
 - 6. Verify the control unit is in the normal condition as detailed in the manufacturer's operating and maintenance manual.
 - 7. Test initiating and indicating circuits for proper signal transmission under open circuit conditions. One connection each should be opened at not less than 10 percent of the initiating and indicating devices. Proper signal transmission in accordance with class of wiring used shall be observed.
 - 8. Test each initiating and indicating device for alarm operating and proper response at the control unit. Test smoke detectors with actual products of combustion.
 - 9. Test the system for all specified functions in accordance with 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. Test both primary power and secondary power. Verify, by test, the secondary power system is capable of operating the system for the period and in the manner specified.

- F. Retesting: Rectify deficiencies indicated by tests and completely retest work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets the Specifications and complies with applicable standards.
- G. Report of Tests and Inspections: Provide a written record of inspections, tests, and detailed test results in the form of a test log. Submit log upon the satisfactory completion of tests.
 - 1. Provide both a "System Record of Completion" and the "System Record of Inspection and Testing" as outlined in NFPA 72. Each shall be fully executed by the manufacturer's representative and the AHJ.
- H. Tag all equipment and stations and other components at which tests have been satisfactorily completed. Place tags upon completion of tests.

3.06 DEMONSTRATION AND TRAINING

- A. Provide the services of a factory authorized service representative to demonstrate and train Owner's maintenance personnel as specified below.
 - 1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 4 hours of training.
 - 2. Schedule training with the Owner at least seven days in advance.

3.07 PROJECT CLOSEOUT

- A. Operation and Maintenance Data
 - 1. Software and Firmware Operational Documentation:
 - a. Software operating and upgrade manuals.
 - b. Program Software Backup: On portable USB drive, complete with data files.
 - c. Device address list with Custom Device Messages. These Messages shall be "Approved" prior to programming the system.
 - d. Printout of software application and graphic screens.

3.08 MAINTENANCE SERVICE

- A. Initial Maintenance Service Contract:
 - 1. Provide maintenance of fire alarm systems and equipment for a period of 12 months commencing with Substantial Completion, using factory-authorized service representatives.
 - 2. Respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.
- B. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls to suit actual occupied conditions. Provide up to three visits to the site for this purpose.
- C. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to the Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

END OF SECTION 26 1900

SECTION 26 1901 - EMERGENCY RESPONDER RADIO COVERAGE SYSTEM (ERRCS)

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of this section include raceways, electrical boxes and fittings, wiring/cabling, and control/signal amplification and transmission media, as specified in applicable Division 26 Common Work Results for Electrical sections, that are used in conjunction with installation of this system.

1.02 SUMMARY

- A. General
 - 1. Provide an in-building radio signal amplification system to provide complete coverage in the building for the public safety agencies as required by the local fire department and other agencies and authorities having jurisdiction. System users shall receive and transmit radio broadcasts from their portable radio units within the building. This shall be accomplished utilizing the following components:
 - a. Bi Directional Amplifiers (Signal Boosters)
 - b. Plenum rated Coaxial Cable
 - c. Antennas
 - d. Cable taps
 - e. Connectors
 - f. Power dividers
 - g. Other components and interconnecting circuitry as required
 - 2. The system shall comply with the requirements of UL2524 1st Edition (pending) In-building 2-Way Emergency Radio Communication Enhancement Systems, NFPA 72 2010 Edition, NFPA 1221 2016 Edition and IFC 2018, as referenced.
 - 3. The entire system shall meet with approval of the Fire Department, the Building Department and all other agencies and authorities having jurisdiction (AHJ).
 - 4. The work in this section shall include the responsibility for all filings with the AHJ. Where filings require engineer's signature, documents shall be submitted for his review and signature. This responsibility shall include furnishing of required quantities of floor plans, descriptive notes and/or specifications, wiring diagrams, shop drawings and amendment forms.
 - 5. Early completion of the in-building emergency radio communication enhancement system will be required as to permit a Certificate of Occupancy to be obtained in a timely manner
 - 6. Any permits necessary for the installation of the work shall be obtained prior to the commencement of the work. All permit costs and inspection fees shall be included as the part of the required work.
 - 7. The in-building emergency radio communication enhancement system shall use a UL2524 1st Edition (pending), NFPA-72 2010 Edition, NFPA 1221 2016 Edition and IFC 2018 compliant NOTIFIER® signal booster or approved equal.
- B. Design Requirements:
 - 1. In-building emergency radio communication enhancement systems for emergency responders are an integral component of the life safety equipment of a building or structure. The primary function is to provide reliable emergency responder communications at the required signal strength within the specified areas.

2. Critical Areas such as emergency command center, fire pump room, exit stairs, exit passageways, elevator lobbies, standpipe cabinets, sprinkler sectional valve locations and similar critical areas shall be provided with 100% floor area radio coverage.
3. General building areas shall be provided with 95% radio coverage, or as specified by AHJ.
4. The In-building emergency radio communication enhancement systems must provide the following signal strengths:
 - a. Downlink - Minimum signal strength of -95 dBm throughout the coverage area.
 - b. Uplink - Minimum signal strength of -95 dBm received at the AHJ Radio System.
5. The system shall be complete with all components and wiring required for compliance with all applicable codes and regulations, and for its operations described hereinafter.
6. EC shall sub-contract an approved manufacturer or a qualified and approved vendor to supply, test and determine locations of components which are required for proper operation as well as to supply, deploy, test and certify the performance of the complete system. Vendor qualifications must be acceptable to the AHJ.
7. All tests shall be conducted, documented, and signed by a person in possession of an FCC General Radio Telephone Operators License. All testing personnel shall be certified and authorized by the signal booster manufacturer in the installation and operation of their equipment. Personnel qualifications must be acceptable to the AHJ.
8. The system design shall be based on the NOTIFIER® line of Public Safety Signal Boosters UL2524 1st Edition (pending), NFPA-72 2010 Edition, NFPA 1221 2016 Edition, IFC 2018 Edition and FCC compliant to establish standards of quality for materials and performance. The naming of a specific manufacturer or a catalog number does not waive any requirement or performance of individual components described in the specifications.
9. Assembly and installation of all components of the Emergency Responder Radio Communication Enhancement System shall comply with all applicable sections of the National Electrical Code.
10. Survivability from attack by fire shall meet NFPA 72, National Fire Alarm and Signaling Code, 2010 edition and NFPA 1221 2016 edition.
11. The system must comply with all applicable sections of the FCC rules. Signal booster shall have FCC certification prior to installation.
12. Antenna isolation shall be maintained between the donor antenna and all inside antennas (D.A.S.) to a minimum of 20dB under all operating conditions

C. Technical Specifications and Performance Requirements

1. The system specified shall be based upon NOTIFIER® line of Public Safety UL2524 1st Edition (pending), NFPA-72 2010 Edition, NFPA 1221 2016 Edition, IFC 2018 Edition compliant signal boosters
2. The signal booster shall be a Class B Public Safety type as designated by the FCC and as required by the AHJ.
3. The secondary power supplies, battery chargers and system monitoring shall be fully compliant with NFPA-72, 2010 Edition and NFPA 1221, 2016 Edition. The signal booster shall have both the primary and the secondary power supplies built in a fully sealed NEMA-4 type approved enclosure.
4. All signal boosters and other active system components must have FCC certification prior to installation. The equipment FCC ID must be shown on the product datasheets and technical submittals. The ID must also be displayed on the product as required by the FCC.
5. The signal booster shall be set and tuned by the equipment manufacturer to pass frequencies as specified by the local fire department.
6. To reduce the possibility of unwanted interference affecting the operation of the system, signal boosters shall be band or channel selective type with a maximum 3dB channel bandwidth of 200KHz (Fc +/- 100KHz). Wide-band signal boosters shall not be accepted, unless required to cover multiple channels within the same band.
7. Signal Boosters shall have oscillation prevention circuitry to protect the public safety radio system in case of signal booster malfunction.
8. Signal Booster gain shall be rated at minimum of 80dB and the gain shall be adjustable in a minimum of 25dB range. System gain shall be set and documented at the time of the final system test.
9. Maximum Propagation delay of the signal booster system shall be 14µs (microseconds) or as specified by AHJ.

10. The signal booster system shall include built-in automatic alarming of malfunctions of the signal booster and battery system as per NFPA 1221 2016 Edition Section 9.6, NFPA 72, 2010 Edition, Sections 24.5.2.6.1, and 24.5.2.6.2. Aftermarket equipment add-ons and modifications to comply with this specification will not be accepted.
11. A dedicated supervised monitoring panel shall be provided within the emergency command center or other location as designated by AHJ to annunciate the status of all signal booster locations. The monitoring panel shall provide visual and labeled indication of the following for each signal booster:
 - a. Normal AC power
 - b. Signal booster trouble
 - c. Antenna Failure
 - d. Loss of normal AC power
 - e. Failure of battery charger
 - f. Low battery capacity
12. The signal booster system shall include a built-in NOTIFIER® addressable monitor module for NOTIFIER® Fire Alarm Panel connection for monitoring the signal booster.
13. The vendor shall verify the system monitoring requirements with the AHJ prior to system installation. System monitoring shall be fully compliant with the AHJ requirements.
14. External filters, attachments or other aftermarket modifications of the original equipment shall not be accepted.
15. All signal booster components shall be contained in a NEMA4-type approved waterproof cabinet. All enclosures shall be painted red with signage in bright yellow or as required by AHJ

D. Installation Requirements

1. Assembly and installation of all components of the Emergency Responder Communication Enhancement System shall comply with all applicable sections of the National Electrical Code, NFPA-70 and the National Fire Alarm and Signaling Code, NFPA-72, NFPA 1221 current enforceable editions.
2. At least 2 independent and reliable power supplies shall be provided as specified in sections 2 and 3 below.
3. The primary power source shall be supplied from a dedicated twenty (20) ampere branch circuit and comply with NFPA-70 National Electrical Code, NFPA 72, National Fire Alarm and Signaling Code, 2010 Edition and NFPA 1221, 2016 Edition.
4. The emergency responder radio coverage enhancement system shall be equipped with a secondary source of power. The secondary source of power shall be a battery system with a dedicated battery charger powered by a separate, dedicated twenty (20) ampere branch circuit. The secondary power supply shall supply power automatically when the primary power source is lost. The secondary source of power shall be capable of operating the emergency responder radio coverage enhancement system for a period of at least 24 hours. The battery system shall automatically charge in the presence of external power input. Battery charger and all other electronic components must be fully enclosed in a non-vented NEMA4 Type approved enclosure. Batteries shall be enclosed in a separate, vented NEMA 3R Type approved enclosure.
5. The signal booster shall be designed to allow degraded performance in adverse conditions, such as high temperatures in the event of heat from a nearby fire, voltage fluctuations or other abnormal conditions that may occur during an emergency. Circuits that intentionally disable the signal booster in such situations (i.e. under/over voltage, over/under current, over/under temperature, etc.) are not acceptable. External UPS (Uninterruptable Power Supplies) are not acceptable. It is the purpose of this specification to assure the maximum possible level of communications to public safety personnel depending upon the signal booster, even to the extent of damaging the signal booster, as long as some communications benefit can be provided during the emergency.
6. System design shall be such that neither the failure of the normal power source, the transfer to an emergency source, nor the re-transfer to the normal source shall cause a change in system status.
7. The amplifier shall be housed in a 2-hour fire rated room or other suitable space as approved by the Engineer, or where specifically shown on the drawing.
8. Radiating cable, if used, shall be run without conduit. All other cable can be run in conduit if required for mechanical protection of the cable, or where specified by the electrical engineer.
9. RF Coaxial Cable shall be a fire-resistant, low-smoke type, U.L. classified as plenum. The classification shall be clearly marked on the outer surface of the cable regular intervals.

E. Acceptance and Test Procedures

1. Acceptance testing for an in-building radio system is required upon completion of installation.
2. The coverage testing shall be done in accordance with NFPA 72, National Fire Alarm and Signaling Code, 2010 Edition, NFPA 1221, 2016 Edition and as required by the local AHJ.
3. All tests shall be conducted, documented, and signed by a person in possession of a current FCC General Radio Operator License.
4. All test records along with system diagrams, equipment specifications, user manuals, RF link budget calculations, battery backup calculation and other design data shall be submitted upon completion of the project.

1.03 MAINTENANCE SERVICE

- A. Maintenance Service Contract: Provide maintenance of fire alarm systems and equipment for a period of 12 months commencing with Substantial Completion, using factory-authorized service representatives.
1. Basic services: Respond to service calls within 24 hours of notification of system trouble. Adjust and replace defective parts and components with original manufacturer's replacement parts, components, and supplies.
 2. Renewal of Maintenance Service Contract: No later than 60 days prior to the expiration of the maintenance services contract, deliver to the Owner a proposal to provide contract maintenance and repair services for an additional one-year term. Owner will be under no obligation to accept maintenance service contract renewal proposal.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In order to assure the Owner of all factory warranties, all equipment shall be obtained from an approved factory authorized distributor. The manufacturer and/or his authorized distributor shall show satisfactory evidence that he maintains a fully equipped factory authorized service organization, stocked with factory approved replacement parts within 50 miles of the project site and is capable of furnishing adequate inspection and service of equipment.
- B. The catalogue numbers specified herein are those of Siemens and constitute the type and quality of equipment to be furnished. The system shall be complete in every respect including all necessary equipment shown or now shown on the drawings to perform the functions relative to the system operation. All published specifications of the above manufacturer shall be considered as part of this specification even though they may not be shown in complete detail.
- C. Manufacturers - subject to compliance with requirements, provide products by the following:
1. Notifier, as represented by Fire Fighter Sales and Services (724-720-6000)
 2. Bird, The RF Experts (866-695-4569)
 3. Advanced Network Services (800-268-0937)
 4. BearCom
 5. Radio Solutions, Inc.
 6. Lord & Company Technologies

PART 3 - EXECUTION

3.01 INSTALLATION - GENERAL

- A. Provide an Emergency Responder Radio Coverage System (ERRCS) as covered by these Specifications, to be wired, connected, and left in first class operating condition. All equipment shall be listed by the Underwriter's Laboratories and shall conform with the requirements of the Pennsylvania Fire Code.
- B. Provide in accordance with the manufacturer's instructions, all wiring, conduit, raceways, outlet boxes, and auxiliary equipment required for the installation of the system.
- C. Install system in accordance with NFPA Standards referenced in Parts 1 and 2 of this Section.

3.02 EQUIPMENT INSTALLATION

- A. Equipment shall be located near the Fire Alarm Control Panel. Cabling and antenna locations shall be placed as to have 100% coverage through-out the building.

3.03 WIRING INSTALLATION

- A. The wiring system shall meet the requirements of all applicable national, state, and local electrical codes and shall conform with the requirements of Standard #72 of the National Fire Protection Association.
- B. Wiring Method: Install wiring in metal raceway provided by the Division 26 Contractor.
- C. Wiring within Enclosures: Install conductors parallel with or at right angles to the sides and back of the enclosure. Bundle, lace, and train the conductors to terminal points with no excess. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal in accordance with the wiring diagrams of the system. Make all connections with approved crimp-on terminal spade lugs, pressure type terminal blocks, or plug connectors.
- D. Cable Taps: Use numbered terminal strips in junction, pull or outlet boxes, cabinets, or equipment enclosures where any circuit tap is made.
- E. Wiring: For the low voltage portion of the antenna system, provide Commscope AL4RPV-50, HELIAX® Plenum Rated Air Dielectric Coaxial Cable, corrugated aluminum, 1/2 in, off white PVC jacket. Cable will not be run in conduit.
- F. Final connections between equipment and wiring system shall be made under the direct supervision of a representative of the fire alarm equipment manufacturer.
- G. The exact wiring arrangement shall be in accordance with the fire alarm equipment manufacturer's requirements and the exact number of initiating and signaling devices to be furnished and installed shall be as shown on the drawings.

3.04 PROGRAMMING

- A. The Contractor and Manufacturer's Representative shall meet with the Owner and review the requirements for device and location identifications prior to entering any script files. All script files shall be in accordance with the Owner's requirements.

3.05 GROUNDING

- A. Ground equipment and conductor and cable shields in accordance with the manufacturer's requirements.

3.06 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a factory authorized service representative to supervise the field assembly and connection of components and the pretesting, testing, and adjustment of the system.
- B. Pretesting: Upon completing installation of the system, align, adjust, and balance the system and perform complete pretesting. Determine, through pretesting, the conformance of the system to the requirements of the Drawings and Specifications. Correct deficiencies observed in pretesting. Replace malfunctioning or damaged items with new and provide additional antennas and cabling at no additional cost if required. Retest until satisfactory performance and conditions are achieved. Prepare forms for systematic recording of acceptance test results.
- C. Report of Pretesting: After pretesting is complete, provide a letter certifying the installation is complete and fully operable. The letter shall include the names and titles of the witnesses to the preliminary tests.

3.07 COMMISSIONING

- A. Provide the services of a factory authorized service representative to demonstrate and train Owner's maintenance personnel as specified below.
 - 1. Train Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventive maintaining of the system. Provide a minimum of 4 hours' training.
 - 2. Schedule training with the Owner at least seven days in advance.
 - 3. Occupancy Adjustments: When requested within one year of date of Substantial Completion, provide on-site assistance in adjusting sound levels and adjusting controls to suit actual occupied conditions. Provide up to three visits to the site for this purpose.

3.08 GUARANTEE

- A. The contractor shall warrant the entire system against mechanical and electrical defects for a period of one (1) year from the date of final acceptance and as described in the contract general conditions.
 - 1. This period shall begin upon completed certification and test of the system or upon first beneficial use of the system, whichever is earlier.

END OF SECTION 26 1901

SECTION 26 2416 - PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes load centers and panelboards, overcurrent protective devices, and associated auxiliary equipment rated 600V and less for the following types:
 - 1. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground fault circuit interrupter.
- C. GFEP: Ground-fault equipment protection.
- D. ICS: Industrial Control Systems
- E. MCOV: Maximum continuous operating voltage.
- F. RFI: Radio frequency interference.

1.04 SUBMITTALS

- A. Product Data - for each type of panelboard, overcurrent protective device, accessory, and component indicated, include:
 - 1. Dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings - for each panelboard, include:
 - 1. Dimensioned plans, elevations, sections, and details.
 - 2. Enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Bus configuration, and current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices.

- C. Maintenance Manuals - in addition to requirements specified in Division 01 and 26, include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device.
- D. Overcurrent Protective Device Coordination Study: Provide in accordance with Section 26 0573.
- E. Layout Drawings: Prepare layout drawing for each room or area of the building containing panelboards and submit for review at the time of the equipment submittal. Layout drawings shall be based on actual submitted equipment dimensions. Indicate working clearances for each panelboard.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E. Firm with at least 5 years of successful installation experience on projects utilizing panelboards similar to those required for this project.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Do not deliver panelboard interiors until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
- B. Remove loose packing and flammable materials from inside panelboards.

1.07 COORDINATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, and encumbrances to workspace clearance requirements.

1.08 WARRANTY

- A. Manufacturer's Warranty: Manufacturer agrees to repair or replace panelboard enclosures, buswork, overcurrent protective devices, accessories, and factory installed interconnection wiring that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: One year from date of Substantial Completion.

1.09 EXTRA MATERIALS

- A. Keys: Furnish six spares of each type for panelboard cabinet locks.
- B. Touch-up Paint: For surface mounted panelboards - one half-pint container.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide panelboards of the following manufacturer:
 - 1. Eaton
 - 2. GE by ABB
 - 3. Schneider Electric/Square D
 - 4. Siemens Industry, Inc.

2.02 GENERAL

- A. Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Refer to Panelboard Schedules on drawings for additional panelboard requirements, including but not limited to, mains type and size, mounting, branch circuit breaker sizes and quantities, SCCR rating, options, etc.
- C. Enclosures:
 - 1. Provide flush and surface mounted enclosures as indicated on the drawings.
 - 2. Standard panel dimensions: 6" deep x 20" wide x 84" high (maximum height).
 - 3. Rated for environmental conditions at installed locations:
 - a. Indoor Dry Locations: Steel, Type 1
 - 4. Backbox Finish:
 - a. Surface-mounted cabinets: Same finish as panel cover.
- D. Incoming Mains:
 - 1. Main breaker or main lugs as indicated on drawings.
 - 2. Location shall be convertible between top and bottom.
 - 3. Main lug interiors shall be field convertible to main breaker.
- E. Phase, Neutral, and Ground Buses:
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - a. Plating shall run entire length of bus.
 - b. Bus shall be fully rated the entire length.
 - 2. Interiors shall be factory assembled into a unit. Replacing switching and protective devices shall not disturb adjacent units or require removing the main bus connectors.
 - 3. All bus work shall be rated to withstand short circuit stresses at specified voltage as described on the panelboard schedules shown on the drawings.
 - 4. Full-Sized Neutral: Equipped with full-capacity bonding strap for service entrance applications. Mount electrically isolated from enclosure. Do not mount neutral bus in gutter.
 - 5. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

- F. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Hard-drawn copper, 98 percent conductivity.
 - 2. Terminations shall allow use of 75 deg C rated conductors without derating.
 - 3. Size: Lugs suitable for indicated conductor sizes, with additional gutter space, if required, for larger conductors.
 - 4. Main and Neutral Lugs: Mechanical type, with a lug on the neutral bar for each pole in the panelboard.
 - 5. Ground Lugs and Bus-Configured Terminators: Mechanical type, with a lug on the bar for each pole in the panelboard.
- G. Panelboard Short-Circuit Current (SCCR) Rating:
 - 1. Fully rated to interrupt symmetrical short-circuit current available at terminals. Panelboards with a Series Short Circuit Rating are not acceptable.
 - 2. Assembly shall be UL listed for 100 percent interrupting capacity.
 - 3. Minimum short circuit current rating of panelboard shall be as specified on the panelboard schedules shown on the drawings. No device within panelboard shall be lower than this rating.
- H. Provision for Future Devices: Equip with mounting brackets, bus connections, and necessary appurtenances, for the overcurrent protective device ampere ratings indicated for future installation of devices.

2.03 DISTRIBUTION PANELBOARDS

- A. NEMA PB 1, distribution type.
- B. Branch overcurrent protective devices shall be bolt-on circuit breakers or plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.
- C. Doors/Covers:
 - 1. Secured with flush latch with tumbler lock; keyed alike.
 - a. For doors more than 36 inches high, provide two latches, keyed alike.
 - 2. Finish:
 - a. Indoor Dry Locations: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.04 LIGHTING AND APPLIANCE BRANCH CIRCUIT PANELBOARDS

- A. NEMA PB 1, lighting and appliance branch-circuit type.
- B. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- C. Doors/Covers:
 - 1. Hinged Front Cover: Door-in-door construction with concealed hinges. Outer door shall permit full access to the panel interior. Inner door shall permit access to breaker operating handles and labeling, but current carrying terminals and bus shall remain concealed. EZ Trim as manufactured by Eaton is not acceptable.
 - 2. Secured with flush latch with tumbler lock; keyed alike.
 - a. For doors more than 36 inches high, provide two latches, keyed alike.

3. Finish:
 - a. Indoor Dry Locations: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

2.05 OVERCURRENT PROTECTIVE DEVICES

- A. Molded Case Circuit Breaker (MCCB) with interrupting capacity to meet available fault currents.
 1. General
 - a. Circuit breakers shall have quick-make, quick-break operating mechanisms and silver alloy contacts.
 - b. The operating handle shall indicate ON, TRIPPED, and OFF positions.
 - c. Multi-pole units enclosed in a factory assembled to operate as a single unit.
 - d. Circuit breakers shall be electrically and mechanically trip free.
 - e. Circuit breakers shall be UL489 listed.
 - f. Circuit breakers and terminals shall have a UL 60/75°C rating.
 - g. UL listed for reverse connection without restrictive line or load ratings.
 - h. Tandem circuit breakers shall not be used.
 - i. Mechanical style lugs, suitable for number, size, trip ratings, and material of conductors.
 - j. Three-pole breakers with ampere ratings greater than 250 amperes shall have interchangeable rating plugs or electronic adjustable trip units.
 - k. Unless indicated otherwise, circuit breakers 800A frame and below shall have thermal-magnetic trip units and inverse time-current characteristics.
 - l. Circuit breakers over 800A frame shall have microprocessor-based RMS sensing trip units (Electronic Trip).
 - m. Circuit breakers 1200A frame and above shall have an energy reduction maintenance setting (ERMS) as follows:
 - 1) Circuit breaker shall be provided with energy reduction maintenance setting per NEC requirements.
 - 2) Provide two position selector switch with integral status indicating blue pilot light installed on face of panelboard.
 - 3) Provide all labeling as required by NEC.
 2. Thermal Magnetic Circuit Breakers:
 - a. Inverse time-current element for low-level overloads.
 - b. Instantaneous magnetic trip element for short circuits.
 - c. Adjustable Trip Circuit Breakers:
 - 1) Provide adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2) Field-adjustable trip settings for magnetic trip element shall be front-mounted.
 3. Electronic Trip Circuit Breakers:
 - a. RMS sensing.
 - b. Field-replaceable rating plug or electronic trip.
 - c. Ten-event, trip-history log. Each trip event shall be recorded with type, phase, and magnitude of fault that caused the trip.
 - d. Field-Adjustable Settings:
 - 1) Instantaneous trip.
 - 2) Long- and short-time pickup levels.
 - 3) Long and short time adjustments.

4. Molded Case Circuit Breaker Options and Accessories:
 - a. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position for circuit(s) feeding fire alarm control and extender panel(s).
 - b. Subfeed Circuit Breakers: Vertically mounted.

2.06 PANELBOARD OPTIONS

A. Integral Surge Protective Device (SPD)

1. UL 1449, Type 2 SPD (Permanently connected SPDs intended for installation on the load side of the service disconnect overcurrent device).
2. Factory installed integral to electrical distribution equipment.
3. Direct bussed connected or breaker fed.
4. UL labeled with 200kA Short Circuit Current Rating (SCCR).
5. UL labeled with 20kA I-nominal (I-n) (verifiable at UL.com).
6. Protection modes shall be as follows: Line to Neutral, Line to Ground, and Neutral to Ground.
7. Minimum single-impulse current rating shall be as follows:
 - a. Line to Neutral: 160,000 A.
 - b. Line to Ground: 160,000 A.
 - c. Neutral to Ground: 160,000 A.
8. UL 1449 Voltage Protection Ratings shall not exceed the following:

VOLTAGE	L-N	L-G	N-G	L-L	MCOV
208Y/120	700V	700V	700V	1200V	150V

9. EMI/RFI Noise Attenuation Using 50-ohm Insertion Loss Test: 55 dB at 100 kHz.
10. The protection status of every surge protective element shall monitored including elements connected across neutral to ground. Diagnostics shall change state if any surge protective element reaches end of life.
11. SPD shall be equipped with the following diagnostics:
 - a. Visual LED diagnostics including a minimum of one green LED indicator per phase, and one red service LED.
 - b. Audible alarm with on/off silence function and diagnostic test function (excluding branch).
 - c. Form C dry contacts
12. SPD shall have a 10 year warranty.

B. Customer Metering

1. General:
 - a. Manufacturer shall be the same as the panelboard.
 - b. Provide a 15A/3P breaker in panelboard for voltage inputs to meter, and provide factory wiring from breaker to meter.
 - c. Provide with display on face of panelboard.
 - d. Provide with Ethernet communications.
 - e. Provide with ability to communicate via BACnet/IP and Modbus TCP for connection to building management system.

2. Power Meter (Square D PM5560/PM5563, Eaton Power Xpert PXM2260, Siemens 9410, or equal): Metering device used to monitor circuits for purposes of network management, energy cost management, energy allocation, and operational efficiency. Provide at a minimum the following features:
- a. Connections and form factor: Direct connect to circuits up to 600 VAC, eliminating the need for voltage (potential) transformers; 5 A nominal current inputs. Removable connectors for voltage inputs, control power, communications, inputs and outputs; easily mountable in the pre-made cutout without tools; form factor will be ¼ DIN with 92 X 92 cut-out and 96 x 96 panel mount integrated display.
 - b. Supported monitoring parameters: Full range of 3-phase voltage, measure each phase and neutral current using 4 current inputs, power and energy measurements, power factor, frequency, total harmonic distortion (THD), individual power harmonics (up to 63rd order).
 - c. Accuracy standards: Use four-quadrant metering and sample current/voltage simultaneously without gaps with 64 samples per cycle (zero blind); comply with ANSI C12.20 class 0.2 and IEC 61557-12 class 0.2 for revenue meters.
 - d. Display: Backlit dot-matrix LCD display, anti-glare and scratch resistant with a minimum of 128 x128 pixels, capable of displaying four values in one screen simultaneously; a summary screen to allow the user to view a snapshot of the system; support either integrated or remote display.
 - e. Inputs: Support 4 digital inputs for Demand Synch Pulse, Time Synch Input, and Conditional Energy Control; have 2 digital outputs that operate either by user command sent over communication link, or in response to a user defined alarm or event.
 - f. Communications: Serial RS-485 Modbus, Ethernet Modbus TCP, Ethernet BACnet IP (BTL listed), and EtherNet IP; provide 2 Ethernet ports to allow wiring from meter to meter as a daisy-chain; be capable of serving data over the Ethernet network accessible through a standard web browser; the monitor shall contain default pages from the factory.
 - g. Onboard data logging capabilities: To log data, alarms and events; logged information shall include data logs, minimum/maximum log files of selected parameter values, and alarm logs for each user defined alarm or event log; support the following on-board nonvolatile memory—14 parameters every 15 minutes for 90 days.
 - h. Alarming capabilities: Support 29 set-point driven alarms, 4 digital alarms, 4 unary alarms, 10 Boolean alarms and 5 custom alarms; user definable alarm events; set-point driven alarms shall be available for voltage/current parameters, input status, and end of interval status; shall send emails and/or text messages containing alarm condition indication via Simple Mail Transfer Protocol [SMTP]; Shall have the capability to manage and monitor devices on the IP network via Simple Network Management Protocol [SNMP]; Indication of an alarm condition shall be delivered by SNMP Traps.
 - i. Firmware: Upgradeable to enhance functionality through the Ethernet or serial communication connection and shall allow upgrades of individual meters or groups.
 - j. Integrated gateway functionality, enabling the capability to connect via Ethernet to downstream, serially connected devices.
 - k. Designed accordingly to eco-design complying with ISO 14062, especially MCCB materials shall be halogen free type; designed for easy disassembly and recycling at end of life, and comply with environmental directives ROHS and WEEE.
 - l. The meter shall provide 4 digital inputs configurable for input metering with on-board pulse weight calculation and conversion to standard units for external water, air, gas, electrical or steam (WAGES) meters.

2.07 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: Computer-generated circuit directory card inside panelboard door, mounted in metal frame with transparent protective cover. Circuit directory shall identify specific purpose with detail sufficient to distinguish it from all other circuits.
- D. Service Equipment Label: Panelboards with main service disconnecting devices (maximum of 6) shall be UL labeled for use as service equipment.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify actual conditions with field measurements prior to ordering panelboards to verify that equipment fits in allocated space in, and comply with, minimum required clearances specified in NFPA 70.
- B. Examine panelboards before installation. Reject panelboards that are damaged, rusted, or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Coordinate layout and installation of panelboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Mounting:
 - 1. Panelboards shall be installed such that the center of the grip of the operating handle of any overcurrent devices (switch or circuit breaker) located in the panelboard, when in its highest position, is not more than 6'-7" above finished floor or working platform.
 - 2. Mount panelboard cabinet plumb and rigid without distortion of box.
 - 3. Mount panelboards with minimum of four anchors.
 - 4. Mount surface-mounted panelboards to steel slotted supports 1-5/8 inch in depth. Orient steel slotted supports vertically.
 - 5. Use sheet metal channel to bridge studs above and below panelboards recessed in hollow partitions.
- C. Maintain required workspace clearances per NEC 110.26.
- D. Install equipment grounding connections for panelboards with ground continuity to main electrical ground bus.
- E. Make grounding connections and bond neutral for services and separately derived systems to ground.
- F. Install filler plates in unused spaces.
- G. Wiring in Panel Gutters: Arrange conductors neatly in groups and bundle and wrap with wire ties after completion of load balancing.

- H. Install Handle Clamp(s) on circuit breaker(s) feeding fire alarm control and extender panel(s).
- I. Tighten electrical connectors and terminals, including grounding connections, in accordance with manufacturer's published torque-tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.03 IDENTIFICATION

- A. Identify field installed conductors, interconnecting wiring, and components; provide warning signs as specified in Division 26 Section 26 0553 "Identification for Electrical Systems."
- B. Panelboard Directory:
 - 1. Create a directory to indicate installed circuit loads.
 - 2. All panelboard directories shall reflect the as built electrical configuration of the job, including the approved changes required to balance the panel loads.
 - 3. Each directory entry shall include a description of the connected load(s) and the room number, which corresponds to the location(s) of the connected loads.
 - 4. Incorporate Owner's final room designations.
 - 5. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
 - 6. Obtain approval before installing.
 - 7. Install directory inside panelboard door.
- C. Panelboard Nameplates: Label each panelboard with engraved laminated-plastic nameplate in accordance with Nameplate Detail – Panelboards shown on the drawings.
- D. Distribution Panelboard Device Nameplates: Label each branch circuit device in Distribution Panelboards with a nameplate complying with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

- A. Inspect for defects and physical damage.
- B. Check panelboard mounting, area clearances, and fit of components.
- C. Check tightness of bolted electrical connections with calibrated torque wrench. Refer to manufacturer's instructions for proper torque values.
- D. Test continuity of each circuit.
- E. Exercise and perform operational tests of all mechanical components and other operable devices in accordance with manufacturer's instruction manual.
- F. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
- G. For circuit breakers 200 amps and larger, perform each visual inspection, mechanical inspection, and electrical test indicated in NETA ATS, Section 7.6. Engage a qualified independent testing agency to perform specified testing and certify compliance with test parameters.

3.05 EQUIPMENT AND SOFTWARE SETUP (METER)

- A. Engage manufacturer's field representatives to perform the following:
 - 1. Set meter date and time clock.
 - 2. Test, calibrate, and connect pulse metering system.
 - 3. Report settings and calibration results.
 - 4. Set up reporting software, insert location names and initial constant values and variable needed for computations.
 - 5. Coordinate with owner for connection to monitoring system and confirm proper operation. Provide commissioning services as required to ensure proper operation.

3.06 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes as follows:
 - 1. Measure as directed during period of normal system loading.
 - 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed.
 - 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 - 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.
 - 5. Make changes to color-coded phase wires as required to reflect installed condition.
- C. Set field adjustable switches and circuit breaker trip ranges as indicated on drawings or as specified in Section 26 0573 Overcurrent Protective Device Coordination Study.

3.07 CLEANING

- A. Upon completion of installation, inspect interior and exterior of panelboards. Remove paint splatters and other spots, dirt, and debris. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2416

SECTION 26 2726 - WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. The extent of wiring device work is indicated by drawings and schedules. Wiring devices are defined as single discrete units of electrical distribution systems that are intended to carry, but not utilize, electric energy.
- B. This Section includes the following:
 - 1. Receptacles:
 - a. Standard receptacles
 - b. GFCI receptacles
 - c. Weather-resistant GFCI receptacles
 - d. USB charging receptacles
 - e. SPD receptacles
 - f. Hospital-grade receptacles
 - 2. Fabricated Wiring Assemblies:
 - a. Floor boxes and service fittings
 - 3. Toggle switches
 - 4. Wiring device accessories

1.03 DEFINITIONS

- A. AFCI: Arc-fault circuit interrupter.
- B. BAS: Building automation system.
- C. EMI: Electromagnetic interference.
- D. GFCI: Ground-fault circuit interrupter.
- E. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- F. RFI: Radio-frequency interference.
- G. SPD: Surge protective device.

1.04 SUBMITTALS

- A. Product data: Submit manufacturer's data for each type of product specified.

PART 2 - PRODUCTS

2.01 GENERAL WIRING-DEVICE REQUIREMENTS

- A. Wiring Devices, Components, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and use.
- B. Comply with the following:
 - 1. NEMA WD 1 and WD 6.
 - 2. NFPA 70.
 - 3. RoHS.
 - 4. UL 498.
- C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:
 - 1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
 - 2. Devices shall comply with requirements in this Section.
- D. Devices for Owner-Furnished Equipment:
 - 1. Receptacles: Match plug configurations.
 - 2. Cord and Plug Sets: Match equipment requirements.
- E. Device Color:
 - 1. Wiring Devices Connected to Normal Power System: White unless otherwise indicated or required by NFPA 70 or device listing.
 - 2. Wiring Devices Connected to Emergency Electrical System: Red.
 - 3. SPD Devices: Blue.
 - 4. The Contractor shall verify color selections with the Architect and Owner prior to ordering any devices.
- F. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.02 RECEPTACLES

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Eaton Wiring Devices/Arrow Hart
 - 2. Hubbell
 - 3. Legrand/Pass & Seymour
 - 4. Leviton

B. Standard Receptacles:

1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.

C. Ground Fault Current Interrupter (GFCI) Receptacles:

1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
2. Provide GFCI-type device. Device shall include indicator light that is lighted when device is tripped. Device shall conduct an automatic test every three seconds, ensuring ground fault protection. If protection is lost, power to the unit is disconnected and indicator light flashes indicating that the unit should be replaced. Device shall be designed for installation in a 2-3/4 inch deep outlet box without an adapter.

D. Weather Resistant GFCI Receptacles:

1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
2. Listed and labeled as complying with NFPA 70 "Receptacles in Damp or Wet Locations" article.
3. Provide GFCI-type device. Device shall include indicator light that is lighted when device is tripped. Device shall conduct an automatic test every three seconds, ensuring ground fault protection. If protection is lost, power to the unit is disconnected and indicator light flashes indicating that the unit should be replaced. Device shall be designed for installation in a 2-3/4 inch deep outlet box without an adapter.
4. Receptacle shall have internal locking shutter mechanism that opens when the two receptacle blade slots are penetrated simultaneously or receptacle requires the presence of an object in both right and left contacts to energize the device. Receptacle shall be listed to UL and federal specification WC596-F.

E. USB Charging Receptacles:

1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
2. USB Type A, 5 V dc, and 2.1 A per receptacle (minimum).
3. Provide combination device with two NEMA type 5-20R and two USB charging outlets.

F. Surge Protective Device (SPD) Receptacles:

1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
2. Shall have visual and audible surge status indicators to alert user to surge suppression circuit condition. Visual indicator will be illuminated (red) when power is on and surge suppression circuit is fully functional. Visual indicator will not be illuminated when power is off, or surge suppression circuit has been damaged. Audible indicator will be silent when surge suppression circuit is fully functional. Audible indicator will sound an alarm ("beep") approximately every thirty seconds if surge suppression circuit has been damaged.
3. Integral SPD in line to ground, line to neutral, and neutral to ground.
4. SPD Components: Multiple metal-oxide varistors; with a nominal clamp level rating of 400 volts and minimum single transient pulse energy dissipation of 240 J line to neutral, and 70 J line to ground and neutral to ground, and minimum 15000 amperes peak current. According to IEEE C62.41.2 and IEEE C62.45.
5. A line voltage rated fuse specially calibrated to disconnect the surge suppression circuit in the event of catastrophic failure shall be used.

- G. Hospital Grade Receptacles:
 - 1. Provide two pole, three wire, self-grounding, specification grade, heavy duty, 125V, 20A, NEMA Type 5-20R, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and wrap around bridge for installation strength.
 - 2. Provide hospital grade device, listed and labeled as complying with NFPA 70, "Health Care Facilities" Article.
- H. NEMA Special Receptacles
 - 1. NEMA configurations as indicated on drawings.

2.03 FABRICATED WIRING ASSEMBLIES

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Hubbell
 - 2. Legrand/Wiremold
- B. General:
 - 1. All devices, mounting plates, etc. shall be manufactured by single source.
 - 2. Provide gang quantity and configuration as indicated on drawings.
 - 3. Provide quantity and type of individual devices mounted in assembly as described on drawings. Each individual device shall meet the requirements of the respective specification section.
 - 4. Provide device mounting and face plates as required to accommodate devices.
- C. Floor Boxes and Service Fittings:
 - 1. Galvanized sheet metal, multi-gang box with fusion-bonded epoxy paint for corrosion protection suitable for on-grade installations.
 - 2. Provide die-cast metal cover as described on drawings. Coordinate cover type and finish with architect.
 - 3. Provide covers on any unused knock-outs prior to concrete placement.

2.04 TOGGLE SWITCHES

- A. Manufacturers - subject to compliance with requirements, provide wiring devices of one of the following (for each type and rating of wiring device):
 - 1. Hubbell Inc.
 - 2. Cooper Wiring Devices
 - 3. Pass & Seymour
 - 4. Leviton
- B. General: Provide specification grade, heavy duty, 120V/277V, 20A, back and side wired, with green ground screw terminal, automatic ground clamp, fully enclosed in composition case, nylon face, and having wrap around bridge for installation strength.

2.05 WIRING DEVICE ACCESSORIES

- A. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. Eaton Wiring Devices/Arrow Hart
 - 2. Hubbell
 - 3. Legrand/Pass & Seymour
 - 4. Leviton

- B. Wall plates for use in interior, dry locations: single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide .04 inch thick, Type 302 brushed stainless steel flush cover plates.
- C. Wall plates for use in interior, dry locations with surface-mounted devices in unfinished areas: Raised galvanized steel with rounded corners.
- D. Blank cover plates shall match adjacent device plates.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Comply with NECA 1, including the mounting heights listed in that standard, unless otherwise noted.
- B. Coordination with Other Trades
 - 1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes, and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
 - 2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
 - 3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
 - 4. Install wiring devices after all wall preparation, including painting, is complete.
- C. Conductors
 - 1. Do not strip insulation from conductors until just before they are spliced or terminated on devices.
 - 2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
 - 3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.
- D. Protection
 - 1. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 2. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.
 - 3. Protect installed components from damage.
 - 4. Replace all devices that have been in temporary use during construction or that show signs that they were installed before building finishing operations were complete.
- E. Device Installation
 - 1. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
 - 2. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, two-thirds to three-fourths of the way around terminal screw.
 - 3. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
 - 4. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 - 5. When conductors larger than No. 12 AWG are installed on 20-A circuits, splice No. 12 AWG pigtails for device connections.
 - 6. Tighten unused terminal screws on the device.
 - 7. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.

8. Unless otherwise indicated, mount flush, with long dimension vertical.
 9. Install receptacles vertically, with ground pin located at the top. Where horizontal mounting is required due to space constraints, install receptacle with neutral blade located at the top.
 10. Group adjacent devices under single, multi-gang wall plates.
- F. Adjust locations of fabricated wiring assemblies to suit arrangement of partitions and furnishings.
- G. Device Plates: Do not use oversized or extra-deep plates. Repair wall finishes and remount outlet boxes when standard device plates do not fit flush or do not cover rough wall opening.

3.02 FIELD QUALITY CONTROL

- A. Tests for Convenience Receptacles
1. Diagnostic testing: Use a digital wiring analyzer with digital readout or illuminated LED indicators of measurement complying with UL 1436. Perform the followings diagnostic tests, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems.
 - a. Line Voltage: Acceptable range is 105 to 132 V.
 - b. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
 - c. Ground Impedance: Values of up to 2 ohms are acceptable.
 - d. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
 2. Using the test plug, verify that the device and its outlet box are securely mounted.
 3. Test straight blade hospital-grade receptacles for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz. Prepare reports that comply with recommendations in NFPA 99.
- B. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.
- C. Wiring device will be considered defective if it does not pass tests and inspections.

END OF SECTION 26 2726

SECTION 26 2813 - FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes cartridge fuses, rated 600 V and less, for use in switches, panelboards, switchboards, controllers, and motor control centers; and spare fuse cabinets.
 - 1. Class RK1 Time Delay Fuses
 - 2. Spare Fuse Cabinet.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product Data - include the following for each fuse type indicated:
 - 1. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
 - 2. Let-through current curves for fuses with current limiting characteristics.
 - 3. Time current curves, coordination charts and tables, and related data.
 - 4. Fuse size for elevator feeders and elevator disconnect switches.
- C. Ambient Temperature Adjustment Information. If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses adjusted.
 - 1. For each adjusted fuse, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - 2. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
- D. Maintenance Data: For tripping devices to include in maintenance manuals specified in Division 01.
- E. Coordination Study: Where fuses of a manufacturer other than those designated herein are selected, submit a full coordination study showing graphically that the substitute fuses coordinate selectively with both upstream and downstream components. Prepare the study under the supervision of a registered professional engineer in accordance with ANSI/IEEE Standard 242-1986, "Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems." Include single line diagram, coordinated time/current characteristics, fuse performance curves, and fault current calculations adequate to demonstrate satisfactory component protection and selective coordination of protective devices.
- F. Shop drawing of spare fuse cabinet showing dimensions and features including storage provision for fuse cartons.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Provide fuses from a single manufacturer.
- B. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."
- C. ANSI Compliance: Comply with applicable requirements of ANSI C97 "Low Voltage Cartridge Fuses 600 Volts or Less".
- D. UL Listing and Labeling: Items provided under this Section shall be listed and labeled by UL.
- E. Comply with NEMA FU 1.
- F. Nationally Recognized Testing Laboratory Listing and Labeling (NRTL): Items provided under this Section shall be NRTL listed and labeled. The term "NRTL" shall be as defined in OSHA Regulation 1910.7.

1.05 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40°F or more than 100°F, apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.06 COORDINATION

- A. Coordinate fuse ratings with HVAC and refrigeration equipment nameplate limitations of maximum fuse size.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver spare fuses stored in locked spare fuse cabinet after cabinet has been installed.

1.08 EXTRA MATERIALS

- A. Maintenance stock - fuses: For types and ratings required, furnish spare fuses, amounting to one unit for every 5 installed units, but not less than one set of 3 of each kind.
- B. Provide three fuse pullers with the spare fuse cabinet.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products by the following:
 - 1. Bussmann Division, Cooper Industries, Inc.
 - 2. Shawmut Division; Gould Inc.
 - 3. Littelfuse, Inc.

2.02 FUSES - GENERAL

- A. General: Provide fuses of types, classes, and current ratings as indicated. Voltage ratings shall be consistent with the circuits on which used.

2.03 CARTRIDGE FUSES

- A. General: Comply with ANSI/IEEE Standard FU1, "Low Voltage Cartridge Fuses." Provide nonrenewable cartridge type fuses.
 - 1. Fuses shall be all of the same manufacturer.
 - 2. Class RK1 Dual Element Time Delay Fuses: Comply with UL 198E, "Class R Fuses."

2.04 SPARE FUSE CABINET

- A. Cabinet: Wall mounted, 18-gauge minimum steel unit with full-length, recessed piano-hinged door with key coded cam lock and pull.
- B. Size: Provide for orderly storage of all spare fuses of this project plus 15 percent spare capacity, minimum.
- C. Finish: Gray baked enamel.
- D. Cabinet Door: Bear the legend in stenciled 1-1/2-inch-high letters, "SPARE FUSES."

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- B. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 APPLICATION OF FUSES

- A. Fusible Switches - apply the following class and types:
 - 1. 30-600 Amperes: Class RK1, time delay.
- B. Combination Starters: Class RK1, time delay.

3.03 INSTALLATION

- A. Provide fuses in all fuse gaps of all equipment provided under this Contract.
- B. Install fuse so that ratings are readable without removing fuse.
- C. Fuses shall not be installed until equipment is ready to be energized.
- D. Install spare fuse cabinet wall mounted where indicated.

3.04 FIELD QUALITY CONTROL

- A. Prior to energization of fusible devices, test devices for continuity of circuitry and for short-circuits. Replace malfunctioning units with new units, and then demonstrate compliance with requirements.

3.05 IDENTIFICATION

- A. Install labels indicating fuse replacement information on inside door of each fusible device.

END OF SECTION 26 2813

SECTION 26 2816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes circuit and motor disconnects.
- B. Extent of circuit and motor disconnect switch work is indicated by drawings and schedules.
- C. Types of circuit and motor disconnect switches in this section include the following:
 - 1. Equipment disconnects
 - 2. Appliance disconnects
 - 3. Motor circuit disconnects
- D. Wires/cables, raceways, and electrical boxes and fittings required in connection with circuit and motor disconnect work are specified in other Division 26 sections.

1.03 SUBMITTALS

- A. Product Data: For each type of switch, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Maintenance data for circuit and motor disconnects, for inclusion in Operation and Maintenance Manual specified in Division 01 and Division 26 Section 26 0100 "Basic Electrical Requirements".
- C. Shop Drawings: Submit shop drawings of electrical circuit and motor disconnect switches showing accurately scaled switches, their layouts, and proximity to associated equipment.
- D. Dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. Include the following:
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short circuit current rating.
 - 4. UL listing for series rating of installed devices.
 - 5. Features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.

- E. Maintenance Data: For enclosed switches and components to include in maintenance manuals specified in Division 01. In addition to requirements specified in Division 01 Section "Closeout Procedures," include the following:
 - 1. Routine maintenance requirements for components.
 - 2. Manufacturer's written instructions for testing and adjusting switches and circuit breakers.
 - 3. Time-current curves, including selectable ranges for each type of circuit breaker.

1.04 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of circuit and motor disconnect switches of types and capacities required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing circuit and motor disconnect work similar to that required for this project.
- C. NEC Compliance: Comply with NEC requirements pertaining to construction and installation of electrical circuit and motor disconnect devices.
- D. UL Compliance: Comply with requirements of UL98, "Enclosed and Dead Front Switches". Provide circuit and motor disconnect switches that have been UL listed and labeled.
- E. UL Compliance: Comply with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use With Copper Conductors" including, but not limited to, tightening of electrical connectors to torque values indicated. Provide electrical connection products and materials that are UL-listed and labeled.
- F. NEMA Compliance: Comply with applicable requirements of NEMA Standards Pub No. KS 1, "Enclosed Switches" and 250, "Enclosures for Electrical Equipment (1000 volts maximum).
- G. Product Selection for Restricted Space: Drawings indicate the location where enclosed switches are to be installed. Verify the suitability for installation in this location, including clearances between enclosures, and adjacent surfaces and other items.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide circuit and motor disconnects of one of the following:
 - 1. Square D Company
 - 2. Eaton Corporation
 - 3. General Electric Company
 - 4. Siemens

2.02 FABRICATED SWITCHES

- A. Heavy Duty Safety Switches
 - 1. Provide surface mounted, heavy duty type, sheet steel enclosed safety switches of types, sizes and electrical characteristics indicated on the drawings.
 - 2. Provide switches with quick-make, quick-break type operation, with switchblades that are visible in the 'OFF' position with door open.

3. Operating handle shall be an integral part of the enclosure base the operating position shall be easily recognizable and pad-lockable in OFF position.
 4. Current carrying parts shall be constructed of 98% conductivity copper, with silver-tungsten type switch contacts and positive pressure type reinforced fuse clips.
 5. Provide disconnect switches having the capability to have auxiliary contacts mounted as required.
- B. Fusible Switches: Heavy duty safety switches as described above, with positive pressure type reinforced fuse clips and fuses of classes and current ratings indicated. See Division 26 Section 26 2813 "Fuses" for specifications. Where current limiting fuses are indicated, provide switches with non-interchangeable feature suitable only for current limiting type fuses.
- C. Manual motor starters:
1. Toggle type manual motor starter having low voltage protection, surface mounted in a NEMA 1 enclosure, Square D Class 2510 where indicated on the drawings.
 2. Where motor switches are located remote or out of sight from equipment controlled, switch shall be provided with an approved neon pilot light.
 3. Provide motor and motor starter disconnects with horsepower ratings suitable to the loads.
- D. Enclosures shall meet environmental conditions of installed location.
1. Indoor Locations: NEMA 250, Type 1
 2. Outdoor Locations: NEMA 250, Type 3R.
 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
- E. Finish shall be manufacturer's standard gray finish unless otherwise noted on drawings.

PART 3 - EXECUTION

3.01 INSTALLATION OF CIRCUIT AND MOTOR DISCONNECTS

- A. Examine elements and surfaces to receive enclosed switches for compliance with installation tolerances and other conditions affecting performance.
1. Proceed with installation only after unsatisfactory conditions have been corrected.
- B. Install circuit and motor disconnect switches as indicated, complying with manufacturer's written instructions, applicable requirements of NEC, NEMA and NECA's "Standard of Installation" and in accordance with recognized industry practices.
- C. Coordinate circuit and motor disconnect switch installation work with electrical raceway and cable work, as necessary for proper interface.
- D. Install disconnect switches for use with motor driven appliances, and motors and controllers within sight of the controller position unless otherwise indicated.
- E. Coordinate layout and installation of switches and components with other construction, including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- F. Install power wiring. Install wiring between switches and control, and indication devices.

- G. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.
- H. Where the motor is located out of sight or more than 50 feet from its circuit breaker (or combination starter) this Contractor shall provide a properly rated motor circuit switch at the motor location in accordance with the CIRCUIT AND MOTOR DISCONNECT section of this Specification.

3.02 NEUTRAL BAR

- A. When a neutral conductor is required for the load connected to a safety switch, the Contractor shall provide a copper neutral bar in the safety switch. This copper neutral bar shall be furnished by the manufacturer of the disconnect switch and shall be designed to be installed within the particular disconnect switch installed.

3.03 GROUNDING

- A. Install equipment grounding connections for switches with ground continuity to main electrical ground bus.
- B. Provide an equipment grounding kit with all disconnect switches.
- C. Connections shall be tightened in accordance with UL Standard 486A, "Wire Connectors and Soldering Lugs for Use with Copper Conductors".

3.04 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed switch, component, and control circuit.
 - 2. Test continuity of each line- and load-side circuit.
- B. Testing Agency: The Contractor shall perform the following testing or engage a qualified independent testing agency to perform testing.
- C. Testing: After installing enclosed switches and after electrical circuitry has been energized, demonstrate product capability and compliance with requirements.
 - 1. Procedures: Perform each visual and mechanical inspection and electrical test indicated in NETA ATS, Section 7.5 for switches 200 amps and larger. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.05 CLEANING

- A. Upon completion of installation, inspect interior and exterior of enclosures. Remove paint splatters and other spots. Vacuum dirt and debris; do not use compressed air to assist in cleaning. Repair exposed surfaces to match original finish.

END OF SECTION 26 2816

SECTION 26 3214 - NATURAL GAS ENGINE GENERATOR

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 DESCRIPTION OF WORK

- A. Provide a natural gas generator set.
- B. Provide an insulated, weatherproof enclosure.

1.03 SUMMARY

- A. Extent of natural gas generator set work is indicated by drawings and schedules, and is hereby defined to include, but not by way of limitation, natural gas engine, electrical generator, engine starting system including batteries, instrument control panel, transfer switches, exhaust silencer, wall thimble, and accessories.
- B. Types of standby generator system equipment required for project include the following:
 - 1. Natural gas engine driven generator.
- C. Concrete and grout for engine driven generator pads, foundations, frames and bedplates are specified in Division 3 CONCRETE sections and shall be provided by the Electrical Contractor.
- D. Vibration control for natural gas engine driven generator units including, pads, springs, rails, bases, hangers, and connectors are specified in Division 23 section pertaining to vibration control and isolation.
- E. Piping and associated accessories required for installation of natural gas engine driven generator units are specified in Division 23 section pertaining to fuel oil systems.
- F. Refer to other Division 26 sections for wires/cables, electrical boxes and fittings, and wiring devices that are required in conjunction with natural gas engine-generator work.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's data on natural gas engine driven generator sets and components. This shall include the operating characteristic curves showing percent voltage dip versus locked rotor KVA and percent efficiency versus KVA.
- B. Provide manufacturer's standard product warranty, for duration of not less than five years, for replacement of materials and equipment used in natural gas generator systems. Warranty shall include all parts and labor.

- C. Shop Drawings: Submit layout drawings of natural gas engine driven generator units and accessories including, but not limited to fuel piping, remote start-stop stations, and instrumentation. In addition, show natural gas generator set units and their spatial relationship to associated equipment. Allow adequate clearance space for removal of natural gas engine generator elements for maintenance purposes.
- D. Wiring Diagrams: Submit wiring diagrams for natural gas engine driven generator units showing connections to electrical power panels, feeders and ancillary equipment. Differentiate between portions of wiring that are manufacturer installed and portions that are field installed.
- E. Agreement to Maintain: Prior to time of final acceptance, the Installer shall submit 4 copies of an agreement for continued service and maintenance of natural gas engine driven generator sets, for Owner's possible acceptance. Offer terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, for one-year period with option for renewal of Agreement by Owner.
- F. Certifications - provide natural gas engine driven generator sets certified test record of the following final production testing:
 - 1. Single-step load pickup.
 - 2. Transient and steady-state governing.
 - 3. Safety shutdown device testing.
 - 4. Voltage regulation.
 - 5. Rated power.
 - 6. Maximum power.
- G. Provide certified test record prior to engine driven generator set being shipped from factory to project location.

1.05 WARRANTY

- A. The complete standby electric power system (equipped with set exerciser and running time meter) shall be warranted for a period of five (5) years or fifteen hundred operating hours, whichever occurs first, from the date of initial start-up. The warranty must be provided by the system manufacturer. Multiple warranties for individual components (engine, alternator, controls, etc.) will not be acceptable. Satisfactory warranty documents must be provided. Warranty shall include all parts and labor.

1.06 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of natural gas engine driven generator units and ancillary equipment, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects with natural gas engine driven generator units similar to those required for this project.
 - 1. Agreement to Maintain: Engage Installer who is willing to execute with the Owner, required agreement for continued maintenance of natural gas engine driven generator sets.
- C. Codes and Standards:
 - 1. Electrical Code Compliance: Comply with applicable local code requirements of the authority having jurisdiction and NEC Articles 230, 240, 250, 445, 517, 620, 695, 700, 701, 702, and 705 pertaining to construction and installation of emergency and standby systems.

2. NFPA Compliance: Comply with applicable requirements of NFPA 37, "Installation and Use of Stationary Combustion Engines and Gas Turbines", NFPA 101, "Code for Safety to Life from Fire in Buildings and Structures", and NFPA 110, "Standard for Emergency and Standby Power Systems".
 3. UL Compliance: UL 486A, "Wire connectors and Soldering Lugs for Use with Copper Conductors", and UL2200, "Stationary Generators".
 4. ANSI/NEMA Compliance: Comply with applicable requirements of ANSI/NEMA MG 1, "Motors and Generators", and MG 2, "Safety and Use of Electric Motors and Generators".
 5. NEMA Compliance: Comply with applicable requirements NEMA's Standards Pub No. 250, "Enclosures for Electrical Equipment (1000-Volts Maximum)".
 6. EPA Compliance: Engine driven generator shall meet all applicable EPA requirements and shall be certified as meeting all emissions requirements.
- D. IEEE Compliance: Comply with applicable portions of IEEE Standard 446, "IEEE Recommended Practice for Emergency and Standby Power Systems for Industrial and Commercial Applications".

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver natural gas engine driven generators properly packaged and mounted on pallets, or skids to facilitate handling of heavy items. Utilize factory-fabricated type of containers or wrappings for engine-generator and components that protect equipment from damage.
- B. Store natural gas engine driven generator equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
- C. Handle natural gas engine driven generator equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The catalog numbers herein specified are those of the Onan Corporation and constitute the type and quality of equipment to be furnished. Substitution of alternate manufacturers, other than those indicated, is not acceptable. The emergency generator system shall be complete in every respect including all necessary equipment shown or not shown on the drawings to perform the functions relative to the system operation. All published specifications of the above manufacturers shall be considered as part of this specification even though they may not be shown in complete detail.
- B. Manufacturer - subject to compliance with requirements, provide natural gas generator sets of one of the following:
 1. Caterpillar Inc.
 2. Cummins
 3. Kohler Power Systems
- C. Natural Gas Generator Set:
 1. General: Except as otherwise indicated, provide manufacturer's standard natural gas engine driven generator set and auxiliary equipment as indicated by published product information, and as required for a complete installation.

D. Natural Gas Engine Driven Generator

1. Provide a packaged standby power natural gas engine driven generator assembly unit at a governed speed of 1800 RPM, and rated .8 power factor for continuous operation, 60 Hz. Refer to the Single Line Diagram for KW/KVA rating of generator and voltage and phase of generator.
2. Provide generator with 4-cycle, 4 cylinder, 1800 RPM, liquid cooled natural gas engine, and fueled with natural gas. Full pressure lubrication shall be supplied by a positive displacement lube oil pump. The engine shall have coolant and oil filters with replaceable elements, and lube oil cooler. Engine speed shall be governed by an electronic governor to maintain isochronous alternator frequency from no-load to full-load alternator output. The engine shall have a 24 Volt DC battery charging alternator with a transistorized voltage regulator. Remote, 2-Wire starting shall be by a 24 Volt, solenoid shift, electric starter.
3. Provide unit-mounted blower fan, thermostat, and radiator duct flange capable of cooling engine to a maximum 122°F ambient temperature.
4. Provide associated control equipment to automatically start engine, transfer load to standby power upon failure of normal power source, transfer load back to normal power upon its restoration, and stop engine.
5. Mount engine generator on heavy steel base with vibration spring isolators to reduce possibility of torsional vibration. Number of isolators to be determined by the engine-generator supplier.
6. Provide engine with low-oil pressure, and automatic over-speed safety shutdown devices.
7. Provide generator with PMG exciter and voltage regulator to maintain voltage regulator within 0.5 percent of rated value.
8. Starting System: Provide engine-generator unit with 24-volt, 2-wire, negative ground, starting system including, 12-volt positive engagement solenoid shift-starting motor, batteries and 45-ampere, or greater, automatic battery charging alternator with solid-state voltage regulation, and disconnect relay to disconnect battery charger during engine starting and running.
9. The fuel system shall include a gas strainer and a secondary gas solenoid valve.
10. Two-stroke natural gas engines shall not be acceptable.

E. Instrument Control Panel

1. Provide engine-generator control panel with the following:
 - a. Voltmeter, 3.5", 2% accuracy
 - b. Ammeter, 3.5", 2% accuracy
 - c. Voltmeter/ammeter phase selector and OFF switch
 - d. Engine oil pressure
 - e. Engine coolant temperature gauge
 - f. Battery charge-rate ammeter
 - g. START - STOP switch for manual operation of unit
 - h. Reset main circuit breaker
 - i. Static voltage regulator
 - j. Voltage-adjusting rheostat for plus or minus 5% voltage adjustment
 - k. Running time indicator
 - l. Frequency meter, 3.5" dial type
 - m. Panel illumination lights and switch
- 1) Solid State 12 Light Engine Monitoring System to include the following:
 - a) Run (green light)
 - b) Over crank Shutdown (red)
 - c) Overspeed Shutdown (red)
 - d) High Coolant Temperature Shutdown (red)
 - e) Low Oil Pressure Shutdown (red)
 - f) Pre-warning for High Coolant Temperature (yellow)
 - g) Pre-warning for Low Oil Pressure (yellow)

- h) Low Coolant Temperature (yellow light indicated inoperative coolant heater)
- i) Switch Off (flashing red indicates genset not in automatic start mode)
- j) Low Fuel Day Tank (yellow)
- k) Low Fuel Main Tank (yellow)
- l) One customer selected fault (red)

2. Instrument panel shall meet annunciation requirements of NFPA 110 for a Level 1 system.

F. Generator Run Relay

1. Provide controller with three (3) configurable relays for owner notification upon generator start-up. Provide control wiring as required between relays and building management system. Coordinate connection to building management system with HVAC contractor and owner requirements.

G. Alternator

1. Brushless Alternator: The alternator shall be a 4-pole, revolving field design with temperature compensated solid state voltage regulator and brushless rotating rectifier exciter system. No brushes shall be allowed. The stator shall be directly connected to the engine flywheel housing, and the rotor shall be driven through a semiflexible driving flange to insure permanent alignment. The insulation system shall be class H as defined by NEMA MG1-1.65. Actual temperature rise measured by resistance method at full load shall not **exceed 105 Degrees C** to provide additional allowance for internal hot spots. The three phase, brushless, broad range, re-connectible alternators shall have be twelve leads reconnectable.
2. Unit Performance: Frequency regulation shall be 5% from no load to rated load. Voltage regulation shall be within plus or minus 0.5% from no load to full rated load. The instantaneous voltage dip shall be less than 17 percent of rated voltage when full, 3-phase, load and rated power factor is applied to the alternator. Stable or steady state operation is defined as operation with terminal voltage remaining constant within plus or minus 1 percent of rated voltage. A rheostat shall provide a minimum of plus or minus 5 percent voltage adjustment from rated value. Temperature rise shall be within NEMA MG1-22.40 definition.
3. Alternator shall have field connections to allow for 480Y/277V or 208Y/120V operation.
4. Entrance Boxes: Provide factory installed entrance box extensions as an integral part of the generator set. The boxes shall be provided as necessary to allow for right or left, and top or bottom connections. Verify box requirements for cable entrances and conduit sizes and types prior to ordering of generator.

2.02 ENGINE GENERATOR SET ACCESSORIES

A. Mainline Circuit Breaker(s)

1. Provide a factory installed mainline circuit breaker(s) as an integral part of the generator set as indicated on the drawings. The mainline circuit breaker shall be sized in accordance with the manufacturer's recommendations and shall be 100% rated with electronic trip units. Breakers and trip units shall meet requirements of NEC 2008, Article 240.6.C.
2. Where multiple circuit breakers are mounted on the emergency generator, they must meet the requirements of NEC 2008 Article 700.9, utilizing separate enclosures.

B. Insulated, Weatherproof Enclosure

1. Provide an insulated, weatherproof enclosure for outdoor installation of generator. Enclosure shall be as manufactured by the generator manufacturer, and shall have proper amount of access panel to allow for proper maintenance of the generator.
2. Enclosure shall be insulated and provided with all necessary dampers, heaters, etc., to maintain a minimum of 40°F ambient as required by NFPA 110. Enclosure shall maintain 40° ambient at an external temperature of -20°F.

3. Muffler shall be located within enclosure.
 4. Provide two stage sound attenuated enclosure. Enclosure shall provide noise reduction to a level of 69 dBA at 7 meters at any point around the generator. Provide factory testing information to verify sound levels.
- C. Exhaust Silencer and Piping
1. Provide insulated super critical grade exhaust silencer with drain, drain cock, and flexible connector, of types and sizes recommended by the generator manufacturer. Exhaust silencer shall be as manufactured by Nelson.
 2. Provide schedule 40 black iron exhaust pipe. All connections shall be threaded.
- D. Battery/Starting System
1. Provide lead acid batteries, battery charger, battery rack, and battery cables as necessary for a complete battery/starting system.
 2. Batteries shall be sized to allow for a minimum of four 30 second cranking periods without recharging.
 3. For exterior applications, provide battery blanket/heater capable of maintaining a battery temperature of 65°F.
 4. Provide battery cabling as required by manufacturer to limit voltage drop to an acceptable level. Locate batteries as close as practical to starting motor. Batteries shall be mounted on a nonconductive support/rack and in a location that permits ready access and maintenance.
 5. Provide a float-equalize charger for battery charging system. Provide normal/emergency circuit in EMT conduit to battery charger.
 6. Provide battery monitoring system to continually monitor and test batteries. System shall load test batteries each time engine starts, and shall indicate if batteries are weakened.
- E. Anchors
1. Provide anchor bolts of galvanized steel, of types and sizes recommended by the generator manufacturer.
 2. Furnish anchor bolts to concrete formwork installer with generator manufacturer's installation drawings and instructions.
- F. Provide remote annunciator panel(s) for generator. Locate where indicated on drawings. Provide all wiring necessary from generator to remote annunciator panel(s) as required by generator manufacturer. All wiring shall be in conduit. Remote annunciator(s) shall not require a separate power connection, but shall be powered through the generator battery system. Communication to remote annunciator panel(s) shall be through networked communication cabling and not through the use of contact closures on wire pairs. Annunciator(s) shall operate up to 2000 feet from generator. Annunciator panel(s) shall meet annunciation requirements of NFPA 110 for a Level 1 system.
- G. Provide connection to building management system to allow for remote monitoring of generator run state.
- H. Provide exerciser clock to set the day, time, and duration of generator exercise period; also include "with/without load switch."
- I. Provide an AC Voltmeter, an Ammeter, and a Frequency meter. Meters to be 2.5 inch, analog with 2% accuracy. Provide a phase selector switch to allow reading voltage and current line-to-line or three phase.
- J. Provide engine generator emergency shutdown push button with guard and reset.
- K. Miscellaneous Accessories: All accessories needed for the proper operation of the generating set shall be furnished. These shall include a super critical muffler as detailed, 30" OAL stainless steel flexible exhaust connection with flange kits, 120 Volt Single Phase Jacket Water Heaters, and 5 sets of detailed operation and maintenance manuals with parts list.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions under which the engine driven generator unit is to be installed and notify the Architect in writing of conditions detrimental to proper completion of the work. Do not proceed with the work until unsatisfactory conditions have been corrected in an acceptable manner.

3.02 GENERATOR BASE

- A. Provide a 6" concrete pad for the generator as follows:
 - 1. Coordinate size of generator pad with actual unit sizes provided. Construct base 4-inches larger in both directions than the overall dimensions of the supported unit.
 - 2. Form concrete pads with framing lumber with form release compounds. Chamfer top edge and corners of pad, 1" at a 45 degree angle.
 - 3. Install reinforcing bars, tied to frame, and place anchor bolts and sleeves to facilitate securing units.
 - 4. Place concrete and allow to cure before installation of units. Use Portland Cement conforming to ASTM C 150, 3,000 psi compressive strength, and normal weight aggregate.

3.03 INSTALLATION OF NATURAL GAS ENGINE GENERATOR SETS

- A. Install the natural gas engine generator unit as indicated, in accordance with the equipment manufacturer's written instructions, and with recognized industry practices, to ensure that engine-generator units fulfill requirements. Comply with NFPA and NEMA standards pertaining to installation of engine generator sets and accessories.
- B. During installation, adjusting and testing of the standby emergency power system at construction site, retain and pay for the services of an approved, factory trained engineer or technician employed by the manufacturer of the engine generator set to technically supervise and participate during all adjustments and tests for the set and major auxiliaries in the presence of the Owner's representative.
- C. Coordinate with other work, including raceways, electrical boxes and fittings, piping and accessories, as necessary to interface installation of engine-generator equipment work with other work. Provide strain relief/expansion fittings and flexible connections to generator for all wiring and conduit connections to generator. All wiring shall be stranded.
- D. Tighten connectors and terminals, including screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL Standards 486A, B and the National Electrical Code.
- E. Install units on spring vibration isolators in accordance with the manufacturer's recommendations.
- F. Align shafts of engine and generator within tolerances recommended by engine-generator unit manufacturer.
- G. Provide a laminated or mounted under plexiglass set of approved operating instructions for the system. Install these instructions under a neat frame on the wall adjacent to the generator.
- H. Provide a sign at the service entrance equipment indicating type and location of emergency generator.

- I. Contractor shall provide lubricating oil, lubrication, coolant water treatment and anti-freeze solution, Prestone or as approved, to -30°F, in accordance with the manufacturer's instructions. Provide coolant additives to help protect the engine from corrosion. Use demineralized water in coolant mixture to help reduce corrosion in generator.

3.04 VIBRATION ISOLATION

- A. Isolation mounting shall be provided for all moving equipment where the energy of the vibration is of sufficient magnitude to produce perceptible vibration or structure transmitted noise in occupied areas. Isolation equipment shall be selected, installed and adjusted in accordance with manufacturer's recommendations.
- B. All equipment and material shall be installed so as to operate without objectionable noise or vibration as determined by Architect and Owner. Should such objectionable noise or vibration be produced and transmitted to occupied portions of the building by apparatus, piping or other parts of this work, any necessary changes as approved shall be made by the Contractor.
- C. All conduit terminations to noise or vibration producing equipment shall be made with a short section of liquidtight flexible metal conduit.

3.05 GROUNDING

- A. Provide equipment grounding connections for natural gas engine driven generator units as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounding.

3.06 FIELD QUALITY CONTROL

- A. Start-Up Testing: Engage local equipment manufacturer's representative to perform start-up and building load tests upon completion of installation, with the Architect/Engineer in attendance; provide certified test record. Tests are to include the following:
 1. Check fuel and lubricating oil for conformity to the manufacturer's recommendations under environmental conditions present.
 2. Test prior to cranking engine for proper operation, accessories that normally function while the set is in a standby mode. Accessories include: engine heaters, battery charger, remote annunciator.
 3. Check, during start-up test mode, for exhaust leaks, path of exhaust gases outside the building, cooling air flow, movement during starting and stopping, vibration during running, normal and emergency line-to-line voltage and phase rotation.
 4. Test, by means of simulated power outage, automatic start-up by remote-automatic starting, transfer of load, and automatic shut-down. Prior to this test adjust, for proper system coordination, transfer switch timers. Monitor throughout the test, engine temperature, oil pressure, battery charge level, generator voltage, amperes, and frequency.
- B. Final site testing of the engine generator set and accessories shall not be less than four hours while carrying all available building loads supplemented by resistive load bank to achieve 100% of set's rating. Generator supplier shall supply load bank and cables as required to complete the above-mentioned test. Test shall simulate a full power outage to the building (i.e., shutting down of building utility source). All arrangements for final test shall be verified with the Owner prior to scheduling final testing.

- C. Upon completion of installation demonstrate capability and compliance of system with requirements. Where possible, correct malfunctioning units at site, then retest to demonstrate compliance; otherwise, remove and replace with new units, and proceed with retesting. Initial testing and retesting to be at no cost to Owner.
- D. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting-up, testing and operating of diesel engine driven generator sets. In addition, train Owner's personnel in periodic maintenance of batteries. Provide 16 hours of onsite training for Owner's personnel. Training shall be scheduled with Owner and shall be performed during off hours or weekends if requested by Owner.

END OF SECTION 26 3214

SECTION 26 3600 - TRANSFER SWITCHES

PART 1 - GENERAL

1.01 REFERENCE

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 DESCRIPTION OF WORK

- A. Provide automatic transfer switches (ATS) with number of poles, amperage, voltage, withstand and close-on ratings as shown on the plans. Each automatic transfer switch shall consist of an inherently double throw power transfer switch and a microprocessor controller to provide automatic operation. All ATSs and controllers shall be the products of the same manufacturer.
- B. Provide automatic delayed transition transfer and bypass-isolation switch (DTTS/BPS) with number of poles, amperage, voltage, and withstand current ratings as shown on the plans. Each DTTS/BPS system(s) shall consist of a delayed transition transfer switch and a two-way bypass/isolation switch. All DTTS/BPSs and controllers shall be the product of the same manufacturer.
 - 1. The DTTS/BPS shall transfer the load in delayed transition (break-before-make) mode. Transfer is accomplished with a user-defined interruption period in both directions adjustable from 1 second to 5 minutes in at least 15 increments.

1.03 SUBMITTALS

- A. Product Data: Include ratings and dimensioned plans, sections and elevations showing minimum clearances, conductor entry provisions, gutter space, installed features and devices, and material lists for each switch specified.
- B. Wiring Diagrams: Detail wiring for transfer switches and differentiate between manufacturer installed and field installed wiring. Show both power and control wiring.
- C. Single Line Diagram: Show connections between transfer switch, bypass/isolation switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.
- D. Product Certificates: Signed by manufacturer certifying that products furnished comply with requirements and that switches have been tested for load ratings and short-circuit closing and withstand ratings applicable to units for Project.
- E. Qualification Data: For firms and person specified in "Quality Assurance" article.
- F. Field Test Reports: Indicate and interpret test and inspection results for compliance with performance requirements.
- G. Maintenance Data: For each type of product to include in maintenance manuals specified in Division 1. Include all features and operating sequences, both automatic and manual. List all factory settings of relays and provide relay-setting and calibration instructions, including software, where applicable.

1.04 QUALITY ASSURANCE

- A. Manufacturer's Qualifications: Firms regularly engaged in manufacture of automatic transfer switch equipment, of types, ratings and characteristics required, whose products have been in satisfactory use in similar service for not less than 10 years.
- B. Installer's Qualifications: Firm with at least 5 years of successful installation experience on projects with automatic transfer switch units similar to those required for this project.
 - 1. Agreement to Maintain: Engage Installer who is willing to execute with the Owner, required agreement for continued maintenance of the automatic transfer switch.
- C. Codes and Standards
 - 1. The transfer and bypass-isolation switches and controls shall conform to the requirements of:
 - a. UL 1008: Standard for Transfer Switch Equipment
 - b. IEC 947-6-1: Low voltage Switchgear and Control gear; Multifunction equipment; Automatic Transfer Switching Equipment
 - c. NFPA 70: National Electrical Code
 - d. NFPA 99: Essential Electrical Systems for Health Care Facilities
 - e. NFPA 110: Emergency and Standby Power Systems
 - f. IEEE Standard 446: IEEE Recommended Practice for Emergency and Standby Power Systems for Commercial and Industrial Applications
 - g. NEMA Standard ICS10-1993 (formerly ICS2-447): AC Automatic Transfer Switches
 - h. UL 508: Industrial Control Equipment
- D. Withstand and Closing Ratings
 - 1. The transfer switch shall be rated to close on and withstand the available RMS symmetrical short circuit current at the transfer switch/bypass switch terminals with the type of overcurrent protection shown on the plans.
 - 2. The transfer switch shall be UL listed in accordance with UL 1008 and be labeled in accordance with that standard's 3 cycle ratings. Transfer switches/bypass switches that are not tested and labeled with a 3 cycle (any breaker) ratings and have series, or specific breaker ratings only, are not acceptable.
- E. Test and Certification
 - 1. The complete transfer switch assembly shall be factory tested to ensure proper operation of the individual components and correct overall sequence of operation and to ensure that the operating transfer time, voltage, frequency and time delay settings are in compliance with the specification requirements.
 - 2. Upon request, the manufacturer shall provide a notarized letter certifying compliance with all of the requirements of this specification including compliance with the above codes and standards, and withstand and closing ratings. The certification shall identify, by serial number(s), the equipment involved. No exceptions to the specifications, other than those stipulated at the time of the submittal, shall be included in the certification.
 - 3. The transfer switch manufacturer shall be certified to ISO 9001 International Quality Standard and the manufacturer shall have third party certification verifying quality assurance in design/development, production, installation, and servicing in accordance with ISO 9001.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver the transfer switch assembly properly packaged and mounted on pallets or skids to facilitate handling of heavy items. Utilize factory fabricated type of containers or wrappings for transfer switch and components that protect equipment from damage.

- B. Store the transfer switch equipment in original packaging and protect from weather and construction traffic. Wherever possible, store indoors; where necessary to store outdoors, store above grade and enclose with watertight wrapping.
- C. Handle the transfer switch equipment carefully to prevent physical damage to equipment and components. Do not install damaged equipment; remove from site and replace damaged equipment with new.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. The transfer switch system shall be complete in every respect including all necessary equipment shown or not shown on the drawings to perform the functions relative to the system operation. All published specifications of the below manufacturers shall be considered as part of this specification even though they may not be shown in complete detail.
 - 1. Manufacturer: Subject to compliance with requirements, provide automatic transfer switches of Cummins, Asco or Russelectric.

2.02 MECHANICALLY HELD TRANSFER SWITCH

- A. The transfer switch shall be electrically operated and mechanically held. The electrical operator shall be a momentarily energized, single-solenoid mechanism. Main operators that include overcurrent disconnect devices, linear motors or gears shall not be acceptable. The switch shall be mechanically interlocked to ensure only two possible positions, normal or emergency.
- B. All transfer switch sizes shall use only one type of main operator for ease of maintenance and commonality of parts.
- C. The switch shall be positively locked and unaffected by momentary outages, so that contact pressure is maintained at a constant value and contact temperature rise is minimized for maximum reliability and operating life.
- D. All main contacts shall be silver composition. Switches rated 600 amperes and above shall have segmented, blow-on construction for high withstand and close-on capability and be protected by separate arcing contacts.
- E. Inspection of all contacts shall be possible from the front of the switch without disassembly of operating linkages and without disconnection of power conductors. Switches rated 600 amps and higher shall have front removable and replaceable contacts. All stationary and moveable contacts shall be replaceable without removing power conductors and/or bus bars.
- F. Designs utilizing components of molded-case circuit breakers, contactors, or parts thereof that are not intended for continuous duty, repetitive switching or transfer between two active power sources, are not acceptable.
- G. Where neutral conductors must be switched as shown on the plans, the transfer switch shall be provided with fully rated neutral transfer contacts.
- H. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0 to 600 seconds minimum.

2.03 MICROPROCESSOR CONTROLLER

- A. The controller's sensing and logic shall be provided by a single built-in microprocessor for maximum reliability, minimum maintenance and the ability to communicate serially through an optional serial communication module.
- B. A single controller shall provide twelve selectable nominal voltages for maximum application flexibility and minimal spare part requirements. Voltage sensing shall be true RMS type and shall be accurate to $\pm 1\%$ of nominal voltage. Frequency sensing shall be accurate to $\pm 0.2\%$. The panel shall be capable of operating over a temperature range of -20° to $+60^{\circ}\text{C}$ and storage from -55° to $+85^{\circ}\text{C}$.
- C. The controller shall be connected to the transfer switch by an interconnecting wiring harness. The harness shall include a keyed disconnect plug to enable the controller to be disconnected from the transfer switch for routine maintenance. Sensing and control logic shall be provided on multi-layer printed circuit boards. Interfacing relays shall be industrial grade plug-in type with dust covers. The panel shall be enclosed with a protective cover and be mounted separately from the transfer switch unit for safety and ease of maintenance. The protective cover shall include a built-in pocket for storage of the operator's manuals.
- D. All customer connections shall be wired to a common terminal block to simplify field-wiring connections.
- E. The controller shall meet or exceed the requirements for Electromagnetic Compatibility (EMC) as follows:
 - 1. IEEE472 (ANSI C37.90A) Ring Wave Test
 - 2. ENC55011 1991 Class A Conducted and Radiated Emission
 - 3. EN61000-4-2 Electrostatic Discharge Immunity, Direct Contact & Air Discharge
 - 4. EN61000-4-3 Radiated Electromagnetic Field Immunity
 - 5. EN61000-4-4 Electrical Fast Transient Immunity
 - 6. EN61000-4-5 Surge Immunity
 - 7. ENV50141 HF Conducted Disturbances Immunity

2.04 ENCLOSURE

- A. The transfer switch assembly shall be furnished in a NEMA Type 1 enclosure unless otherwise shown on the plans.
- B. All standard and optional door-mounted switches and pilot lights shall be 16-mm industrial grade type or equivalent for easy viewing and replacement. All indicated lights shall be push-to-test, LED type. Door controls shall be provided on a separate removable plate, which can be supplied loose for open type units.

2.05 CONTROLLER DISPLAY AND KEYPAD

- A. A four line, 20 character LCD display and keypad shall be an integral part of the controller for viewing all available data and setting desired operational parameters. Operational parameters shall also be available for viewing and limited control through the serial communications input port. The following parameters shall only be adjustable via DIP switches on the controller:
 - 1. Nominal line voltage and frequency
 - 2. Single or three phase sensing
 - 3. Operating parameter protection
 - 4. Transfer operating mode configuration (Open transition, Closed transition or Delayed transition)
- B. All instructions and controller settings shall be easily accessible, readable and accomplished without the use of codes, calculations, or instruction manuals.

2.06 VOLTAGE, FREQUENCY, AND PHASE ROTATION SENSING

- A. Voltage and frequency on both the normal and emergency sources (as noted below) shall be continuously monitored, with the following pickup, dropout and trip setting capabilities (values shown as % of nominal unless otherwise specified):

<u>Parameter</u>	<u>Sources</u>	<u>Dropout/Trip</u>	<u>Pickup/Reset</u>
Under voltage	N&E, 3 ϕ	70 to 98%	85 to 100%
Overvoltage	N&E, 3 ϕ	102 to 115%	2% below trip
Under frequency	N&E	85 to 98%	90 to 100%
Over frequency	N&E	102 to 110%	2% below trip
Voltage unbalance	N&E	5 to 20%	1% below dropout

- B. Repetitive accuracy of all settings shall be within $\pm 0.5\%$ over an operating temperature range of -20°C to 60°C .
- C. Voltage and frequency settings shall be field adjustable in 1% increments whether locally with the display and keypad or remotely via serial communications port access.
- D. The controller shall be capable (when activated by the keypad or through the serial port) of sensing the phase rotation of both the normal and emergency sources. The source shall be considered unacceptable if the phase rotation is not the preferred rotation selected (ABC or CBA).
- E. Source status screens shall be provided for both normal and emergency to provide digital readout of voltage and current on all 3 phases, frequency, and phase rotation.

2.07 TIME DELAYS

- A. An adjustable time delay of 0 to 6 seconds shall be provided to override momentary normal source outages and delay all transfer and engine starting signals. Capability shall be provided to extend this time delay to 60 minutes by providing an external 24 VDC power supply.
- B. A time delay shall be provided on transfer to emergency, adjustable from 0 to 60 minutes, for controlled timing of transfer of loads to emergency.
- C. Two time delay modes (that are independently adjustable) shall be provided on re-transfer to normal. One time delay shall be for actual normal power failures and the other for the test mode function. The time delays shall be adjustable from 0 to 60 minutes. Time delay shall be automatically bypassed if the emergency source fails and the normal source is acceptable.
- D. A time delay shall be provided on shut down of engine generator for cool down, adjustable from 0 to 60 minutes.
- E. A time delay activated output signal shall also be provided to drive an external relay(s) for selective load disconnect control. The controller shall have the ability to activate an adjustable 0 to 5 minute time delay in any of the following modes:
1. Prior to transfer only.
 2. Prior to and after transfer.
 3. Normal to emergency only.
 4. Emergency to normal only.
 5. Normal to emergency and emergency to normal.
 6. All transfer conditions or only when both sources are available.

- F. The controller shall also include the following built-in time delays for optional Closed Transition and Delayed Transition operation:
 - 1. 1 to 5 minute time delay on failure to synchronize normal and emergency sources prior to closed transition transfer.
 - 2. 0.1 to 9.99 second time delay on an extended parallel condition of both power sources during closed transition operation.
 - 3. 0 to 5 minute time delay for the load disconnect position for delayed transition operation.
- G. All time delays shall be adjustable in one second increments, except the extended parallel time, which shall be adjustable in 0.01 second increments.
- H. All time delays shall be adjustable by using the LCD display and keypad or with a remote device connected to the serial communications port.

2.08 ADDITIONAL FEATURES

- A. A three-position momentary-type test switch shall be provided for the test/automatic/reset modes. The test position will stimulate a normal source failure. The reset position shall bypass the time delays on either transfer to emergency or retransfer to normal.
- B. A set of DPDT gold-flashed contacts rated 10 amps, 32 VDC shall be provided for a low-voltage engine start signal. The start signal shall prevent dry cranking of the engine by requiring the generator set to reach proper output, and run for the duration of the cool down setting, regardless of whether the normal source restores before the load is transferred.
- C. Auxiliary contacts, rated 10 amps, 250 VAC shall be provided consisting of two contacts, closed when the ATS is connected to the normal source and two contacts closed, when the ATS is connected to the emergency source.
- D. LED indicating lights (16mm industrial grade, type 12) shall be provided; one to indicate when the ATS is connected to the normal source (green), one to indicate when the ATS is connected to the emergency source (red), one to indicate normal power is available (yellow) and one to indicate emergency power is available (yellow).
- E. LED indicating lights (16mm industrial grade, type 12) shall be provided and energized by controller outputs. The lights shall provide true source availability of the normal and emergency sources, as determined by the voltage sensing trip and reset setting for each source.
- F. Provide engraved nameplates for each light. Nameplates shall be attached using screws.
- G. Terminals shall be provided for a remote contact that opens to signal the ATS to transfer to emergency and for remote contacts that open to inhibit transfer to emergency and/or retransfer to normal. Both of these inhibit signals can be activated through the keypad or serial port.
- H. An In-phase monitor shall be provided in the controller. The monitor shall control transfer so that motor load inrush currents do not exceed normal starting currents, and shall not require external control of power sources. The in-phase monitor shall be specifically designed for and be the product of the ATS manufacturer.
- I. The controller shall be capable of accepting a normally open contact that will allow the transfer switch to function in a non-automatic mode using an external control device.

- J. The controller shall provide an internal engine exerciser. The engine exerciser shall allow the user to program up to seven different exercise routines. For each routine, the user shall be able to:
 - 1. Enable or disable the routine.
 - 2. Enable or disable transfer of the load during routing.
 - 3. Set the start time, time of day, day of week, week of month (1st, 2nd, 3rd, 4th, alternate or every)
 - 4. Set the duration of the run.
- K. At the end of the specified duration, the switch shall transfer the load back to normal and run the generator for the specified cool down period. A 10-year life battery that supplies power to the real time clock in the event of a power loss will maintain all time and date information.
- L. The controller LCD display shall include a "System Status" screen that shall be readily accessible from any point in the menu by depressing the "ESC" key a maximum of two times. This screen shall display a clear description of the active operating sequence and switch position. Controllers that require multiple screens to determine system status or display "coded" system status messages, which must be explained by references in the operator's manual, are not permissible.
- M. The controller shall contain a diagnostic screen for the purpose of detecting system errors. This screen shall provide information on the status input signals to the controller that may be preventing load transfer commands from being completed.
- N. The controller shall have the ability to log data and to maintain the last 99 events, even in the event of total power loss. The following events shall be time and date stamped and maintained in a non-volatile memory:
 - 1. Event Logging
 - a. Date and time and reason for transfer normal to emergency.
 - b. Date and time and reason for transfer emergency to normal.
 - c. Date and time and reason for engine start.
 - d. Date and time engine stopped.
 - e. Date and time emergency source available.
 - f. Date and time emergency source not available.
 - 2. Statistical Data
 - a. Total number of transfers.
 - b. Total number of transfer due to source failure.
 - c. Total number of days controller is energized.
 - d. Total number of hours both normal and emergency sources are available.
- O. Provide a digital ammeter on the front of the ATS. Ammeter shall simultaneously display current on all three phases. Meter shall also store and display peak current values for each phase. Provide meter, necessary CT's, shorting blocks, and all wiring at factory.
- P. A full duplex RS485 interface shall be installed in the ATS controller to enable serial communications. The serial communications shall be capable of a direct connect or multi-drop configured network. This module shall allow for the seamless integration of existing or new communication transfer devices.

2.09 FIELD WIRING

- A. Provide all control wiring necessary between ATS(s) and generator(s) for startup and operation of emergency power system. All wiring shall be run in EMT conduit indoors, and rigid steel conduit outdoors or underground.

- B. Provide all control wiring necessary for remote annunciator(s). All wiring shall be run in EMT conduit indoors, and rigid steel conduit outdoors or underground.

2.10 SERVICE REPRESENTATION

- A. The transfer switch manufacturer shall maintain a national service organization of company-employed personnel located throughout the contiguous United States. The service center's personnel must be factory trained and must be on call 24 hours a day, 365 days a year. The service center must be located within a 75 mile radius of the project site.
- B. The manufacturer shall maintain records of each switch, by serial number, for a minimum of 20 years and guarantee availability of parts for the same time frame.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality control testing under the supervision of the manufacturer's factory authorized service representative in addition to test recommended by the manufacturer:
 - 1. Before energizing equipment, after transfer switch products have been installed:
 - a. Measure insulation resistance phase-to-phase and phase-to-ground with insulation-resistance tester. Include external annunciation and control circuits. Use test voltages and procedure recommended by manufacturer. Meet manufacturer's specified minimum resistance.
 - b. Check for electrical continuity of circuits and for short circuits.
 - c. Inspect for physical damage, proper installation and connection, and integrity of barriers, covers, and safety features.
 - d. Verify that manual transfer warnings are properly placed.
 - 2. After energizing circuits, demonstrate interlocking sequence and operational function for each switch at least three times.
 - a. Simulate power failures of normal source to automatic transfer switches and of emergency source with normal source available.
 - b. Simulate loss of phase-to-ground voltage for each phase of normal source.
 - c. Verify time delay settings.
 - d. Verify pickup and dropout voltages by data readout or inspection of control settings.
 - e. Test bypass/isolation unit functional modes and related automatic transfer switch operations.
 - f. Perform contact resistance test across main contacts and correct values exceeding 500 microohms and values for one pole deviating by more than 50 percent from other poles.
 - g. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power and engine cool down and shutdown sequence.
- B. Ground Fault Tests: Coordinate with testing of ground-fault protective devices for power delivery from both sources.
 - 1. Assist in verifying grounding connections and locations and ratings of sensors.
 - 2. Assist in observing reaction of circuit-interrupting devices when simulated fault current is applied at sensors.
- C. Coordinate tests with test of generator set and run them concurrently.
- D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.02 WARRANTY

- A. The complete automatic transfer switch system shall be warranted for a period of five (5) from the date of initial start-up. The warranty must be provided by the system manufacturer, and shall include all parts and labor. Satisfactory warranty documents must be provided.

END OF SECTION 26 3600

SECTION 26 4113 - LIGHTNING PROTECTION FOR STRUCTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENT

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 DESCRIPTION OF WORK

- A. Provide a complete lightning protection system as described hereinafter. Provide full coverage of the existing and new building, including, but not limited to, all roof ridges, and roof perimeters.
- B. Types of lightning protection system material and components specified in this section include the following:
 - 1. Air terminals.
 - 2. Bonding plates.
 - 3. Conductors.
 - 4. Connectors.
 - 5. Grounding rods.
 - 6. Rod clamps.
 - 7. Splicers.
 - 8. Wire.

1.03 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of lightning protection system components, of types, sizes and ratings required, whose products have been in satisfactory use in similar service for not less than 2 years.
- B. Manufacturers: Firms regularly engaged in manufacture of lightning protection system components, of types, sizes, and ratings required, and who are Class I manufacturer-members of Lightning Protection Institute.
- C. Installer's Qualifications: Firm with at least 2 years of successful installation experience with projects utilizing lightning protection systems similar to that required for this project.
- D. NEC Compliance: Comply with NEC requirements pertaining to lightning (surge) arresters, grounding, grounding electrodes, and down conductor clearances.
- E. NFPA Compliance: Comply with requirements of NFPA No. 78, "Lightning Protection Code", as applicable to lightning protection systems for building projects.
- F. ANSI Compliance: Comply with applicable requirements of ANSI Standard C2, C62.1, C62.2, and C114.1.
- G. UL Compliance: Comply with Master Label provisions of UL 96A, "Installation Requirements for Lightning Protection Components". Provide components that are UL listed and labeled.

- H. LPI Compliance: Comply with requirements of Lightning Protection Institute (LPI) Standards 175, 176, and 177, pertaining to lightning protection system material, components, installation and testing procedures.

1.04 SUBMITTALS

- A. Product Data: Submit manufacturer's data on lightning protection systems and associated components.
- B. Shop Drawings: Submit layout drawings of lightning protection system equipment and components including, but not limited to, conductor routing, connections, roof penetration details, and grounding.
- C. UL Certification: Provide Owner with UL Master Label for overall system that is suitable for fastening to building for display purposes. Comply with UL 96A, "Master Labeled Lightning Protection Systems"

PART 2 - PRODUCTS

2.01 ACCEPTABLE INSTALLERS

- A. Subject to compliance with requirements, installers offering lightning protection components that may be incorporated in the work include, but are not limited to, the following:
 - 1. Ace Lightning Protection Co., Pittsburgh, PA. 724-733-5216
 - 2. Maxwell Lightning Protection, Dayton, OH. 937-228-7250
 - 3. Heary Brothers Lightning Protection, Springville, NY. 716-941-6141
 - 4. B&B Lightning Protection, Trenton, NJ. 609-392-1929

2.02 ACCEPTABLE PRODUCT MANUFACTURERS

- A. Subject to compliance with requirements, installers offering lightning protection components that may be incorporated in the work include, but are not limited to, the following:
 - 1. Thompson Lightning Protection, Inc.
 - 2. East Coast Lightning Equipment, Inc.
 - 3. Robbins Lightning Inc.
 - 4. Harger

2.03 LIGHTNING PROTECTION SYSTEM COMPONENTS

- A. General: Provide lightning protection system material and components, of types, sizes, ratings for Class 1 service, that comply with manufacturer's standard materials, design, and construction in accordance with published product information, and as required for a complete installation. Where type components or materials are not otherwise indicated, comply with NFPA 78 and LPI standards.
- B. Class 1 Installations Materials:
 - 1. Air Terminals: Solid copper; minimum diameter 3/8".
 - 2. Main Conductors: Copper cable; minimum size strand diameter, 0.045"; 0.187#/ft; 57,400 circular mils.
 - 3. Secondary Conductors: Copper cable; minimum size strand diameter 0.045"; number of wires 14.

2.04 ANCILLARY COMPONENTS

- A. Connectors: Bronze right-angle thru-roof cable connector; bronze and lead seal flashing washer, 1/2" x 8" threaded stem, to fit 6" roof thickness.
- B. Connectors: 4" bronze parallel bonding clamp for connecting 1/0 or 2/0 cables.
- C. Splicer: Bronze straight cable splicer for splicing No. 4 and No. 6 cables.
- D. Splicer: Bronze pressure type "T" cable splicer for clamping standard cables through 2/0, with hex bolts and washers.
- E. Splicer: Bimetal straight splicer of cast aluminum and bronze for 2/0 cable with moisture tight sealing capability.
 - 1. Ground Rod: Solid copper clad steel 3/4" diameter x 10'.
- F. Aluminum-To-Copper Connections: Bimetallic type, conforming to UL 96, "Lightning Protection Components," or UL 467.

2.05 WELDED CONNECTORS:

- A. Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- B. Manufacturers - subject to compliance with requirements, provide products of one of the following:
 - 1. nVent ERICO Cadweld
 - 2. Hubbell Continental Industries thermOweld

PART 3 - EXECUTION

3.01 INSTALLATION OF LIGHTNING PROTECTION SYSTEMS

- A. Install lightning protection systems as indicated, in accordance with equipment manufacturer's written instructions, and in compliance with applicable requirements of NEC and NFPA 78 to ensure that lightning protection systems comply with requirements.
- B. Coordinate with other work, including electrical wiring and roofing work, as necessary to interface installation of lightning protection system with other work.
- C. Install conductors with direct paths from air terminals to ground connections avoiding sharp bends and narrow loops.
- D. Install all conductors (except as noted below) concealed inside structure. Provide conduit sleeves at roof, wall, and other structural penetrations. Coordinate locations and routing of conductors with the Architect before ordering material. Install conductor running length of roof ridge exposed.

3.02 GROUNDING AND BONDING

- A. Provide equipment grounding and bonding connections, sufficiently tight to assure permanent and effective grounds and bonds, for lightning protection connection devices as indicated.

3.03 TESTING

- A. Upon completion of installation of lightning protection system, test resistance-to-ground (earthing connecting) with resistance tester. Where tests indicate resistance-to-ground is over 5 ohms, take appropriate action to reduce resistance to 5 ohms or less, by driving additional, properly spaced, ground rods, and treating soil in proximity to ground rods with common salt, copper sulfate or magnesium sulfate. Then retest to demonstrate compliance.
- B. Perform resistance-to-ground tests of lightning protection system periodically, at 6 month intervals or less, following time of substantial completion and submit written report indicating results. Where resistance is greater than 5 ohms, chemically treat soil to reduce resistance to 5 ohms or less, then retest to demonstrate compliance.

3.04 PERSONNEL TRAINING

- A. Building Maintenance Personnel Training: Train Owner's building maintenance personnel in procedures for testing and determining resistance-to-ground values of lightning protection system. Also instruct maintenance personnel in preparation and application of chemical solution for earth surrounding grounding rods for reducing ohmic resistance to required levels.

END OF SECTION 26 4113

SECTION 26 5100 - INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Interior lighting fixtures.
 - 2. Exit signs.
 - 3. Emergency lighting units.

1.03 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 SUBMITTALS

- A. Product data for each type of product.
 - 1. Arrange in order of fixture designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of fixtures.
 - 4. Include installation and attachment details.
 - 5. Include emergency lighting units, including batteries and chargers.
 - 6. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 - 7. Include "Lighting Facts".

8. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the fixture as applied in this Project.

- a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

B. Shop Drawings

1. Pendant-mounted fixtures:
 - a. Detailed scaled shop drawings of all pendant mounted fixture systems containing the following information: support canopy type, support spacing, pendant type, power feed type and locations, fixture joint locations, trim details, closure piece details, end plates, corner details, and continuous louver or lens details, where applicable.
 - b. Manufacturers shall be prepared to submit point-by-point computer generated plot diagram of horizontal foot-candles that shows values of illuminance projected from the arrangement of light fixtures as shown on the drawings.

C. Samples

1. Manufacturers shall be prepared to submit complete fixture samples for approval by Architect and Engineer. Samples shall be submitted only at the request of the Architect/Engineer. Sample fixtures shall be shipped prepaid by the Contractor and shall be furnished within two weeks of request. Fixtures shall be complete with specified lamps and mounting hardware. Samples shall be evaluated for two weeks prior to acceptance or rejection. Samples shall remain on the project site as an example of materials, workmanship, finish, color, tolerance, performance, and general quality of all other fixtures of the respective type to be installed on the project. Fixtures judged inferior to the sample shall not be accepted. The Architect/Engineer shall be the final judge of fixture acceptance.

1.05 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Fixture manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Each fixture type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among fixtures.
- C. Fixtures must meet the following:
 1. LM-79: Approved Method for Electrical and Photometric Measurement of SSL Products
 2. LM-80: Approved Method for Measuring Lumen Maintenance of LED Light Sources
 3. L-70: 70% Lumen Maintenance
 4. TM-21: Establishes a method for projecting lumen maintenance (and useful lifetime) of LED light sources from available LM-80 data

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver lighting fixtures and accessories in factory fabricated containers or wrappings that properly protect fixtures from debris and physical damage.
- B. Handle lighting fixtures carefully to prevent damage, breaking, and scoring. Do not install damaged fixtures or components; replace with new.

- C. Store lighting fixtures in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.

1.07 WARRANTY

- A. Manufacturer and Installer agree to repair or replace components of fixtures that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 LIGHTING FIXTURES

- A. Manufacturers
 - 1. Provide lighting fixtures of types described on the drawings under the 'LIGHTING FIXTURE SCHEDULE'.
 - 2. Provide lighting fixtures complete with, but not limited to, housings, drivers, and wiring.
 - 3. Manufacturer and product series are indicated in the 'LIGHTING FIXTURE SCHEDULE' and constitute the type and quality of fixture to be provided. All published specifications of the manufacturer that correspond to the indicated catalog number, shall be considered as part of this specification even though they may not be shown in complete detail.
 - 4. Manufacturer's product series indicate the general line of fixtures required and may not necessarily include all prefixes and suffixes for options, trim and/or configurations required.
 - 5. Bid prices shall be based on information in all columns of the 'LIGHTING FIXTURE SCHEDULE'.
 - 6. Where a conflict exists between the fixture description and the manufacturer's product series, the price shall include the more expensive option. Coordinate conflicts with engineer prior to submitting bid.
 - 7. The listing of a manufacturer does not guarantee that manufacturer will have a product that meets the requirements put forth in the fixture description. Approval of specific fixtures by an approved manufacturer will be subject to review by the Specifier.
 - 8. No substitutions shall be accepted unless listed.
 - 9. The Lumen Output column of the 'LIGHTING FIXTURE SCHEDULE' lists the nominal lumen output for each fixture type. Submitted fixture shall be capable of providing listed lumen output within 10% of listed lumen output.
 - 10. Provide fixtures from a single manufacturer for each fixture type.
 - 11. Pricing for light fixture types shall be through local lighting rep listed only.
- B. General
 - 1. Ship fixtures factory assembled, complete in every respect, including all necessary parts, shown or not shown on the drawings, required for a complete installation in accordance with the manufacturer's recommendations.
 - 2. EC to verify and provide fixture mounting options that are compatible with ceiling type as shown on the architectural drawings.
- C. Listings
 - 1. Provide fixtures for use in damp or wet locations that are UL Listed for the specific installation.
 - 2. Provide fixtures for recessed use in combustible construction that are UL Listed for the specific installation.
 - 3. Fixtures for hazardous locations shall be listed and labeled for indicated class and division of hazard by FMG.

D. Fixture Construction

1. Fixtures shall be designed with metal parts grounded as common unit.
2. Fixture housing shall be formed and supported to prevent warping and sagging.
3. Metal parts shall be free of burrs, sharp corners, and edges.
4. Doors, Frames, and Other Internal Access:
 - a. Smooth operating, free of light leakage under operating conditions, and designed to permit access without use of tools.
 - b. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally when secured in operating position.
 - c. All troffers with hinged doors shall have spring-loaded cam latches.
5. Provide metal trim rings for recessed downlights and wall wash type fixtures, unless noted otherwise.
6. Provide metal flange for recessed linear fixtures mounted in drywall construction, unless noted otherwise.
7. Provide drywall frame kits for recessed fixtures installed in other than suspended grid type acoustical ceiling systems.
8. Finishes:
 - a. Manufacturers' standard, unless otherwise indicated.
 - b. All troffers shall be post-painted or painted after fabrication, including driver covers, doors, and all trim. Fixtures shall be powder-finished with a minimum reflectance of 90%.

E. Light Engines:

1. Color temperature shall be 3500K, unless noted otherwise in the 'LIGHTING FIXTURE SCHEDULE'
2. Color Rendering Index: 80 CRI
3. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire light engine.
4. LED light engine shall be suitable for field maintenance or service from below the ceiling with plug-in connectors.
5. LED light engine shall be upgradable.
6. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to ensure proper operation of the light engine over the expected useful life.

2.02 DRIVERS

A. Manufacturers

1. Furnished with fixture as tested and recommended by fixture manufacturer as a complete lighting system.
2. All fixtures of the same type shall be furnished with the same manufactured driver type.

B. General:

1. All drivers shall be equipped with a disconnecting means internal to the fixture. The line side terminals of the disconnecting means shall be guarded. Provide Sta-Kon Series LD3 Luminaire Disconnect or equivalent.
2. LED driver shall be rated for dual 120/277 volt operation at 60 Hertz.
3. Drivers shall be electronic-type, labeled as compliant with radio frequency interference (RFI) requirements of FCC Title 47 Part 15, and comply with NEMA SSL 1 "Electronic Drivers for LED Devices, Arrays, or Systems".
4. Drivers shall have a sound rating of "A", have a minimum efficiency of 85%, and be rated for a THD of less than 20 percent at all input voltages.
5. Dimmable LED drivers shall be 0-10V type, 10% minimum, unless noted otherwise on the 'LIGHTING FIXTURE SCHEDULE'.
6. Dimmable LED drivers shall be capable of dimming without LED strobing or flicker across their full dimming range.

2.03 EMERGENCY LIGHTING

A. Manufacturers

1. Provide lighting fixtures, of sizes, types and ratings indicated on the Drawings under the 'LIGHTING FIXTURE SCHEDULE' complete with, but not limited to, housings, drivers, and wiring.

B. Exit Signs

1. General:
 - a. Comply with UL 924.
 - b. Light-emitting diodes, 70,000 hours minimum of rated lamp life.
 - c. Provide universal mounting kit, unless noted otherwise.
 - d. Provide single face with extra faceplate and color panel. Install extra faceplate where two-sided exit signs are indicated on drawings.
 - e. Provide with removable chevron inserts. Remove chevrons to match arrowhead(s) shown on drawings.

C. Emergency Lighting Units

1. General:
 - a. Self-contained units complying with UL 924.
 - b. Provide complete emergency battery units, including remote heads, as shown on drawings.
2. Battery:
 - a. Sealed, nickel cadmium with minimum 5-year nominal life.
 - b. Unit shall operate for a minimum of 90 minutes after power interruption.
 - c. Fully automatic current-limiting charger.
3. Battery Operation:
 - a. Relay automatically turns lamp(s) on when power supply circuit voltage drops to 80 percent of nominal voltage or below.
 - b. Lamp automatically disconnects from battery when voltage approaches deep-discharge level.
 - c. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - d. Integral time-delay relay to hold unit on for fixed interval when power is restored after an outage.
 - e. Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
 - f. Test Switch and Light Emitting Diode Indicator Light: Visible and accessible without opening fixture or entering ceiling space.

2.04 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section 26 0529 "Hangers and Supports for Electrical Systems" for additional support components not specified below.
- B. Single-Stem Hangers: ½" steel tubing with swivel ball fittings and ceiling canopy. Finish same as fixture.
- C. Hook Hangers: Integrated assembly matched to fixture and equipped with threaded attachment. Provide with secondary safety cable connected to structure.

- D. Aircraft Cable Support: Use cable and anchorages recommended by fixture manufacturer.
- E. Suspension Bars: Provide Caddy Series 517, 520 or equal from fixture manufacturer.
- F. T-Bar Support Clips: Provide Caddy Series 515 or equal from fixture manufacturer.
- G. Ceiling Support System Wires:
 - 1. General: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated, 12 gauge.
 - 2. Humid Spaces: ASTM A 580/A 580M, Composition 302 or 304, annealed stainless steel, 12 gauge.

2.05 FIXTURE MOUNTED LIGHTING CONTROLS

- A. Provide Fixture Mounted Lighting Controls where indicated in 'LIGHTING FIXTURE SCHEDULE':
 - 1. Embedded sensor shall consist of occupancy sensor and/or dimming photocell provided integral to the light fixture such that only the lens shows on fixture face.
 - 2. Occupancy Sensing Technology:
 - a. Dual technology, for ceiling heights up to 15'
 - b. Passive infrared, for ceiling heights over 15'
 - 3. Daylight Sensing Option: Occupancy only, Daylight only, or combination Occupancy/Daylight sensor
 - 4. Networked LED luminaire shall be capable of communicating wirelessly to other networked luminaires or intelligent control devices (sensors, photocells, wall stations).

2.06 FIRE RATED CEILING COVERS

- A. Where fire rated ceilings exist, provide a fire rated enclosure over the light fixture housing above the ceiling. Fire rated enclosure shall be the Fire Rated Light Enclosure as manufactured by Tenmat. Coordinate exact type of fire rated enclosure in field with Architect prior to purchase.
 - 1. The test standard for this product shall be ASTM E-119/UL 263.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Inspection
 - 1. Inspect each fixture for damage prior to installation. Replace damaged fixtures and components.
 - 2. Examine areas, structure, and other conditions under which lighting fixtures are to be installed and supported.
 - 3. Review room finish schedule on architectural drawings for ceiling construction in each area and verify details with ceiling installer. Provide hardware and additional supporting devices as necessary to install lighting fixtures in each area.
 - 4. Where lighting fixtures are recessed into ceiling construction, obtain information from the ceiling installer as to the specific type of ceiling to be installed, and provide recommended hardware and trim.
 - 5. Review architectural drawings for fire rated ceiling assemblies and provide fire rated fixture enclosures as required.

B. General

1. Install fixtures plumb, square, and level with ceiling and walls, and secure according to manufacturer's printed instructions and approved shop drawings.
2. Install lighting fixtures at locations and heights as indicated on drawings. Where mounting heights are not indicated, coordinate with architect prior to rough-in.
3. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.
4. Install fixtures after building is enclosed, weathertight, and environmental conditions are nominally the same as expected for the completed spaces.
5. Recessed fixtures in suspended lay-in type grid ceilings shall have final connection of flexible metal conduit not exceeding 72".
6. Install recessed fixtures to eliminate light leakage between fixture frame and finished surface.
7. Install fire rated enclosures around light fixtures in fire rated ceilings. Mount enclosure prior to installation of finished ceiling.
8. Tighten connectors and terminals, including set screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL and NEC.
9. Adjust fixtures that require field adjustment or aiming.
10. Install remote drivers in accordance with manufacturer's recommendations.

C. Supports

1. Provide fixtures and/or fixture outlet boxes with hangers to properly support fixture weight.
2. Able to maintain fixture position after cleaning or maintenance.
3. Provide support for fixture without causing deflection of ceiling or wall.
4. Fixture-mounting devices shall be capable of supporting a horizontal force of 100 percent of fixture weight and a vertical force of 400 percent of fixture weight.
5. Provide all necessary additional or auxiliary supporting steel for fixtures not mounted on building framework, and where necessary to span ceiling channels of suspended ceiling construction.
6. Support all fixtures directly from the building structure. Do not utilize any of the following items for support.
 - a. Acoustic materials.
 - b. Gypsum-base materials.
 - c. Mechanical or plumbing items or equipment.
 - d. Ceiling grid system.
 - e. Ceiling grid system hangers.
7. Metal decking shall not be pierced for fixture support.

D. Flush Mounted Fixtures in Grid-Type Suspended Ceilings

1. Install a minimum of two ceiling support system wires for each fixture from structural members. Locate not more than 6 inches from fixture corners.
2. Fasten fixtures to ceiling grid members at or near each fixture corner with support clips that are UL listed for the application.
3. For fixtures of sizes less than ceiling grid, install as indicated on reflected ceiling plans or center in acoustical panel, and support fixtures independently with at least two ¾ inch metal channels spanning and secured to ceiling tees.

E. Flush Mounted Fixtures in Drywall Ceilings

1. Install a minimum of two ceiling support system wires for each fixture from structural members to fixture frame or frame kit.
2. Install drywall frames where required. Brace frames temporarily to prevent distortion during handling.
3. Install trim ring or flange flush with finished surface, where applicable.

4. Where fixtures are specified as trimless and utilizing a spackle flange, provide supporting structure along entire perimeter of fixture for support of flange.
5. Coordinate installations with ceiling installer.

F. Wall Mounted Fixtures

1. Attached to junction box or as recommended by fixture manufacturer.
2. Do not attach fixtures directly to gypsum board.

G. Pendant Mounted Fixtures

1. Rigidly align continuous rows of linear pendant lighting fixtures for in-line appearance.
2. Install intermediate supports along the length of linear pendant-mounted fixtures as recommended by fixture manufacturer.
3. Install pendant mounted fixtures in unfinished spaces near obstructions, such as ducts or pipes, suspended so the bottom of the fixture is at the same height as the bottom of the obstruction. All fixtures in the space should be located at the height of the lowest fixture, minimum 8'-0" above the finished floor, unless noted otherwise. Do not install fixtures until the locations of the obstructions are installed or coordinated.
4. Do not use ceiling grid as support for pendant fixtures. Connect support wires or rods to building structure.

H. Surface Mounted Fixtures

1. Secured to outlet box. Outlet box to be supported directly to structure.
2. Support fixtures that are centered in acoustical ceiling tile, independently with metal suspension bar spanning an electrical outlet box and clipped to the ceiling grid tees.
3. Support fixtures that are centered on ceiling grid structure independent of ceiling grid, using support clips that wrap around grid. The support clip shall include means for fixture mounting. Provide a wire hanger from clip to structure.
4. Support surface-mounted fixtures greater than 2' in length at a point in addition to the outlet box.

3.02 COORDINATION

- A. Coordinate layout and installation of lighting fixtures and supports with other construction that penetrate ceilings or are supported by them, including HVAC equipment, fire-suppression system, and partition assemblies.
- B. Sequence lighting fixture installation with other work to reduce the possibility of damage to fixtures during remainder of construction period.

3.03 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized. Replace or repair malfunctioning fixtures and components.
- C. During warranty period, replace fixtures that show any signs of corrosion.
- D. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify normal transfer to battery power source and retransfer to normal.

3.04 ADJUSTING AND CLEANING

- A. Remove protective wrapping on fixtures before installation of furniture, but after interior finish work, such as painting and carpeting, is completed.
- B. Clean fixtures upon completion of installation. Use methods and materials recommended by manufacturer. Lenses and louvers with dust, dirt, scratches, or fingerprints shall not be acceptable.

3.05 STARTUP SERVICE

- A. Burn-in LED fixtures prior to occupancy by Owner for a minimum of 100 hours at full light output.

3.06 GROUNDING

- A. Provide equipment grounding connections for all lighting fixtures. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

END OF SECTION 26 5100

SECTION 26 5600 - EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 26.
- B. All Division 26 Specification Sections apply to this section.

1.02 SUMMARY

- A. Section Includes:
 - 1. Exterior lighting fixtures.
 - 2. Fixture mounted controls.
 - 3. Poles and accessories.

1.03 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. LED: Light-emitting diode.
- F. Lumen: Measured output of lamp and luminaire, or both.
- G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 SUBMITTALS

- A. Product data for each type of product.
 - 1. Arrange in order of fixture designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of fixtures.
 - 4. Include installation and attachment details.
 - 5. Include fixture-mounted lighting controls.
 - 6. Include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 - 7. Include "Lighting Facts".

8. Photometric data and adjustment factors based on laboratory tests, complying with IES "Lighting Measurements Testing and Calculation Guides" for each fixture type. The adjustment factors shall be for lamps and accessories identical to those indicated for the fixture as applied in this Project.
 - a. Manufacturers' Certified Data: Photometric data certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.
9. Include the following for poles:
 - a. Materials, dimensions, and finishes.
 - b. Means of attaching fixtures to supports, and indication that attachment is suitable for components involved.
 - c. Anchor bolt templates keyed to specific poles and certified by manufacturer.
 - d. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that dead load, live load, and wind load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

B. Shop Drawings

1. Upon request, provide point-by-point computer generated plot diagram of horizontal foot-candles at 30" above finished floor, unless noted otherwise, that shows values of illuminance projected from the arrangement of light fixtures as shown on the drawings, including mounting heights, and as described in the 'LIGHTING FIXTURE SCHEDULE'. Indicate on the computer report the locations, spacing, and heights of fixtures.

C. Samples

1. Manufacturers shall be prepared to submit complete fixture samples for approval by Architect and Engineer. Samples shall be submitted only at the request of the Architect/Engineer. Sample fixtures shall be shipped prepaid by the Contractor and shall be furnished within two weeks of request. Fixtures shall be complete with specified lamps and mounting hardware. Samples shall be evaluated for two weeks prior to acceptance or rejection. Samples shall remain on the project site as an example of materials, workmanship, finish, color, tolerance, performance, and general quality of all other fixtures of the respective type to be installed on the project. Fixtures judged inferior to the sample shall not be accepted. The Architect/Engineer shall be the final judge of fixture acceptance.

1.05 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Fixture manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Each fixture type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among fixtures.
- C. Fixtures must meet the following:
 1. LM-79: Approved Method for Electrical and Photometric Measurement of SSL Products
 2. LM-80: Approved Method for Measuring Lumen Maintenance of LED Light Sources
 3. L-70: 70% Lumen Maintenance
 4. TM-21: Establishes a method for projecting lumen maintenance (and useful lifetime) of LED light sources from available LM-80 data

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver lighting fixtures and accessories in factory fabricated containers or wrappings that properly protect fixtures from debris and physical damage.
- B. Handle lighting fixtures carefully to prevent damage, breaking, and scoring. Do not install damaged fixtures or components; replace with new.
- C. Store lighting fixtures in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- D. Store poles on decay-resistant-treated skids at least 12 inches above grade and vegetation.
- E. Support poles to prevent distortion and arrange to provide free air circulation.
- F. Retain factory applied pole wrappings on poles until right before pole installation.

1.07 WARRANTY

- A. Manufacturer and Installer agree to repair or replace components that fail in materials or workmanship within specified warranty period. Warranty shall include repair or replacement of products that fail in materials or workmanship, that corrode, fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from warranty coverage.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 LIGHTING FIXTURES

- A. Manufacturers
 - 1. Provide lighting fixtures of types described on the drawings under the 'LIGHTING FIXTURE SCHEDULE'.
 - 2. Provide lighting fixtures complete with, but not limited to, housings, drivers, and wiring.
 - 3. Manufacturer and product series are indicated in the 'LIGHTING FIXTURE SCHEDULE' and constitute the type and quality of fixture to be provided. All published specifications of the manufacturer that correspond to the indicated catalog number, shall be considered as part of this specification even though they may not be shown in complete detail.
 - 4. Manufacturer's product series indicate the general line of fixtures required and may not necessarily include all prefixes and suffixes for options, trim and/or configurations required.
 - 5. Bid prices shall be based on information in all columns of the 'LIGHTING FIXTURE SCHEDULE'.
 - 6. Where a conflict exists between the fixture description and the manufacturer's product series, the price shall include the more expensive option. Coordinate conflicts with engineer prior to submitting bid.
 - 7. The listing of a manufacturer does not guarantee that manufacturer will have a product that meets the requirements put forth in the fixture description. Approval of specific fixtures by an approved manufacturer will be subject to review by the Specifier.
 - 8. No substitutions shall be accepted unless listed.

9. The Lumen Output column of the 'LIGHTING FIXTURE SCHEDULE' lists the nominal lumen output for each fixture type. Submitted fixture shall be capable of providing listed lumen output within 10% of listed lumen output.
10. Provide fixtures from a single manufacturer for each fixture type.
11. Pricing for light fixture types shall be through local lighting rep listed only.

B. General

1. Ship fixtures factory assembled, complete in every respect, including all necessary parts, shown or not shown on the drawings, required for a complete installation in accordance with the manufacturer's recommendations.

C. Listings

1. Provide fixtures for use in damp or wet locations that are UL Listed for the specific installation.

D. Fixture Construction

1. Fixtures shall be designed with metal parts grounded as common unit.
2. Fixture housing shall be formed and supported to prevent warping and sagging.
3. Metal parts shall be free of burrs, sharp corners, and edges.
4. Doors, Frames, and Other Internal Access:
 - a. Smooth operating and designed to permit access without use of tools.
 - b. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally when secured in operating position.
5. Provide metal trim rings for recessed downlights and wall wash type fixtures, unless noted otherwise.
6. Provide metal flange for recessed linear fixtures mounted in drywall construction, unless noted otherwise.
7. Finishes: Manufacturers' standard, unless otherwise indicated.
8. Exposed Hardware Material: Stainless steel.

E. Light Engines

1. Color temperature shall be 4000K, unless noted otherwise in the 'LIGHTING FIXTURE SCHEDULE'
2. Color Rendering Index: 80 CRI
3. Individual LEDs shall be connected such that a catastrophic loss or the failure of one LED will not result in the loss of the entire light engine.
4. LED light engine shall be suitable for field maintenance or service from below with plug-in connectors.
5. LED light engine shall be upgradable.
6. The thermal management (of the heat generated by the LEDs) shall be of sufficient capacity to ensure proper operation of the light engine over the expected useful life.

2.02 DRIVERS

A. Manufacturers

1. Furnished with fixture as tested and recommended by fixture manufacturer as a complete lighting system.
2. All fixtures of the same type shall be furnished with the same manufactured driver type.

B. General

1. All drivers shall be equipped with a disconnecting means internal to the fixture. The line side terminals of the disconnecting means shall be guarded. Provide Sta-Kon Series LD3 Luminaire Disconnect or equivalent.
2. LED driver shall be rated for dual 120/277 volt operation at 60 Hertz.
3. Drivers shall be electronic-type, labeled as compliant with radio frequency interference (RFI) requirements of FCC Title 47 Part 15, and comply with NEMA SSL 1 "Electronic Drivers for LED Devices, Arrays, or Systems".

4. Drivers shall have a sound rating of "A", have a minimum efficiency of 85%, and be rated for a THD of less than 20 percent at all input voltages.
5. Dimmable LED drivers shall be 0-10V type, 10% minimum, unless noted otherwise on the 'LIGHTING FIXTURE SCHEDULE'.
6. Dimmable LED drivers shall be capable of dimming without LED strobing or flicker across their full dimming range.

2.03 FIXTURE MOUNTED LIGHTING CONTROLS

A. Photoelectric Relays

1. Comply with UL 773 or UL 773A.
2. Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc and off at 4.5 to 10 fc with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.
3. Relay with locking-type receptacle shall comply with ANSI C136.10.
4. Adjustable window slide for adjusting on-off set points.

B. Wireless Lighting Controls

1. Provide fixture with 7-pin dimming twist-lock receptacle for use with twist lock wireless lighting controller.
2. Provide fixture with twist lock wireless lighting controller as follows:
 - a. Manufacturer: Synapse Model No. TL7-B1 or approved equivalent.
 - b. The wireless light controller shall be suitable for control of commercial and industrial luminaries.
 - c. The wireless light controller shall be capable of controlling multiple lighting fixtures by daisy chaining fixture power and dimming wires between fixtures as long as the maximum current rating of the light controller is not exceeded.
 - d. The wireless light controller shall be capable of responding to multiple inputs (switches, sensors, etc.) as well as calendar based events and schedules.
 - e. The wireless light controller shall be capable of setting the correct dimming level through multiple control strategies based on inputs from sensors and switches and calendar events.
 - f. The wireless light controller shall have a universal power supply that operates from 110 to 480VAC plus or minus 10%. The wireless light controller shall be capable of being remotely monitored and controlled via the site controller using a standard web browser across either a LAN or Wi-Fi connection
 - g. The wireless light controller shall be capable of responding to wireless communication messages from the site controller to set lights to specific dimming levels. The wireless light controller shall automatically recover from any power failure. Should power be interrupted and subsequently returned, the lights shall default to a user configured light level.
 - h. The lighting controller shall include an internal relay to switch power to the fixture.
 - i. The lighting controller shall be capable of 0-10V dimming.
 - j. The wireless light controller shall communicate with the integral motion sensor mounted in light fixture to adjust light levels when motion is detected.
3. Provide fixture with motion sensor mounted integral with light fixture. Provide all internal wiring as required.

2.04 FIXTURE SUPPORT COMPONENTS

- A. Comply with Division 26 Section 26 0529 "Hangers and Supports for Electrical Systems" for additional support components not specified below.
- B. Comply with luminaire manufacturers' mounting requirements.
- C. Use stainless steel fasteners and mounting bolts unless otherwise indicated.

2.05 POLES

A. Pole Construction:

1. Seamless, extruded structural tube complying with ASTM B 429/B 429M, Alloy 6063-T6.
2. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches, with cover secured by stainless steel captive screws.
3. Mounting Provisions: Butt flange for bolted mounting on foundation.
4. Grounding and Bonding Lugs: Welded 1/2-inch threaded lug, complying with requirements in Division 26 Section 260526 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.
5. Finishes: Manufacturers' standard, unless otherwise indicated.
6. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers:
 - a. Hot-dip galvanized after fabrication unless otherwise indicated.
 - b. Corrosion-resistant items compatible with support components.
 - c. Materials shall not cause galvanic action at contact points.
7. Anchor Bolt Template: Plywood or steel.

B. Mounting Components:

1. Finish: Same as pole.
2. Fixture Support Brackets: Detachable, cantilever, without underbrace. Adapter fitting welded to pole and bracket, then bolted together with stainless steel bolts.
3. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.
4. Concrete Pole Foundations: Cast in place, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03 CONCRETE.

C. Pole Accessories

1. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Inspection

1. Inspect each fixture for damage prior to installation. Replace damaged fixtures and components.
2. Examine areas, structure, and other conditions under which lighting fixtures are to be installed and supported.
3. Review architectural drawings for ceiling construction where applicable and verify details with ceiling installer. Provide hardware and additional supporting devices as necessary to install lighting fixtures in each area.
4. Where lighting fixtures are recessed into ceiling construction, obtain information from the ceiling installer as to the specific type of ceiling to be installed, and provide recommended hardware and trim.

B. General

1. Install fixtures plumb, square, and level with ceiling and walls, and secure according to manufacturer's printed instructions and approved shop drawings.
2. Install lighting fixtures at locations and heights as indicated on drawings. Where mounting heights are not indicated, coordinate with architect prior to rough-in.
3. Install lighting fixtures in strict conformance with manufacturer's recommendations and instructions.

4. Install recessed fixtures to eliminate light leakage between fixture frame and finished surface.
5. Tighten connectors and terminals, including set screws and bolts, in accordance with equipment manufacturer's published torque tightening values for equipment connectors. Where manufacturer's torquing requirements are not indicated, tighten connectors and terminals to comply with tightening torques specified in UL and NEC.
6. Adjust fixtures that require field adjustment or aiming.
7. Install remote drivers in accordance with manufacturer's recommendations.

C. Supports

1. Provide fixtures and/or fixture outlet boxes with hangers to properly support fixture weight.
2. Able to maintain fixture position after cleaning or maintenance.
3. Provide support for fixture without causing deflection of ceiling or wall.
4. Fixture-mounting devices shall be capable of supporting a horizontal force of 100 percent of fixture weight and a vertical force of 400 percent of fixture weight.
5. Provide all necessary additional or auxiliary supporting steel for fixtures not mounted on building framework, and where necessary to span ceiling channels of suspended ceiling construction.
6. Support all fixtures directly from the building structure. Do not utilize any of the following items for support.
 - a. Acoustic materials.
 - b. Gypsum-base materials.
 - c. Mechanical or plumbing items or equipment.
7. Metal decking shall not be pierced for fixture support.

D. Flush-Mounted Fixtures in Drywall Ceilings

1. Install a minimum of two ceiling support system wires for each fixture from structural members to fixture frame or frame kit.
2. Install drywall frames where required. Brace frames temporarily to prevent distortion during handling.
3. Install trim ring or flange flush with finished surface, where applicable.
4. Where fixtures are specified as trimless and utilizing a spackle flange, provide supporting structure along entire perimeter of fixture for support of flange.
5. Coordinate installations with ceiling installer.

E. Wall Mounted Fixtures

1. Attached to junction box or as recommended by fixture manufacturer.
2. Do not attach fixtures directly to gypsum board.

F. Surface Mounted Fixtures

1. Secured to outlet box. Outlet box to be supported directly to structure.
2. Support surface-mounted fixtures greater than 2' in length at a point in addition to the outlet box.

G. Poles

1. Inspect each pole for damage prior to installation. Replace damaged poles.
2. Examine areas and other conditions under which poles are to be installed and supported.
3. Review all design drawings, including civil, landscape, and architectural, for pole locations in relation to the following underground features and notify the engineer immediately of any potential conflicts:
 - a. Fire Hydrants and Storm Drainage Piping: minimum 5 feet.
 - b. Water, Gas, Electric, Communication, and Sewer Lines: minimum 10 feet.
 - c. Trees: minimum 15 feet from tree trunk.
 - d. Curbs: minimum 2 feet from edge of curb.
4. Align pole foundations and poles to allow for orientation of fixture(s) as shown on drawings.

5. Set anchor bolts in concrete pole foundations according to anchor-bolt templates furnished by pole manufacturer.
6. Use anchor bolts and nuts defined for the application and approved by manufacturer.
7. Raise and set pole using web fabric slings (not chain or cable). Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.
8. Grout void between pole base and foundation. Use non-shrink or expanding concrete grout firmly packed to fill space.
9. Install base covers unless otherwise indicated.

H. Individual Ground-Mounting Luminaires

1. Install on concrete base with top 4 inches above finished grade or surface at luminaire location. Cast conduit into base, and finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03 CONCRETE.

3.02 COORDINATION

- A. Sequence lighting fixture installation with other work to reduce the possibility of damage to fixtures during remainder of construction period.
- B. Coordinate exact location of all light fixtures with architect, civil engineer, and site contractor prior to installation. Fixture locations shall be installed relative to other site features installed by site contractor and should not be scaled off of drawings.

3.03 FIELD QUALITY CONTROL

- A. Inspect each installed fixture and pole for damage or corrosion. Replace damaged fixtures, poles, and components.
- B. Verify normal operation of each fixture after fixtures have been installed and circuits have been energized. Replace or repair malfunctioning fixtures and components.
- C. Verify operation of photoelectric controls.

3.04 ADJUSTING AND CLEANING

- A. Remove protective wrapping on fixtures.
- B. Clean fixtures upon completion of installation. Use methods and materials recommended by manufacturer. Lenses and louvers with dust, dirt, scratches, or fingerprints shall not be acceptable.

3.05 STARTUP SERVICE

- A. Burn-in LED fixtures prior to occupancy by Owner for a minimum of 100 hours at full light output.

3.06 GROUNDING

- A. Provide equipment grounding connections for all lighting fixtures. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.

- B. Ground metal poles and support structures according to Division 26 Section 260526 "Grounding and Bonding for Electrical Systems."

END OF SECTION 26 5600

SECTION 27 0100 - BASIC COMMUNICATIONS SYSTEM REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this and the other sections of Division 27.
- B. This section is a Division 27 COMMUNICATIONS section, and is a part of each Division 27 Section.

1.02 SUMMARY

- A. This Section includes general administrative and procedural requirements for Telecommunications installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01 - reference individual sections for further expansion of these requirements:
 - 1. Abbreviations and Definitions
 - 2. Contractor Qualifications
 - 3. Permits, Codes, and Inspections
 - 4. Visiting Premises
 - 5. Project Drawings and Specifications
 - 6. Nameplate Data
 - 7. Cooperation and Coordination with Other Trades
 - 8. Submittals
 - 9. Product Listing
 - 10. Delivery, Storage, and Handling
 - 11. Sequence of Work
 - 12. Installations
 - 13. Cleaning
 - 14. Testing
 - 15. Instructions to the Owner
 - 16. Warranty
 - 17. Operation Manuals
 - 18. Record Documents

1.03 ABBREVIATIONS

- A. General: Utilize the following abbreviations and definitions for discernment within the Drawings and Specifications.
 - 1. Abbreviations:
 - a. ANSI American National Standards Institute
 - b. ASA American Standards Association
 - c. ASTM American Society of Testing Materials
 - d. BICSI Building Industry Consulting Services International
 - e. CBM Certified Ballast Manufacturers
 - f. EC Electrical Contractor
 - g. EIA Electronic Industries Association

h.	ETL	Electrical Testing Laboratories, Inc.
i.	GC	General Contractor
j.	HVAC	Heating, Ventilating, Air Conditioning Contractor
k.	ICEA	International Cable Engineers Association
l.	IEEE	Institute of Electrical and Electronics Engineers
m.	MC	Mechanical Contractor
n.	NEC	National Electrical Code
o.	NEMA	National Electrical Manufacturers Association
p.	NFPA	National Fire Protection Association
q.	OEM	Original Equipment Manufacturer
r.	OSHA	Occupational Safety and Health Act
s.	PC	Plumbing Contractor
t.	TIA/EIA	Telecommunications Industry Association/Electronic Industries Association
u.	UL	Underwriters' Laboratories, Inc.

1.04 DEFINITIONS

- A. PROVIDE means to furnish, place, erect, connect, test, and turn over to Owner, complete and ready for the regular operation, the particular work referred to.
- B. INSTALL means to join, unite, fasten, link, attach, set up or otherwise connect together before testing and turning over to Owner, complete and ready for regular operation, the particular work referred to.
- C. FURNISH means to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories, and all other items customarily required for the proper and complete application for the particular work referred to.
- D. WIRING means the inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such work.
- E. CONDUIT means the inclusion of all fittings, hangers, supports, sleeves, etc.
- F. AS DIRECTED means as directed by the Architect or their representative.
- G. CONCEALED means embedded in masonry or other construction, installed behind wall furring or within double partitions or installed within hung ceilings.
- H. ACCEPTED means as accepted by the Architect or their representative.
- I. APPROVED means as approved by the Architect or their representative.
- J. EQUAL means equivalent as approved by the Architect or their representative.
- K. CONTRACTOR as stated herein shall mean Communication Contractor.

1.05 CONTRACTOR QUALIFICATIONS

- A. The apparent low bidder shall demonstrate their qualifications by providing the following documents for the local area network cabling:
 - 1. A listing of the LAST five (5) Local Area Network (LAN) systems that were installed by the bidder:
 - a. The listing shall include only LANs that included the installation of fiber optic cable, unshielded twisted pair (UTP) cable, and Gigabit Ethernet equipment.
 - b. The listing shall be for the last five projects, regardless of size or location, which are operational and have been turned over to the Owner.
 - c. The listing shall include a brief description of the project, type of LAN, size of the system, Owner's name and address and representative, date started, and date of completion.
 - d. The listing shall include a letter from the Owner of each of the 5 projects. The letter shall be on the Owner's letterhead and shall be signed by an officer or authorized agent of the Owner. The letter shall state the overall satisfaction or dissatisfaction with the performance of the Contractor, and the quality of workmanship in regards to installation of the cabling, hardware, and software.
 - 2. The bidder shall furnish a list of the names of all full-time employees that the Contractor plans to use on the project.
 - a. The listing shall include each person's title, length of current employment with the company, training, and certification.
 - b. The listing shall also include a resume for the Project Manager.
 - c. The listing shall also include registration number and a copy of the current BICSI certificate for each RCDD.
- B. All bidders shall be certified and registered by the applicable cable/connector manufacturer and submit certifications of training in the installation and maintenance of the specified systems.
- C. The bidder shall furnish a list of all test equipment that will be used in the installation and testing of the fiber optics cable and the twisted pair cable.
- D. All of the above documents shall be submitted within 48 hours (excluding weekends and holidays) following the Bid due date/time.

1.06 PERMITS, CODES, AND INSPECTIONS

- A. General: Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules, and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. Codes: The installation shall comply fully with all local, county, and state laws, ordinances and regulations applicable to local area network and related communication installations.
- C. The installation shall be in compliance with the requirements of the latest revisions of:
 - 1. Building Communication International (BISCI)
 - 2. Telecommunications Industry Association/Electronic Industries Association (TIA/EIA)
 - 3. Occupational Safety and Health Act (OSHA)
 - 4. Institution of Electrical and Electronic Engineers (IEEE)
 - 5. National Electric Code (NEC)
 - 6. Underwriter's Laboratories, Inc. (UL)
 - 7. National Electrical Manufacturer's Association (NEMA)
 - 8. National Electrical Contractors Association (NECA)
 - 9. National Safety Code

10. Legislative Act 235 (1965) - Handicapped
11. Legislative Act 287 (1974) - Excavation
12. International Building Code (IBC) 2003
13. Americans with Disabilities Act (ADA)
14. All approved published instructions set forth by equipment manufacturers.

D. The installation shall be in compliance with the requirements of:

1. Middle Department Inspection Agency (MDIA)
 - a. Exception: Where the regulations of the local municipality require inspection services by an agency other than MDIA.
2. All local codes and ordinances in effect and having jurisdiction.
3. All requirements of electrical power utility companies.
4. All requirements of telephone utility companies.
5. All requirements of cable television utility companies.

E. Submit certificates issued by approved authorized agencies to indicate conformance of all work with the above requirements, as well as any additional certificates as may be required for the performance of this contract work.

F. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect prior to execution of the work. The work shall be carried out according to the requirements of such code in accordance with the instructions of the Architect and at no additional cost to the Owner.

G. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from MIDA, or other required inspection agency, and deliver it to the Architect before final payment is made.

1.07 VISITING PREMISES

- A. General: The Bidder shall visit the project site before submitting his/her bid, in order to familiarize him/herself with existing conditions that may affect the work. It is the Contractor's responsibility to analyze existing conditions. Sufficient allowances shall be provided in the Contractor's bid to cover work, due to existing conditions, that will be required to complete this contract work.
- B. By submission of a bid the Contractor is attesting that responsible personnel did, in fact, visit the site during the bidding period and verified all existing pertinent conditions.
- C. Contractor shall verify all measurements and dimensions at the site prior to submitting a bid.

1.08 PROJECT DRAWINGS AND SPECIFICATIONS

- A. Contractor shall carefully examine the Drawings and Specifications of all trades and report all discrepancies to the Architect in writing to obtain corrective action. No departures from the Contract Documents will be made without prior written approval from the Architect.
- B. Questions or disputes regarding the intent or meaning of Contract Documents shall be resolved by the interpretation of the Architect. The Architect's interpretation is final and binding.
- C. The Drawings and Specifications are not intended to define all details, finish materials, and special construction that may be required or necessary. The Contractor shall provide all installations complete and adequate as implied by the project documents.

- D. Drawings are diagrammatic only and do not show exact routes of cabling and locations of equipment. The Contractor shall verify the work of all other trades and shall arrange his work to avoid conflicts. In the event of a conflict, the Contractor shall obtain corrective action from the Architect.
- E. All work shall be considered new, unless noted otherwise.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The contractor shall not provide any products that have been discontinued or are otherwise no longer supported by the manufacturer. If a specified product has been discontinued, the contractor shall provide an equivalent product by the same manufacturer with no fewer features or functionality than that which was originally specified.
- B. Major items of equipment shall have manufacturer's name, address and catalog number on a plate securely attached in a convenient place. All equipment or apparatus of any one system must be the product of one manufacturer, or approved equivalent products of a number of manufacturer's that are suitable for use in a unified system.
- C. All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.
- D. In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.
- E. All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units and shall be furnished as such.
- F. In certain instances, specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.
- G. Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.
- H. Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Architect.
- I. Where the contractor proposes substitute equipment, he shall submit acceptable evidence to indicate compliance with all requirements of the documents, including performance rating, equivalent to the specified item. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.
- J. All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.

2.02 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplate in an accessible location.

PART 3 - EXECUTION

3.01 GENERAL

- A. All construction under this contract shall be completed in a neat and craftsman-like manner. Work that, in the judgement of the Architect, is not satisfactorily installed shall be removed and replaced to the Architect's satisfaction, at the Contractor's expense.
- B. Throughout construction, all work areas and storage areas shall be kept clean. The Contractor shall keep all items clean of dirt, rust, dust and fingermarks.
- C. The Contractor shall furnish, set, erect, and maintain all scaffolding, aerial equipment and ladders required in the installation of this Contract work.
- D. Install temporary platforms so as to be supported only by the existing steel truss framework. Do not allow any additional loading from construction operations to transfer to suspended lath and plaster ceilings.
- E. Painting: Provide in accordance with Division 09 FINISHES Sections and as stated below.
 - 1. Except in Mechanical Rooms, Electrical Rooms, attics, and chase spaces all exposed items provided or installed under this Contract shall be painted.
 - 2. Unless painting is provided by others as elsewhere specified, all painting for items furnished or installed under this Contract shall be the responsibility of this Contractor.
 - 3. Factory-painted equipment cabinets and trim shall not be field-painted except for touching up scratches or damage where necessary to achieve like-new finish. Touching up shall be done after equipment is in its final location.
 - 4. Paint for metal surfaces shall be Rust-o-leum or as approved, one prime coat and two finish coats of color selected by Architect.
 - 5. Items to be painted shall be cleaned and degreased and shall be free of dirt, rust and corrosion prior to application of paint. All paint shall be applied in accordance with all the manufacturer's recommendations (i.e., temperature, dew point, ventilation).
- F. All patchwork performed under this Contract shall be painted. Color shall match the color of adjacent walls, ceilings and floors in which patchwork occurs. Area to be painted shall extend a minimum of 24" all around patchwork; however, final limit shall be set by the Architect. Blend new paint work with existing painted surfaces. Where existing finish is stained or varnished woodwork, all damaged or patched surfaces shall be restored to match the existing adjacent surface, as approved. Paint, stain, varnish and method of application shall be as set out in the specifications for General Construction, or as otherwise approved. Except where painting of patchwork is provided by others, as elsewhere specified, all painting of patchwork required under this Contract shall be the responsibility of this Contractor.

3.02 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. This Contractor shall cooperate completely and coordinate work with the contractors of other trades. Due to the Project Schedule this Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.

- B. Prepare floor plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
1. Specific equipment installations, including, but not limited to racks for LAN equipment, racks for sound system equipment, cable television equipment, etc.
 2. Where additional conduit sleeves are required in order to limit UTP cable length to 90 meters.
 3. Wiring diagrams: Indicating field installed communication wiring and cabling layouts, equipment, and equipment connections.

3.03 SUBMITTALS

- A. General: Follow the procedures specified in Division 1 and as stated below.
- B. The Contractor shall submit a complete set of Project Documents and complete product data for the proposed system to the system vender for review prior to submission to the Architect/Engineer. The System Vender shall review the complete system package and provide documentation attesting to the system compliance with the extended system product and performance warranty. This documentation must accompany all submittals to the Architect/Engineer. Submittals will not be reviewed by the Architect/Engineer without the System Vender approval documentation.
- C. Submit for approval a complete Material Source of Supply and Subcontractor list for all work required under this project. Shop drawing submittals will not be reviewed until a complete Material Source of Supply and Subcontractor list is received.
- D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect, will not be processed.
- E. Prepare and submit detailed shop drawings for materials, systems, and equipment as listed herein, including locations and sizes of all required openings in floor decks, walls and floors.
- F. All shop drawings must be produced electronically with digital font. Hand written notes are not allowed.
- G. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.
- H. All shop drawings shall be stamped by the Contractor, indicating approval, and space shall be provided for the Engineer's stamp and the Architect's stamp.
- I. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and re-submittal as may be required. All submittals shall be complete and contain all required and detailed information.
- J. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing all items of proper dimensions, weight, capacities, sizes, quantity and quality as intended by the Contract. Such acceptance shall not relieve the Contractor from responsibility for errors, omissions, or inadequacies of any sort on submitted data or shop drawings.
- K. Each shop drawing shall contain job title and reference to the applicable drawing and specification article, including the Contractor's drawings, specifications, and verification of compatibility with the systems involved.

- L. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be return without review.
- M. All nameplate data shall be complete at time of equipment submittals - refer to other sections for identification requirements.
- N. For each room or area of the building containing sound system cabinets, telephone backboards, consoles, etc., coordination drawings are required to be submitted for review and acceptance at the time of the equipment submittal.
- O. Equipment shall not be purchased until the shop drawing approval is received.
- P. Shop Drawings shall show conformance with specified equipment characteristics, or Contractor shall assume responsibility for all deviations including all additional costs involved for the deviations.
- Q. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
1. Outlet Boxes
 2. Sound System(s)
 3. Data Networking Systems
 4. Wiring/Cables
 5. Data Network
 6. Projectors and Video Equipment
- R. Submittals shall include plan, riser and wiring diagrams complete with all wiring and required equipment.
- S. Product Options:
1. The product manufacturers listed in each section are either the product the design is based on or a product that the Engineer feels would be an acceptable substitution if that product can meet the intent of the written specifications and the scheduled capacities. The Communication Contractor is responsible for ensuring that the substituted product complies with the intent of the specifications, the scheduled capacities and the drawings. Substitutions of manufacturers not listed are not permitted unless prior approval is obtained from the Engineer as required by Part 2.2, SUBSTITUTIONS, of this specification section.
 2. It will be the responsibility of the Communication Contractor to pay any and all costs associated with any approved substitutions that impact the architectural layout, structure, electrical system(s), mechanical systems, and/or the plumbing systems, due to an increase in physical dimensions, weight, electrical requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.
- T. In order for the manufacturer to certify this local area network cabling system, the system components must meet the requirements of the manufacturer. Review the system with the manufacturer in accordance with their system certification program and provide a letter from the manufacturer documenting the following;
1. That the Contractor is a manufacturer certified installer.
 2. That all the materials in the submittal are in accordance with the manufacturer's certification program.
 3. That the manufacturer has reviewed the entire system in accordance with their certification program and the system is in compliance.
- U. A system that does not have a manufacturer's certification will not be accepted.

3.04 PRODUCT LISTING

- A. Prepare a listing of equipment and materials for the project.
- B. Submit this listing as a part of the submittal requirement specified in Division 1.
- C. When two or more items of same material or equipment are required, they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, fasteners, and similar items used in work, except as otherwise indicated.
- D. Provide products that are compatible within systems and other connected items.

3.05 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage and handling.
- B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Coordinate deliveries of materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

3.06 SEQUENCE OF WORK

- A. Construct work in a sequence in accordance with Division 01.
- B. Due to current Project Schedule, the Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.

3.07 INSTALLATIONS

- A. General - sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for installations of cabling. Arrange such chases, slots and openings such that UTP cable does not exceed 90 meters.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.

8. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
9. Coordinate the cutting and patching of building components to accommodate installation of equipment and materials.
10. Coordinate the installation of materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.
11. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.

3.08 CLEANING

- A. Refer to the Division 1 Section for general requirements for final cleaning.

3.09 TESTING

- A. Contractor, at his own expense, shall make any and all tests directed by an inspection authority, or connector manufacturer, or the Architect, and shall provide all equipment, instruments and materials to make such tests.
- B. Unless otherwise approved, all terminations shall be made and all components shall be in place, complete and operational, at time of final inspection and tests.
- C. Time of such tests, the manner in which they are made and the results of the tests, shall be subject to approval.
- D. Upon completion of work, all component parts, both singularly and as a whole, shall be set, calibrated, adjusted, and left in satisfactory operating condition to suit load conditions, by means of instruments furnished by the Contractor.
- E. Complete testing of equipment and systems shall be provided throughout this project.
- F. Industry standards shall apply except as otherwise specified.
- G. Provide all labor, premium labor, and materials required by field-testing as specified in the Contract Documents and as required.
- H. Notify the Architect seven (7) days prior to the testing dates. Upon completion of a test, a statement of certification shall be forwarded to the Architect for his approval.
- I. Conduct tests at a time agreeable to the Architect. Provide premium labor as necessary.
- J. Products that are found defective or do not pass such tests shall be removed and replaced at the Contractor's expense. Tests shall be repeated.

3.10 INSTRUCTIONS TO THE OWNER

- A. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.
- B. Additional instruction requirements are included in each section of the Specifications.

- C. The Contractor shall video tape all instruction sessions. Prepare a separate video for each system as shown on the schedule below. Clearly label the file with the title "INSTRUCTIONS FOR THE USE OF ...". Provide a copy of each video to the Owner at the completion of the Contract, ensure each video gets to the maintenance staff and the administrative staff.
- D. Prepare an instructional training form indicating the topic of instruction, the date, the time, the purpose of instruction and lines for signatures of attendees. Each person attending the instruction shall print their name and sign the form. Provide a copy of the completed form to the Owner in the O&M manual as proof of instructional training. The Contractor shall keep the original in the Contractor's project file.
- E. Refer to individual system specification sections for training session length requirements.

3.11 WARRANTIES

- A. Refer to the Division 1 for procedures and submittal requirements for warranties and to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- B. Compile and assemble the warranties specified in Division 27 into a separated set of vinyl covered, three-ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- D. Warranty and Certification of the Data Network Wiring and connectors:
 - 1. The Contractor shall provide a minimum 20-year performance and product warranty that all cable, connectors, and connecting hardware shall be free from defects in material, workmanship, and fabrication.
 - 2. The system shall be certified by the cable/connector manufacturer and warranted for the specified performance for a minimum of 20 years. The Contractor shall conform to the manufacturer's certification program including testing and the submittal of all required documentation to the manufacturer.
 - 3. The Contractor shall obtain from the manufacturer, a "systems application assurance" warranty for a minimum of 20 years.
 - 4. The Contractor shall obtain, from the manufacturer, a Registration Document and Certificate for the specific installation. Upon receipt of the Registration Document and Certificate the Contractor shall forward a copy to the Engineer and deliver the original to the Owner.
- E. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner. Obtain similar warranties from subcontractors, manufacturers, suppliers, and sub-trade specialists.
- F. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or which are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

3.12 OPERATION MANUALS

- A. Prepare operation manuals in accordance with Division 1. In addition to the requirements specified in Division 1, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's data of each piece of equipment including:
 - a. Installation instructions.
 - b. Drawings and Specifications.
 - c. Parts list, including recommended items to be stocked.
 - d. Complete wiring diagrams.
 - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
 - f. Test and inspection certificates.
- B. Format:
 - 1. Provide five (5) copies of each manual.
 - 2. Manuals to be 8-1/2 inches x 11 inches size in hard back 3-ring loose-leaf binders. Use more than one volume if required. Do not overfill binders.
 - 3. Submit one (1) copy to Architect. After review and acceptance, assemble other copies.
 - 4. Manuals to be completed and in Owner's hands prior to turning building over to Owner and at least 10 days prior to instruction to operating personnel.

3.13 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1.
- B. When all work has been completed and before final acceptance, the Contractor shall furnish to the Architect a complete set of reproducible contract drawings clearly showing all contract work "as-built". Prior to delivery each drawing shall be signed and dated by the Contractor's project manager attesting to the accuracy of the as-built drawing.
- C. In addition to the above referenced reproducible contract drawings, the Communication Contractor shall furnish to the Architect a pdf containing all of the floor plans. The floor plans shall be in Revit 2023 format, and shall indicate the "as-built" conditions. A pdf shall be provided to the Communication Contractor prior the completion of the project, with the drawing files from the bid set of documents. The Communication Contractor shall make changes to these files, indicating all changes made during construction, including tagging and room names. The Communication Contractor shall make these changes or retain the services of a third party to make the changes.
- D. Mark up a clean set of Specifications to indicate approved substitutions, change orders and actual equipment and materials used.

3.14 LIST OF INSTALLED EQUIPMENT

- A. Provide a list of all active devices installed under this contract. This list shall include both contractor furnished, contractor installed and owner furnished, contractor installed equipment.
- B. Active devices shall include, but not be limited to, the following:
 - 1. AV Equipment
 - 2. Intercom Headend Equipment
 - 3. Clocks

4. Network Switches
5. UPS Units
6. Servers
7. Phones
8. Distributed Antenna System Equipment

C. In Microsoft Excel format, include the following information:

1. Device Symbol as Indicated on As-Built Drawings
2. Location (Room #)
3. Manufacturer/Model
4. Serial Number
5. Manufacturer Warranty Valid Through Date
6. Static IP address (provide address) or DHCP (address not required)
7. MAC address
8. Login Credentials
9. Replacement Cost (for owner's insurance)

END OF SECTION 27 0100

SECTION 27 0526 - GROUNDING FOR COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.01 DESCRIPTION

- A. This section specifies general grounding and bonding requirements of electrical and telecommunication installations for personnel safety, equipment operations and to provide a low impedance path for possible ground fault currents.
- B. "Grounding electrode system" refers to all electrodes required by NEC, as well as including made, supplementary, lightning protection system and telecommunications system grounding electrodes.
- C. The terms "connect" and "bond" are used interchangeably in this specification and have the same meaning.

1.02 RELATED WORK

- A. Section 27 0528: Cable Trays for Communications System
- B. Section 27 0529: Hangers and Supports for Communication Systems
- C. Section 27 1100: Communications Equipment Room Fittings and Grounding

1.03 SUBMITTALS

- A. Submit in accordance with Division 1 submittal procedures.
- B. Shop Drawings
 - 1. Sufficient information, clearly presented, shall be included to determine compliance with drawings and specifications.
 - 2. Include the location of system grounding electrode connections and the routing of aboveground and underground grounding electrode conductors.
- C. Test Reports: Provide certified test reports of ground resistance.
- D. Certifications: Two weeks prior to final inspection, submit four copies of the following to the Engineer:
 - 1. Certification that the materials and installation is in accordance with the drawings and specifications.
 - 2. Certification, by the Contractor, that the complete installation has been properly installed and tested.

1.04 APPLICABLE PUBLICATIONS

- A. Publications listed below (including amendments, addenda, revisions, supplements, and errata) form a part of this specification to the extent referenced. Publications are referenced in the text by the basic designation only.
- B. American Society for Testing and Materials (ASTM):
 - 1. B1-2001: Standard Specification for Hard-Drawn Copper Wire
 - 2. B8-2004: Standard Specification for Concentric-Lay-Stranded Copper Conductors, Hard, Medium-Hard, or Soft.

- C. Institute of Electrical and Electronics Engineers, Inc. (IEEE):
 - 1. 81-1983: IEEE Guide for Measuring Earth Resistivity, Ground Impedance, and Earth Surface Potentials of a Ground System
- D. National Fire Protection Association (NFPA):
 - 1. 70-2005: National Electrical Code (NEC)
 - 2. 99-2005: Health Care Facilities
- E. Telecommunications Industry Association, (TIA)
- F. J-STO-607-D-2019: Commercial Building Grounding (Earthing) and Bonding Requirements for Telecommunications
- G. Underwriters Laboratories, Inc. (UL):
 - 1. 44-2005: Thermoset Insulated Wires and Cables
 - 2. 83-2003: Thermoplastic Insulated Wires and Cables
 - 3. 467-2004: Grounding and Bonding Equipment
 - 4. 486A-486B-2003: Wire Connectors

PART 2 - PRODUCTS

2.01 GROUNDING AND BONDING CONDUCTORS

- A. Equipment grounding conductors shall be UL 83 insulated stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be solid copper. Insulation color shall be continuous green for all equipment grounding conductors, except that wire sizes 25 mm² (4 AWG) and larger shall be permitted to be identified per NEC.
- B. Bonding conductors shall be ASTM B8 bare stranded copper, except that sizes 6 mm² (10 AWG) and smaller shall be ASTM B1 solid bare copper wire.
- C. Isolated Power System: Type XHHW-2 insulation with a dielectric constant of 3.5 or less.
- D. Telecom System Grounding Riser Conductor: Telecommunications Grounding Riser shall be in accordance with J STO-607A. Use a minimum 50mm² (1/0 AWG) insulated stranded copper grounding conductor unless indicated otherwise.
- E. Electrical System Grounding: Conductor sizes shall not be less than what is shown on the drawings and not less than required by the NEC, whichever is greater.

2.02 SPLICES AND TERMINATION COMPONENTS

- A. Components shall meet or exceed UL 467 and be clearly marked with the manufacturer, catalog number, and permitted conductor size(s).

2.03 TELECOMMUNICATION SYSTEM GROUND BUSBARS (PROVIDED BY DIVISION 26 CONTRACTOR)

- A. Provide solid copper bus bar, pre-drilled from two-hole lug connections with a minimum thickness of 1/4 inch for wall and backboard mounting using standard insulators sized as follows:
 - 1. Room Signal Grounding: 12 inches x 4 inches
 - 2. Master Signal Ground: 24 inches x 4 inches

2.04 GROUND CONNECTIONS

- A. Below Grade: Exothermic-welded type connectors.
- B. Above Grade:
 - 1. Bonding Jumpers: compression type connectors, using zinc-plated fasteners and external tooth lock washers.
 - 2. Ground Bus bars: Two-hole compression type lugs using tin-plated copper or copper alloy bolts and nuts.
 - 3. Rack and Cabinet Ground Bars: one-hole compression-type lugs using zinc-plated or copper alloy fasteners.
- C. Cable Shields: Make ground connections to multi-pair communications cables with metallic shields using shield bonding connectors with screw stud connection.

2.05 EQUIPMENT RACK AND CABINET GROUND BARS

- A. Provide solid copper ground bars designed for mounting on the framework of open or cabinet-enclosed equipment racks with minimum dimensions of 3/8 inch thick x 3/4 inch wide.

2.06 GROUND TERMINAL BLOCKS

- A. At any equipment mounting location (e.g., backboards and hinged cover enclosures) where rack-type ground bars cannot be mounted, provide screw lug-type terminal blocks.

2.07 SPLICE CASE GROUND ACCESSORIES

- A. Splice case grounding and bonding accessories shall be supplied by the splice case manufacturer when available. Otherwise, use 16 mm² (6 AWG) insulated ground wire with shield bonding connectors.

2.08 LIGHTNING ARRESTORS

- A. Lightning protectors shall be supplied on all OSP cables as specified by the manufacturer. At minimum, use 16 mm² (6 AWG) insulated ground wire with shield bonding connectors.

2.09 GROUNDING AND BONDING PRODUCTS

- A. Manufacturers - subject to compliance with requirements, provide products by the following:
 - 1. B-Line Systems Inc.
 - 2. Burndy Corporation
 - 3. Crouse-Hinds Company

4. Electrical Components Division; Gould Inc.
5. General Electric Supply Company
6. Ideal Industries, Inc.
7. Thomas and Betts Corporation

- B. Products: Of types indicated and of sizes and ratings to comply with NEC. Where types, sizes, ratings, and quantities indicated are in excess of NEC requirements, the more stringent requirements and the greater size, rating, and quantity indications govern.
- C. Conductor Materials: Copper with 98% conductivity.

2.10 WIRE AND CABLE CONDUCTORS

- A. General: Comply with Division 26 Section 26 0519 "Low Voltage Electrical Power Cables."
- B. Equipment Grounding Conductor: Green insulated.
- C. Grounding Electrode Conductor: Stranded cable.
- D. Bare Copper Conductors - conform to the following:
 1. Solid Conductors: ASTM B-3.
 2. Assembly of Stranded Conductors: ASTM B-8.
- E. Tinned Conductors: ASTM B-33.

2.11 MISCELLANEOUS CONDUCTORS

- A. Ground Bus: Bare annealed copper bars of rectangular cross section.
- B. Braided Bonding Jumpers: Copper tape, braided No. 30 gauge bare copper wire, terminated with copper ferrules.
- C. Bonding Strap Conductor/Connectors: Soft copper, 0.05 inch thick and 2 inches wide, except as indicated.
- D. Flexible Jumper Strap: Flexible flat conductor, 480 strands of 30-gauge bare copper wire; 3/4" wide, 9-1/2" long. Protect braid with copper bolt hole ends with holes sized for 3/8" diameter bolts.

2.12 CONNECTOR PRODUCTS

- A. General: Listed and labeled as grounding connectors for the materials used.
- B. Pressure Connectors: High-conductivity-plated units.
- C. Bolted Clamps: Heavy-duty units listed for the application.

2.13 GROUNDING ELECTRODES

- A. Signal and Communications: For communication systems, provide a #6 AWG minimum green insulated copper conductor in raceway from the grounding electrode system to each rack, cabinet or central equipment location.

- B. Bonding Plates, Connectors, Terminals, and Clamps: Provide electrical bonding plates, connectors, terminals, lugs and clamps as recommended by bonding plate, connector, terminal and clamp manufacturers for indicated applications.
- C. Electrical Grounding Connection Accessories: Provide electrical insulating tape, heat-shrinkable insulating tubing, welding materials, bonding straps, as recommended by accessories manufacturers for type services indicated.

PART 3 - EXECUTION

3.01 GENERAL

- A. Ground in accordance with the NEC, as shown on drawings, and as hereinafter specified.
- B. System Grounding
 - 1. Secondary service neutrals: Ground at the supply side of the secondary disconnecting means and at the related transformers.
 - 2. Separately derived systems (transformers downstream from the service entrance): Ground the secondary neutral.
 - 3. Isolation transformers and isolated power systems shall not be system grounded.
- C. Equipment Grounding: Metallic structures (including ductwork and building steel), enclosures, raceways, junction boxes, outlet boxes, cabinets, machine frames, and other conductive items in close proximity with electrical circuits shall be bonded and grounded.
- D. Special Grounding: For patient care area electrical power system grounding, conform to NFPA 99, and NEC.

3.02 CORROSION INHIBITORS

- A. When making ground and ground bonding connections, apply a corrosion inhibitor to all contact surfaces. Use corrosion inhibitor appropriate for protecting a connection between the metals used.

3.03 TELECOMMUNICATIONS SYSTEM

- A. Bond telecommunications system grounding equipment to the electrical grounding electrode system.
- B. Furnish and install all wire and hardware required to properly ground, bond and connect communications raceway, cable tray, metallic cable shields, and equipment to a ground source.
- C. Ground bonding jumpers shall be continuous with no splices. Use the shortest length of bonding jumper possible.
- D. Provide ground paths that are permanent and continuous with a resistance of 1 ohm or less from raceway, cable tray, and equipment connections to the building grounding electrode. The resistance across individual bonding connections shall be 10 milli ohms or less.
- E. Above-Grade Grounding Connections: When making bolted or screwed connections to attach bonding jumpers, remove paint to expose the entire contact surface by grinding where necessary; thoroughly clean all connector, plate and other contact surfaces; and apply an appropriate corrosion inhibitor to all surfaces before joining.

F. Bonding Jumpers

1. Use insulated ground wire of the size and type shown on the Drawings or use a minimum of 16 mm² (6 AWG) insulated copper wire.
2. Assemble bonding jumpers using insulated ground wire terminated with compression connectors.
3. Use compression connectors of proper size for conductors specified. Use connector manufacturer's compression tool.

G. Bonding Jumper Fasteners

1. Conduit: Fasten bonding jumpers using screw lugs on grounding bushings or conduit strut clamps, or the clamp pads on push-type conduit fasteners. When screw lug connection to a conduit strut clamp is not possible, fasten the plain end of a bonding jumper wire by slipping the plain end under the conduit strut clamp pad; tighten the clamp screw firmly. Where appropriate, use zinc-plated external tooth lock washers.
2. Wire way and Cable Tray: Fasten bonding jumpers using zinc plated bolts, external tooth lock washers, and nuts. Install protective cover, e.g., zinc plated acorn nuts on any bolts extending into wire way or cable tray to prevent cable damage.
3. Ground Plates and Bus bars: Fasten bonding jumpers using two-hole compression lugs. Use tin-plated copper or copper alloy bolts, external tooth lock washers, and nuts.
4. Unistrut and Raised Floor Stringers: Fasten bonding jumpers using zinc-plated, self-drill screws and external tooth lock washers.

3.04 COMMUNICATION ROOM GROUNDING

A. Telecommunications Ground Bus bars:

1. Provide communications room telecommunications ground bus bar hardware at 18 inches at locations indicated on the Drawings.
2. Connect the telecommunications room ground bus bars to other room grounding bus bars as indicated on the Grounding Riser diagram.

B. Self-Supporting and Cabinet-Mounted Equipment Rack Ground Bars:

1. When ground bars are provided at the rear of lineup of bolted together equipment racks, bond the copper ground bars together using solid copper splice plates supplied by the ground bar manufacturer.
2. Bond together nonadjacent ground bars on equipment racks and cabinets with 16 mm² (6 AWG) insulated copper wire bonding jumpers attached at each end with compression-type connectors and mounting bolts.
3. Provide a 16 mm² (6 AWG) bonding jumper between the rack and/or cabinet ground bus bar and the aluminum pan of an overhead cable tray or the raised floor stringer as appropriate.

C. Backboards: Provide a screw lug-type terminal block or drilled and tapped copper strip near the top of backboards used for communications cross-connect systems. Connect backboard ground terminals to the aluminum pan in the telephone-type cable tray using an insulated 16 mm² (16 AWG) bonding jumper.

D. Other Communication Room Ground Systems: Ground all metallic conduit, wire ways, and other metallic equipment located away from equipment racks or cabinets to the cable tray pan or the telecommunications ground bus bar, whichever is closer, using insulated 16 mm² (6 AWG) ground wire bonding jumpers.

3.05 COMMUNICATIONS CABLE GROUNDING

A. Bond all metallic cable sheaths in multipair communications cables together at each splicing and/or terminating location to provide 100 percent metallic sheath continuity throughout the communications distribution system.

1. At terminal points, install a cable shield bonding connector provide a screw stud connection for ground wire. Use a bonding jumper to connect the cable shield connector to an appropriate ground source like the rack or cabinet ground bar.
2. Bond all metallic cable shields together within splice closures using cable shield bonding connectors or the splice case grounding and bonding accessories provided by the splice case manufacturer. When an external ground connection is provided as part of splice closure, connect to an approved ground source and all other metallic components and equipment at that location.

3.06 COMMUNICATIONS CABLE TRAY SYSTEMS

- A. Bond the metallic structures of one cable tray in each tray run following the same path to provide 100 percent electrical continuity throughout this cable tray systems as follows:
 1. Splice plates provided by the cable tray manufacturer can be used for providing a ground bonding connection between cable tray sections when the resistance across a bolted connection is 10 milliohms or less. The contractor shall verify this loss by testing across one splice plate connection in the presence of the Engineer.
 2. Install a 16 mm² (6 AWG) bonding jumper across each cable tray splice or junction where splice plates cannot be used.
 3. When cable tray terminations to cable rack, install 16 mm² (6 AWG) bonding jumper between cable tray and cable rack pan.

3.07 COMMUNICATIONS RACEWAY GROUNDING

- A. Conduit: Use insulated 16 mm² (6 AWG) bonding jumpers to ground metallic conduit at each end and to bond at all intermediate metallic enclosures.
- B. Cable Tray Systems: Use insulated 16 mm² (6 AWG) bonding jumpers to ground cable tray to column-mounted building ground plates (pads) at each end and approximately every 16 meters (50 feet).

3.08 GROUND RESISTANCE

- A. Grounding system resistance to ground shall not exceed 5 ohms. Make necessary modifications or additions to the grounding electrode system for compliance without additional cost to the Government. Final tests shall assure that this requirement is met.
- B. Resistance of the grounding electrode system shall be measured using a four-terminal fall-of-potential method as defined in IEEE 81. Ground resistance measurements shall be made before the electrical distribution system is energized and shall be made in normally dry conditions not less than 48 hours after the last rainfall. Resistance measurements of separate grounding electrode systems shall be made before the systems are bonded together below grade. The combined resistance of separate systems may be used to meet the required resistance, but the specified number of electrodes must still be provided.

3.09 GROUNDING FOR RF/EMI CONTROL

- A. Install bonding jumpers to bond all conduit, cable trays, sleeves, and equipment for low voltage signaling and data communications circuits. Bonding jumpers shall consist of 4 inches wide copper strip or two 6 mm² (10 AWG) copper conductors spaced minimum 4 inches apart. Use 16 mm² (6 AWG) copper where exposed and subject to damage.
- B. Comply with the following when shielded cable is used for data circuits.
 1. Shields shall be continuous throughout each circuit.

2. Connect shield drain wires together at each circuit connection point and insulate from ground. Do not ground the shield.
3. Do not connect shields from different circuits together.
4. Shield shall be connected at one end only. Connect shield to signal reference at the origin of the circuit. Consult with equipment manufacturer to determine signal reference.

END OF SECTION 27 0526

SECTION 27 0528 - CABLE TRAYS FOR COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Requirements of the following Division 26 Sections apply to this section:
 - 1. Basic Electrical Requirements.
 - 2. Hangers and Supports for Electrical Systems.
 - 3. Common Work Results for Electrical.

1.02 SUMMARY

- A. This section includes metallic cable trays. Types of cable trays in this section include the following:
 - 1. Wire Basket Type.

1.03 DEFINITIONS

- A. Refer to NEMA Standard VE 1 for definitions of cable tray terminology used in this section.

1.04 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 1 Specification Sections:
- B. Product Data for wire basket tray products.
- C. Shop Drawings: Layout floor plans and elevations showing wire basket tray system. Designate components and accessories including clamps, dividers, brackets, hanger rods, splice plates connectors, expansion joint assemblies, straight lengths, and fittings. Show accurately scaled components and spatial relationships to adjacent equipment. Show tray types, dimensions, and finishes.
- D. Factory Test Reports: Certified copies of factory test reports performed in conformance with NEMA Standard VE 1 on wire basket trays of types and size specified for this project.

1.05 QUALITY ASSURANCE

- A. Manufacturer: Firms regularly engaged in manufacturer of wire basket trays whose products have been in satisfactory use in similar service for not less than 5 years.
- B. UL and NEMA Compliance: Wire basket trays and components shall be listed and labeled by UL and comply with NEMA Standard VE 1, "Cable Tray Systems."
- C. Electrical Component Standard: Components and installation shall comply with NFPA 70 "National Electrical Code."

- D. Single-Source Responsibility: All wire basket tray components shall be the product of a single manufacturer.
- E. Coordination Drawings: Include wire basket tray systems in coordination drawings.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products by the following:
 - 1. T. J. Cope
 - 2. B-Line Systems, Inc.
 - 3. Cablofil
 - 4. Mono-Systems
 - 5. Basor Electric Inc.

2.02 WIRE BASKET TRAYS - GENERAL REQUIREMENTS

- A. Wire basket tray systems shall be of indicated types, sizes, and NEMA classes and shall be complete with manufacturer's recommended covers, barrier strips, dropouts, fittings, conduit adapters, hold-down devices, grommets, and blind ends as required and indicated.
- B. Wire basket tray products shall have rounded edges and smooth surfaces.
- C. Wire basket trays shall be manufactured from high strength steel wires. Wire to be welded, formed, and coated after fabrication.
- D. Straight section to be provided in 10' sections.
- E. Wire basket tray shall be Cope Cat-Tray as manufactured by T. J. Cope, or equal of B-Line.

2.03 MATERIALS AND FINISHES

- A. Wire Basket Trays, Fittings, and Accessories: Carbon Steel.
- B. Wire Basket Trays, Fittings, and Accessories: Hot Dip Galvanized Finish. Hot dip galvanizing to be applied to welded and formed wire mesh surfaces.
- C. Minimum Tray Bending Radius: 12 inches.

2.04 SIZES AND CONFIGURATIONS

- A. Wire Basket Tray Mesh Opening: 4" x 2"
- B. Wire Basket Side Rail Depth: 4 inches.
- C. Wire Basket Tray Width: As noted on drawings.

2.05 CABLE TRAY ACCESSORIES

- A. Barrier Strips: Minimum two continuous full height dividers to separate wiring of the various systems. Same materials and finishes as wire basket trays.

2.06 SUPPORTS AND CONNECTORS

- A. Wire basket tray supports and connectors, including bonding jumpers shall be as recommended by wire basket tray manufacturer.
- B. Supports shall be spaced a maximum of 5' on center and at all change of directions.
- C. Wire basket tray support system shall be installed at manufacturer's suggested support span of 5' at a span load of L/300.

2.07 FASTENERS FOR SUPPORTS

- A. Fasteners to connect wire basket tray supports to the building structure shall be as follows:
 - 1. Expansion Anchors: Carbon steel wedge or sleeve type.
 - 2. Toggle Bolts: All steel springhead type.
 - 3. Powder Driven Threaded Studs: Heat-treated steel, designed specifically for the intended service.

2.08 FIRE STOPPING

- A. General: Materials shall be UL listed and labeled and FM approved for fire ratings consistent with penetrated barriers.
- B. Sleeves: Schedule 40, welded, black steel pipe sleeves. Sizes as indicated or minimum NEC size for cable or cable group to be installed.
- C. Sealing Fittings: Suitable for sealing cables in sleeves or core drilled holes.
- D. Sealing Mortar: Suitable for sealing cable penetration slots/openings in fire barriers.
- E. Sealant: One-part compound for sealing cables, sleeves, and openings in fire barriers.
- F. Two-Part Sealant: Formed-in-place sealant as specified in Division 26 Section 260500 "Common Work Results for Electrical".

2.09 WARNING SIGNS

- A. Lettering: 1-1/2 inch high, black on yellow background with legend "WARNING! NOT TO BE USED AS WALKWAY, LADDER, OR SUPPORT FOR LADDERS OR PERSONNEL."
- B. Materials and Fastening: Conform to Section 26 0553 "Electrical Identification."

PART 3 - EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which the wire basket trays are to be installed, coordinate locations with all other Contractors and light fixtures. The exact location will be as directed by Owner/Architect. Provide all necessary steel supports, hanger rods, and miscellaneous hardware. Provide all necessary horizontal and vertical offsets to complete the installation around obstacles, building structure, and other systems.

3.02 INSTALLATION OF CABLE TRAY SYSTEMS

- A. Wire basket tray shall be installed with a minimum 18" clearance from light fixtures, electrically operated equipment and all wiring operating at 120 or more volts.
- B. Install wire basket trays in accordance with equipment manufacturer's written instructions.
- C. Remove burrs and sharp edges of wire basket trays.
- D. Support wire basket tray independently from the building structural components.
- E. Conform to manufacturer's recommendations for selection and installation of supports.
- F. Support Locations: Locate supports in accordance with the recommendations of the wire basket tray manufacturer.
- G. Installation of supports shall be in accordance with wire basket tray manufacturer's written instructions and the recommendations of Paragraph 6.5 of NEMA Standard VE 1.
- H. Fastening Supports: Unless otherwise indicated, fasten cable tray supports securely to the building structure as specified in Division 26 Section 26 0529 "Hangers and Supports for Electrical Systems".
- I. Support at Connections to Equipment: Where wire basket trays connect to equipment, provide flanged fittings fastened to the tray and to the equipment. Support the tray separately. Do not carry the weight of the tray on the equipment enclosure.
- J. Thermal Contraction and Expansion: Install expansion connectors in wire basket tray runs as recommended by the manufacturer.
- K. Direction Changes: All bends, intersections, elevation changes, reducers, etc., are to be field fabricated utilizing straight sections, hardware, and instructions provided by the manufacturer.
- L. Locate wire basket tray above piping except as required for tray accessibility and as otherwise indicated.
- M. Firestopping: Where wire basket trays penetrate fire and smoke barriers including walls, partitions, floors, and ceilings, install fire- stopping at penetrations after cables are installed.
- N. Sleeves for Future Cables: Install capped sleeves for future cables through firestopped wire basket tray penetrations of fire/smoke barriers.
- O. Working Space: Install wire basket trays with sufficient space to permit access for installing cables.
- P. Barriers: Where trays carry conductors of different systems, such as television, communications, and data processing, install barriers to separate the systems

3.03 GROUNDING

- A. Electrically ground wire basket trays and ensure continuous electrical conductivity of wire basket tray system. Use tray as an equipment ground conductor for itself only, not for connected equipment.

3.04 WARNING SIGNS

- A. After installation of wire basket trays is completed, install warning signs, on or in proximity to wire basket trays, where easily seen by occupants of space.

3.05 FIELD TESTING

- A. Grounding: Test wire basket trays to ensure electrical continuity of bonding and grounding connections.
- B. Anchorage: Test pull-out resistance of one of each type, size, and anchorage material for toggle bolts and powder-driven threaded studs.
- C. Furnish equipment, including jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the Architect's approval before transmitting loads to the structure. Test to 90 percent of rated proof-load for fastener. If fastening fails test, replace fastener and retest until satisfactory results are achieved.

3.06 CLEANING AND FINISH REPAIR

- A. Upon completion of installation of wire basket trays, inspect trays, fittings, and accessories. Remove burrs, dirt, and construction debris and repair damaged finish including chips, scratches, and abrasions.
- B. Galvanized Finish: Repair damage with a zinc-rich paint recommended by the tray manufacturer.

END OF SECTION 27 0528

SECTION 27 0529 - HANGERS AND SUPPORTS FOR COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 27 Sections apply to this section:
 - 1. Division 27 Section 27 0100 "Basic Communications System Requirements".

1.02 SUMMARY

- A. This Section includes secure support from the building structure for communication items by means of hangers, supports, anchors, sleeves, inserts, seals, and associated fastenings.
- B. All supports shall utilize threaded fasteners for all connections/attachments. The use of clips or clip-on type supports is not acceptable.
- C. Types of supports, anchors, sleeves, and seals specified in this section include the following:
 - 1. Clevis hangers
 - 2. Riser clamps
 - 3. C-clamps
 - 4. I-beam clamps
 - 5. Conduit straps
 - 6. Round steel rods
 - 7. Lead expansion anchors
 - 8. Toggle bolts
 - 9. Wall and floor seals
- D. Supports, anchors, sleeves, and seals furnished as part of factory fabricated equipment, are specified as part of that equipment assembly in other Division 27 sections.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product Data: Submit manufacturer's data on supporting devices including catalog cuts, specifications, and installation instructions, for each type of support, anchor, sleeve and seal.
- C. Shop Drawings: Submit dimensioned drawings of fabricated products, indicating details of fabrication and materials.

1.04 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of supporting devices, of types, sizes, and ratings required, whose products have been in satisfactory use in similar service for not less than 3 years.

- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing supporting device work similar to that required for this project.
- C. NEC Compliance: Comply with NEC requirements as applicable to construction and installation of supporting devices.
- D. MSS Compliance: Comply with applicable MSS standard requirements pertaining to fabrication and installation practices for pipe hangers and supports.
- E. NECA Compliance: Comply with National Electrical Contractors Association's "Standard of Installation" pertaining to anchors, fasteners, hangers, supports, and equipment mounting.
- F. UL Compliance: Provide components that are UL listed and labeled.
- G. FS Compliance: Comply with Federal Specification FF-S-760 pertaining to retaining straps for conduit, pipe, and cable.
- H. Components shall be listed and labeled by ETL, CSA, or other approved, nationally recognized testing and listing agency that provides third-party certification follow-up services.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products by the following:
 - 1. Slotted Metal Angle and U-Channel Systems:
 - a. Allied Tube & Conduit
 - b. American Electric
 - c. B-Line Systems, Inc.
 - d. Cinch Clamp Co., Inc.
 - e. Elcen Metal Products Company
 - f. Greenfield Mfg. Co., Inc.
 - g. Haydon Corporation
 - h. Kin-Line, Inc.
 - i. Midland-Ross Corporation
 - j. Power-Strut Division; Van Huffel Tube Corporation
 - k. Unistrut Diversified Products
 - 2. Anchors:
 - a. Abbeon Cal Inc.
 - b. Ackerman Johnson Fastening Systems Inc.
 - c. Elcen Metal Products Company
 - d. Ideal Industries, Inc.
 - e. Joslyn Mfg and Supply Company
 - f. McGraw Edison Company
 - g. Rawl Plug Co. Inc.
 - h. Star Expansion Company
 - i. U.S. Expansion Bolt Company
 - j. Hilti, Inc.

2.02 U-CHANNEL STRUT SYSTEMS

- A. Provide U-channel strut system for supporting communication equipment, 12-gauge hot-dip galvanized steel, of types and sizes indicated; construct with 9/16" diameter holes, 8" o.c. on top surface, with standard green finish, and with the following fittings which mate and match with U-channel and are of the same manufacturer:
1. Fixture hangers
 2. Channel hangers
 3. End caps
 4. Beam clamps
 5. Wiring stud
 6. Thin wall conduit clamps
 7. Rigid conduit clamps
 8. Conduit hangers
 9. U-bolts

2.03 SUPPORTING DEVICES

- A. Provide supporting devices of types, sizes and materials indicated; and having the following construction features:
1. Clevis Hangers: For supporting 2" rigid metal conduit; galvanized steel; with 1/2" diameter hole for round steel rod; approximately 54 pounds per 100 units.
 2. Riser Clamps: For supporting 5" rigid metal conduit; black steel; with 2 bolts and nuts; and 4" ears; approximately 510 pounds per 100 units.
 3. Reducing Couplings: Steel rod reducing coupling 1/2" x 5/8"; black steel; approximately 16 pounds per 100 units.
 4. C-Clamps: Black malleable iron; 1/2" rod size; approximately 70 pounds per 100 units.
 5. I-Beam Clamps: Black steel, 1-1/4" x 3/16" stock, 3/8" cross bolt; flange width 2"; approximately 52 pounds per 100 units.
 6. One-Hole Conduit Straps: For supporting 3/4" rigid metal conduit; galvanized steel; approximately 7 pounds per 100 units.
 7. Two-Hole Conduit Straps: For supporting 3/4" rigid metal conduit, galvanized steel; 3/4" strap width; and 2-1/8" between center of screw holes.
 8. Hexagon Nuts: For 1/2" rod size; galvanized steel; approximately 4 pounds per 100 units.
 9. Round Steel Rod: Black steel; 1/2" diameter; approximately 67 pounds per 100 feet.
 10. Offset Conduit Clamps: For supporting 2" rigid metal conduit; black steel; approximately 200 pounds per 100 units.

2.04 ANCHORS

- A. Provide anchors of types, sizes and materials indicated; and having the following construction features:
1. Lead Expansion Anchors: 1/2", approximately 38 pounds per 100 units.
 2. Toggle Bolts: Springhead; 3/16" x 4"; approximately 5 pounds per 100 units.

2.05 SLEEVES AND SEALS

- A. Provide sleeves and seals, of types, sizes and materials indicated, with the following construction features:
1. Wall and Floor Seals: Provide factory assembled watertight wall and floor seals, of types and sizes indicated; suitable for sealing around conduit, pipe, or tubing passing through concrete floors and walls. Construct seals with steel sleeves, malleable iron body, neoprene sealing grommets and rings, metal pressure rings, pressure clamps, and cap screws.

2.06 COATINGS

- A. Coating: Supports, support hardware, and fasteners shall be protected with zinc coating or with treatment of equivalent corrosion resistance using approved alternative treatment, finish, or inherent material characteristic. Products for use outdoors shall be hot-dip galvanized.

2.07 FABRICATED SUPPORTING DEVICES

- A. General: Shop or field fabricated supports or manufactured supports assembled from U-channel components.
- B. Steel Brackets: Fabricated of angles, channels, and other standard structural shapes. Connect with welds and machine bolts to form rigid supports.

PART 3 - EXECUTION

3.01 GENERAL

- A. Provide supporting devices that comply with manufacturer's standard materials, design and construction in accordance with published product information, and as required for complete installation; and as herein specified. Where more than one type of supporting device meets indicated requirements, selection is Contractor's option.
- B. Install hangers, anchors, sleeves and seals as indicated, in accordance with manufacturer's written instructions and with recognized industry practices to ensure supporting devices comply with requirements. Comply with requirements of NECA and NEC for installations of supporting devices.
- C. Coordinate with the building structural system and electrical work, including raceway and wiring work, as necessary to interface installation of supporting devices with other work.
- D. Do not fasten supports to pipes, ducts, mechanical equipment, and conduit.
- E. Obtain approval from the Architect before drilling or cutting structural members.
- F. Install surface mounted cabinets with minimum of four anchors.

3.02 MISCELLANEOUS SUPPORTS

- A. Support miscellaneous components as required to produce the same structural safety factors as specified for raceway supports. Install metal channel racks for mounting cabinets, boxes, and other devices.

3.03 FASTENING

- A. Unless otherwise indicated, fasten items and their supporting hardware securely to the building structure, including but not limited to conduits, raceways, cables, cable trays, cabinets, boxes, and control components in accordance with the following:
 - 1. Fasten by means of wood screws or screw-type nails on wood, toggle bolts on hollow masonry units, concrete inserts, or expansion bolts on concrete or solid masonry, and machine screws, welded threaded studs, or spring-tension clamps on steel. Threaded studs driven by a powder charge and provided with lock washers and nuts may be used instead of expansion bolts and machine or wood screws. Do not weld conduit, pipe

straps, or items other than threaded studs to steel structures. In partitions of light steel construction, use sheet metal screws.

2. Holes cut into reinforced concrete beams or in concrete shall not cut reinforcing bars. If the Contractor cuts into any reinforcing bars, stop work and notify the Architect immediately. Fill holes that are not used.
3. Ensure that the load applied to any fastener does not exceed 25 percent of the proof test load. Use vibration- and shock-resistant fasteners for attachments to concrete slabs.

3.04 TESTS

- A. Test pull-out resistance of one of each type, size, and anchorage material for the following fastener types:
 1. Expansion anchors.
 2. Toggle bolts.
 3. Powder driven threaded studs.
- B. Provide all jacks, jigs, fixtures, and calibrated indicating scales required for reliable testing. Obtain the structural Engineer's approval before transmitting loads to the structure. Test to 90 percent of rated proof load for fastener. If fastening fails test, revise all similar fastener installations and retest until satisfactory results are achieved.

END OF SECTION 27 0529

SECTION 27 0553 - IDENTIFICATION FOR COMMUNICATIONS SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 27 Sections apply to this section:
 - 1. Division 27 Section 27 0100 "Basic Communications System Requirements".

1.02 SUMMARY

- A. This Section includes identification of communication cables, equipment, and installations. It includes requirements for identification components including but not limited to the following:
 - 1. Identification labeling for cables.
 - 2. Operational instruction signs.
 - 3. Equipment labels and signs.
- B. Refer to Division 01 General Requirements Section, "Identification Systems" for equipment and system nameplates, and performance data; not work of this section.
- C. Refer to other Division 27 sections for additional specific identification requirements associated with specific items.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product Data: Manufacturer's data for each type of product specified.
- C. Schedule of identification nomenclature to be used for identification signs and labels.
- D. Samples of each color, lettering style, and other graphic representation required for identification materials; samples of labels and signs.

1.04 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of electrical or communication identification products of types required, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer's Qualifications: Firm with at least 3 years of successful installation experience with projects utilizing identification work similar to that required for this project.
- C. NEC Compliance: Comply with NEC as applicable to installation of identifying labels and markers for wiring and equipment.

- D. UL Compliance: Comply with applicable requirements of UL Standard 969, "Marking and Labeling Systems", pertaining to identification systems.
- E. ANSI Compliance: Comply with applicable requirements of ANSI Standard A13.1 "Scheme for the Identification of Piping Systems", with regard to type and size of lettering for cable labels.
- F. NEMA Compliance: Comply with applicable requirements of NEMA Standard No's. WC-1 and WC-2 pertaining to identification of control conductors.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers - subject to compliance with requirements, provide products by the following (for each type marker):
 - 1. Ideal Industries, Inc.
 - 2. Panduit Corporation
 - 3. Seton Name Plate Company

2.02 ELECTRICAL IDENTIFICATION PRODUCTS

- A. Adhesive Marking Labels for Raceway and Metal-clad Cable: Pre-printed, flexible, self-adhesive labels with legend indicating voltage and service (Communications, Control, etc.).
 - 1. Label size as follows:
 - a. Raceways 1 Inch and Smaller: 1-1/8 inches high by 4 inches long.
 - b. Raceways larger than 1 Inch: 1-1/8 inches high by 8 inches long.
- B. Cable Identification Bands
 - 1. General: Provide manufacturer's standard plastic wrap-around cable markers, of size required for proper application, and numbered to show cable identification.
- C. Equipment Labels
 - 1. General: Provide engraving stock melamine plastic laminate, complying with FS L-P-387, in sizes and thicknesses indicated, engraved with engraver's standard letter style of the sizes and wording indicated, black face and white core plies (letter color) except as otherwise indicated, punched for mechanical fastening.
 - 2. Thickness: 1/16" for units up to 20 sq. in. or 8" length; 1/8" for larger units.
- D. Lettering and Graphics
 - 1. General: Coordinate names, abbreviations and other designations used in identification work, with corresponding designations shown, specified or scheduled. Provide numbers, lettering and wording as indicated or, if not otherwise indicated, as recommended by manufacturers or as required for proper identification and operation/maintenance of the systems and equipment. Comply with ANSI A13.1 pertaining to minimum sizes for letters and numbers.
- E. Fasteners for Plastic Laminated and Metal Signs
 - 1. Self-tapping stainless steel screws or number 10/32 stainless steel machine screws with nuts and flat and lock washers. Exception: Where specifically approved contact type permanent adhesive may be used in areas where screws cannot or should not penetrate substrate.

PART 3 - EXECUTION

3.01 GENERAL

- A. Except as otherwise indicated, provide manufacturer's standard products of categories and types required for each application. Where more than single type is specified for an application, selection is Installer's option, but provide single selection for each application.
- B. Lettering and Graphics: Coordinate names, abbreviations, colors, and other designations used in identification work with corresponding designations specified or indicated. Install numbers, lettering, and colors as approved in submittals and as required by code.
- C. Install identification devices as indicated, in accordance with manufacturer's written instructions and requirements of NEC.
- D. Sequence of Work: Where identification is to be applied to surfaces that require finish, install identification after completion of finish work.
- E. Regulations: Comply with governing regulations and requests of governing authorities for the identification of work.

3.02 CABLE IDENTIFICATION

- A. Apply cable identification on each voice/data cable in each rack/cabinet and for all sound system cabling and cable television cabling. Match identification with marking system used on shop drawings, contract documents, and similar previously established identification for project's work.
- B. Each cable shall be marked at both ends. For local area network, each patch cable or cross connect cable shall be marked at both ends.
- C. The Contractor shall review the identification scheme with the Owner prior to commencing work. The identification scheme shown on the floor plans is based on architectural room numbers and may not necessarily be the final post-construction room numbers.

3.03 OUTLET LABEL

- A. For the tele/data cabling, provide labels for each data outlet, using faceplate manufacturer's standard label holder and recommendations of TIA/EIA.

3.04 OPERATION SIGNS

- A. Provide instruction signs with approved legend where instructions or explanations are needed for system or equipment operation.

3.05 INSTALLATION

- A. Provide equipment identification labels of engraved plastic-laminate on each major unit of communication equipment in the building, including each rack, cabinet and main network switch, unless unit is specified with its own self-explanatory identification. Except as otherwise indicated, provide single line of text, with 1/2-inch high lettering on

1-1/2-inch high label (2-inch high where two lines are required), white lettering in black field. Text shall match terminology and numbering of the Contract Documents and shop drawings.

- B. Apply labels for each communication system component.
 - 1. Telephone switching equipment.
 - 2. Clock/program master equipment.
 - 3. Call system master station.
 - 4. TV/audio monitoring master station.
- C. Provide labels at locations indicated and at locations for best convenience of viewing without interference with operation and maintenance of equipment.

END OF SECTION 27 0553

SECTION 27 0800 - COMMISSIONING OF COMMUNICATIONS

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This Section includes the minimum requirements for the test certification, identification and administration of backbone and horizontal cabling.
- B. This Section includes minimum requirements for:
 - 1. Copper cabling test instruments
 - 2. Copper cabling testing
 - 3. Identification
 - a. Labels and labeling
 - 4. Administration
 - a. Test results documentation
 - b. As-built drawings
- C. Testing shall be carried out in accordance with this document. This includes testing the attenuation and polarity of the installed cable plant with an optical loss test set (OLTS) and the installed condition of the cabling system and its components with an optical time domain reflectometer (OTDR).
- D. Testing shall be performed on each cabling link (connector to connector).
- E. Testing shall be performed on each cabling channel (equipment to equipment) that is identified by the owner.
 - 1. Testing shall not include any active devices or passive devices within the link or channel other than cable, connectors, and splices, i.e., link attenuation does not include such devices as optical bypass switches, couplers, repeaters, or optical amplifiers.
- F. All tests shall be documented including OLTS dual wavelength attenuation measurements and OTDR traces with event tables as well as OTDR maps.
 - 1. Optionally, documentation shall also include optical length measurements and pictures of the connector end face.
- G. Provide all labor, materials, tools, field-test instruments and equipment required for the complete testing, identification and administration of the work called for in the Contract Documents.
- H. In order to conform to the overall project event schedule, the cabling contractor shall survey the work areas and coordinate cabling testing with other applicable trades.
- I. In addition to the tests detailed in this document, the contractor shall notify the Owner or the Owner's representative of any additional tests that are deemed necessary to guarantee a fully functional system. The contractor shall carry out and record any additional measurement results at no additional charge.

J. Related Sections

1. Consult all other Sections and Divisions, determine the extent and character of related work and properly coordinate work specified herein with that specified elsewhere to completely test a complete and operable system.
2. Section 27 0100: "Basic Communications System Requirements"
3. Section 27 1500: "Communications Cabling"

K. Products Furnished and Installed Under Other Sections

1. Telecommunications Cabling

1.02 REFERENCES

- A. Comply with Section 27 0100 "Basic Communications System Requirements" references requirements.
- B. Additional references to those listed in Section 27 0100 "Basic Communications System Requirements".

1.03 DEFINITIONS

- A. Refer to Definitions of Sections 27 0100 and 27 1500.
- B. In addition, the following list of terms as used in this specification shall be defined as follows:
 1. "Adapter" (associated with fiber connectivity): Shall mean a connecting device joining 2 fiber connectors, either like or unlike.
 2. "Channel": Shall mean a testing configuration which includes the Permanent Link and the line cord (at the workstation), the equipment cord, and if a full cross connection is implemented, a patch cord and the cross connect termination/connecting apparatus.
 3. "Connect": Shall mean install all required patch cords, equipment cords, cross-connect wire, etc. to complete an electrical or optical circuit.
 4. "Cord": Shall mean a length of cordage having connectors at each end. The term "Cord" shall be synonymous with the term "Jumper". The cord may be:
 - a. Unshielded twisted pair
 - b. Fiber (multimode or single mode), jacketed and buffered
 5. "Launch Cord": Shall mean the cord certified for use in fiber optic characterization testing, as described in this section.
 6. "OTDR": Shall mean Optical Time Domain Reflectometer.
 7. "Passive Link Segment": Shall mean the cable, connectors, couplings, and splices between two fiber optic termination units.
 8. "Permanent Link": Shall mean the 'permanent' portion of the Horizontal cabling to each outlet with the test cords de-embedded from the measurements; this includes cable, consolidation point (if used), termination/connecting apparatus in the IDF and the connector at the outlet.
 9. "System Cord": Shall mean the cord used in the operating electrical or optical circuit.
 10. "Test Cord": Shall mean the cord certified for use in testing, as described in this section.

1.04 SYSTEM DESCRIPTION

- A. Work Provided Under Other Sections
 1. Refer to Section 27 1500 "Communications Cabling" for a complete system description.

1.05 SUBMITTALS

- A. Refer to Submittals of to Section 27 0100 for procedural, quantity, and format requirements.
- B. Preconstruction Submittal Requirements:
 - 1. Testing Procedures Submittal, describing step-by-step procedures used by the field technicians.
 - 2. Product Submittal, including cut sheets of testing equipment to be used (note all software/firmware versions as applicable) and certificate of last calibration.
 - 3. Schedule Submittal, consisting of proposed schedule of work. This schedule may be combined with the schedule developed for 27 XX XX series Sections.
- C. Submittal Requirements at Closeout
 - 1. Record Documents.
- D. Submittal Description: Record Documents
 - 1. Test Reports: Record documents submittal shall include test reports showing the following information:
 - a. A title page which includes:
 - 1) Client Name
 - 2) Project Name
 - 3) Project Address
 - 4) General Contractor name / Telecommunications Installer name
 - 5) Date of Submittal
 - b. Individual tabs which break down the test results by building, and then by telecommunications room.
 - c. All Backbone UTP test results.
 - d. All Horizontal cable test results, per cable
 - 2. Furnish all test results on CD-ROM in their native data format and an exported Microsoft Excel compatible format.
 - a. Include all necessary software to allow viewing and printing of individual test results.
 - b. CD shall be labeled with the project name, contractor name, and date of submission.

1.06 QUALITY ASSURANCE

- A. Comply with the Quality Assurance requirements of Section 270100 "Basic Communications Systems Requirements".
- B. All testing procedures and field-test instruments shall comply with applicable requirements of:
 - 1. ANSI/TIA-1152, Requirements for Field Test Instruments and Measurements for Balanced Twisted-Pair Cabling
 - 2. ANSI/TIA-568-0. D, Generic Telecommunications Cabling for Customer Premises.
 - 3. ANSI/TIA-568-1. D, Commercial Building Telecommunications Cabling Standard
 - 4. ANSI/TIA-568-C.2, Balanced Twisted-Pair Telecommunications Cabling and Components Standards.
 - 5. ANSI/TIA-606-B, Administration Standard for Commercial Telecommunications Infrastructure, including the requirements specified by the customer, unless the customer specifies their own labeling requirements.
 - 6. TIA-TSB-4979, Practical Considerations for Implementation of Multimode Launch Conditions in the Field
- C. Trained technicians who have successfully attended an appropriate training program, which includes testing with an OLTS and an OTDR and have obtained a certificate as proof thereof shall execute the tests. These certificates may have been issued by any of the following organizations or an equivalent organization:
 - 1. Manufacturer of the connectors or cable.

2. Manufacturer of the test equipment used for the field certification.
 3. Training organizations (e.g., BICSI, A Telecommunications Association headquarters in Tampa, Florida; ACP [Association of Cabling Professionals™] Cabling Business Institute located in Dallas, Texas)
- D. The Owner or the Owner's representative shall be invited to witness and/or review field-testing.
1. The Owner or the Owner's representative shall be notified of the start date of the testing phase five business days before testing commences.
 2. The Owner or the Owner's representative will select a random sample of five percent of the installed links. The Owner or the Owner's representative shall test these randomly selected links and the results are to be stored in accordance with Part 3 of this document. The results obtained shall be compared to the data provided by the installation contractor. If more than two percent of the sample results differ in terms of the pass/fail determination, the installation contractor under supervision of the representative shall repeat one hundred percent testing at no cost to the Owner.

1.07 WARRANTY

- A. Warrant the validity of the test results. Under no circumstances shall any cable's test results be substituted for another's. If a single instance of falsification is confirmed, the Contractor shall be liable for a complete retest of the cabling system at no additional cost to the Owner. This includes the retaining the services of a neutral party to observe all retesting.

PART 2 - PRODUCTS

2.01 GENERAL

- A. The manufacturer may change the product numbers listed in this Section at any time, as well as software and firmware versions. In the event this Section contains an invalid product number or conflicts with the written description, or specifies an out-of-date software and/or firmware version, notify the Engineer in writing prior to issuing submittals or field testing.

2.02 BALANCED TWISTED-PAIR CABLE TESTERS

- A. The field-test instrument shall be within a 12-month calibration period.
- B. Certification tester
1. Accuracy
 - a. Level III accuracy in accordance with ANSI/TIA-1152-A
 - b. Independent verification of accuracy shall be provided
 - c. Acceptable manufacturer
 - 1) Fluke Networks
 2. Permanent Link Adapters
 - a. RJ45 plug must meet the requirements for NEXT, FEXT and Return Loss in accordance with ANSI/TIA-568-C.2 Annex C
 - b. Twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures

3. Results Storage
 - a. Must be capable of storing > 10,000 results for all measurements found in 2.1.B.4 below
4. Measurement capabilities
 - a. Wire Map
 - b. Length
 - c. Propagation Delay
 - d. Delay Skew
 - e. DC Loop Resistance
 - f. DC Resistance Unbalance within a pair
 - g. DC Resistance Unbalance between pairs
 - h. Insertion Loss
 - i. NEXT (Near-End Crosstalk)
 - j. PS NEXT (Power Sum Near-End Crosstalk)
 - k. ACR-N (Attenuation to Crosstalk Ratio Near-End)
 - l. PS ACR-N (Power Sum Attenuation to Crosstalk Ratio Near-End)
 - m. ACR-F (Attenuation to Crosstalk Ratio Far-End)
 - n. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)
 - o. Return Loss
 - p. TCL (Transverse Conversion Loss)
 - q. ELTCTL (Equal Level Transverse Conversion Transfer Loss)
 - r. Time Domain Reflectometer
 - s. Time Domain Xtalk Analyzer
 - t. PS ANEXT (Power Sum Alien Near-End Crosstalk)
 - u. Average PS ANEXT (Average Power Sum Alien Near-End Crosstalk)
 - v. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)
 - w. Average PS AACR-F (Average Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

C. PC Software

1. LinkWare PC

2.03 IDENTIFICATION

A. Labels

1. Shall meet the legibility, defacement, exposure and adhesion requirements of UL 969.
2. Shall be preprinted using a mechanical means of printing (e.g., laser printer).
3. Where used for cable marking, provide vinyl substrate with a white printing area and a clear "tail" that self laminates the printed area when wrapped around the cable. If cable jacket is white, provide cable label with printing area that is any other color than white, preferably orange or yellow – so that the labels are easily distinguishable.
4. Where insert type labels are used provide clear plastic cover over label.
5. Provide plastic warning tape 6 inches wide continuously printed and bright colored 18" above all direct buried services, underground conduits and duct-banks.
6. Acceptable Manufacturers:
 - a. Panduit
 - b. Silver Fox
 - c. W.H. Brady
 - d. d-Tools
 - e. Brother
 - f. Dymo
 - g. Epson

2.04 ADMINISTRATION

- A. Administration of the documentation shall include test results of each Permanent Link.
- B. The test result information for each link shall be recorded in the memory of the field-test instrument upon completion of the test.
- C. The test result records saved within the field-test instrument shall be transferred into a Windows-based and/or cloud-based database utility that allows for the maintenance, inspection and archiving of these test records.
- D. The test result records saved within the field-test instrument shall be transferred to LinkWare PC via LinkWare Live.
- E. Alien Crosstalk measurements shall be stored to a PC upon completion of the test.

PART 3 - EXECUTION

3.01 SCHEDULING

- A. Schedule both the Engineer of Record and a representative of the test equipment manufacturer for a demonstration of testing methods. Execute a demonstration of testing methods with aforementioned parties prior to 'production' testing activities. Test reports and acceptance testing will not be accepted without proof of methods demonstration.

3.02 FIELD QUALITY CONTROL

- A. Complete testing as delineated below prior to system acceptance.
- B. Permanently record all test results and presented in a format acceptable to the Owner or Engineer before system acceptance.
- C. Remove and replace with new, at no cost to the Owner, any cables or conductors (copper or glass) failing to meet the indicated standards. The Owner will not accept the installation until testing has indicated a 100% availability of all cables and conductors or the Owner has approved any deviation from this requirement.
- D. Calibrate test sets and associated equipment per the manufacturers printed instructions at the beginning of each day's testing and after each battery charge. Fully charge the test sets prior to each day's testing to ensure proper operation.

3.03 "PRE-INSTALLATION" CONTINUITY TESTING PROCEDURES

- A. Reports from "pre-installation" continuity testing are not required to be submitted at project close out.

3.04 BALANCED TWISTED PAIR CABLE TESTING

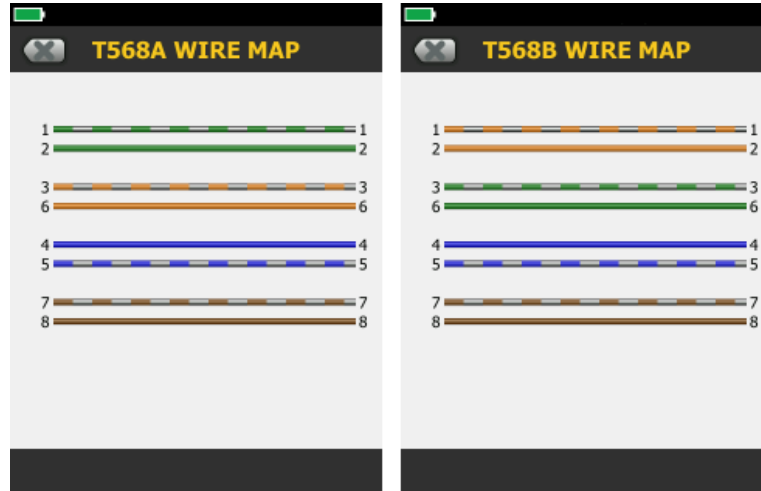
- A. Precautions:
 - 1. Adhere to the equipment manufacturer's instructions during all testing.
 - 2. Prior to any testing activity or any measurements taken, ensure the test equipment is at room temperature - approximately 70°F (e.g., if necessary, bring the test equipment in from outdoors and let it set for about 15 minutes or for however long it takes to bring the test equipment to reach room temp).
 - 3. Fully charge power sources before each day's testing activity

- B. Field-test instruments shall have the latest firmware installed.
- C. Permanent Link test results, including the individual frequency measurements from the tester, shall be recorded in the test instrument upon completion of each test for subsequent uploading to LinkWare PC via LinkWare Live in which the administrative documentation (reports) may be generated.
- D. Permanent Link testing shall be performed on each cabling segment (connector to connector). Sampling is not acceptable.
- E. Alien Crosstalk testing shall be performed using a sampling plan. An acceptance quality level (AQL) of 0,4 %, normal inspection, general inspection level I as defined in ISO 2859-1 for populations of up to 500,000 links shall be used. The following table represents this sampling level.

Total number of links (N)	Sample size (No. of links to test)
3 – 33	3 or 0.1 x N (Whichever is greatest)
34 – 3,200	33
3,201 – 35,000	126
35,001 – 150,000	201
150,001 – 500,000	315

- F. Disturbed (Victim) links chosen for Alien Crosstalk testing shall be an equal combination of short, medium and long links.
- G. Permanent Link adapters made from twisted pair Category 5e, 6, 6A, 7 or 7A cords are not permitted as their performance degrades with use and can cause false Return Loss failures.
- H. The installer shall build a reference link. All components shall be anchored so it is not possible to disturb them. The technician is to conduct a Category 6A Permanent Link test each day to ensure no degradation of the tester or its Permanent Link adapters.
- I. Wire Map Measurement
 - 1. The wire map test is intended to verify pin-to-pin termination at each end and check for installation connectivity errors.
 - 2. For each of the eight conductors in the cabling, the wire map indicates:
 - a. Continuity to the remote end
 - b. Shorts between any two or more conductors
 - c. Reversed pairs
 - d. Split pairs
 - e. Transposed pairs
 - f. Distance to open on shield
 - g. Any other miss-wiring
 - 3. The correct connectivity of telecommunications outlets/connectors is defined in ANSI/TIA-568-C.2. Two color schemes are permitted. The user shall define which scheme is to be used. The field tester shall document which color scheme was used.

4. Examples are given below:



J. Length Measurement

1. The length of each balanced twisted pair shall be recorded.
2. Since physical length is determined from electrical length, the physical length of the link calculated using the pair with the shortest electrical delay shall be reported and used for making the pass or fail determination.
3. The pass or fail criteria is based on the maximum length allowed for the Permanent Link as specified in ANSI/TIA-568-C.2 plus the nominal velocity of propagation (NVP) uncertainty of 10%. For a Permanent Link, the length measurement can be 325 ft. (99 m) before a fail is reported.

K. Propagation Delay measurement

1. Is the time it takes for a signal to reach the end of the link.
2. The measurement shall be made at 10 MHz per ANSI/TIA-1152.
3. The propagation delay of each balanced twisted pair shall be recorded.
4. Is not to exceed 498 ns per ANSI/TIA-568-C.2 Section 6.3.18.

L. Delay Skew measurement

1. Is the difference in propagation delay @ 10 MHz between the shortest delay and the delays of the other wire pairs.
2. The delay skew of each balanced twisted pair shall be recorded.
3. Is not to exceed 44 ns per ANSI/TIA-568-C.2 Section 6.3.19.

M. DC Loop Resistance

1. Often reported as Resistance, is the DC loop resistance of both conductors in the pair.
2. The DC Resistance shall be reported for all four pairs.
3. Is not to exceed 21 Ω for all four pairs per ANSI/TIA-568-C.2 Section 6.3.1.

N. DC Resistance Unbalance within a pair

1. Is the difference in DC resistance of the two wires within the same pair.
2. The DC Resistance Unbalance within a pair shall be reported for all four pairs.
3. Is not to exceed 200 m Ω or 3%, whichever is the greatest per ANSI/TIA-568-C.2 Section 6.2.2.

O. DC Resistance Unbalance between pairs

1. Is the difference in DC parallel resistance of the conductors of a pair compared to the DC parallel resistance of another pair, given in the formula below:
2. The DC Resistance Unbalance shall be reported for the following pairs
 - a. 1,2-3,6
 - b. 1,2-4,5
 - c. 1,2-7,8
 - d. 3,6-4,5
 - e. 3,6-7,8
 - f. 4,5-7,8
3. Is not to exceed 200 mΩ or 7.5%, whichever is the greatest.

P. Insertion Loss

$$Resistance_Unbalance_{Between_pairs} = \left(\frac{|R_{P1} - R_{P2}|}{R_{P1} + R_{P2}} \right) 100\%$$

Where:

R_{P1} is the DC parallel resistance of the conductors of a pair.

R_{P2} is the DC parallel resistance of the conductors of another pair.

1. Is the loss of signal strength over the cabling (in dB).
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in one direction for all four pairs.
4. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.7.

Q. NEXT (Near-End Crosstalk)

1. Is the difference in amplitude (in dB) between a transmitted signal and the crosstalk received on other wire pairs at the same end of the cabling.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for the following pair combinations
 - a. 1,2-3,6
 - b. 1,2-4,5
 - c. 1,2-7,8
 - d. 3,6-4,5
 - e. 3,6-7,8
 - f. 4,5-7,8
4. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.8.
5. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
6. The Time Domain Xtalk data shall be stored for any marginal or failing NEXT results.

R. PS NEXT (Power Sum Near-End Crosstalk)

1. Is the difference (in dB) between the test signal and the crosstalk from the other pairs received at the same end of the cabling.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.9.
5. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
6. The Time Domain Xtalk data shall be stored for any marginal or failing PS NEXT results.

S. ACR-N (Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for the following pairs
 - a. 1,2-3,6
 - b. 1,2-4,5
 - c. 1,2-7,8
 - d. 3,6-4,5
 - e. 3,6-7,8
 - f. 4,5-7,8
4. Although not specified in ANSI/TIA-568-C.2, it shall be recorded for all twelve possible combinations.

T. PS ACR-N (Power Sum Attenuation Crosstalk Ratio Near-End)

1. Is a calculation of PS NEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Although not specified in ANSI/TIA-568-C.2, it shall be recorded for all eight possible combinations.

U. ACR-F (Attenuation Crosstalk Ratio Far-End)

1. Is a calculation of FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz

3. Both worst case and worst margins shall be reported in both directions for the following pairs
 - a. 1,2-3,6
 - b. 1,2-4,5
 - c. 1,2-7,8
 - d. 3,6-1,2
 - e. 3,6-4,5
 - f. 3,6-7,8
 - g. 4,5-1,2
 - h. 4,5-3,6
 - i. 4,5-7,8
 - j. 7,8-1,2
 - k. 7,8-3,6
 - l. 7,8-4,5
4. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.11.
5. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

V. PS ACR-F (Power Sum Attenuation to Crosstalk Ratio Far-End)

1. Is a calculation of PS FEXT minus Insertion Loss of the disturbed pair in dB.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.13.
5. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).

W. Return Loss

1. Is the difference (in dB) between the power of a transmitted signal and the power of the signals reflected back.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Shall be ignored at all frequencies where the Insertion Loss is less than 3 dB for that pair.
5. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.6.
6. Reported margins found to be within the accuracy of the field tester shall be marked with an asterisk (*).
7. The Time Domain Reflectometer data shall be stored for any marginal or failing Return Loss results.

X. TCL (Transverse Conversion Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the near-end on the same wire pair.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz

3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Is not to exceed the Category 6A limits found ANSI/TIA-568-C.2 Section 6.2.14.

Y. ELTCTL (Equal Level Transverse Conversion Transfer Loss)

1. Is the ratio (in dB) between a differential mode signal inject at the near-end and the common-mode signal measured at the far end on the same wire pair minus the Insertion Loss of that pair.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Both worst case and worst margins shall be reported in both directions for all four pairs.
4. Is not to exceed the Category 6A limits found in ANSI/TIA-568-C.2 section 6.2.16.

Z. PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Takes into account the combined alien crosstalk (statistical) on a receive pair from all external near-end disturbers operating simultaneously.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. The disturbed (victim) link shall have disturber links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links
5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.21.

AA. Average PS ANEXT (Power Sum Alien Near-End Crosstalk)

1. Is calculated by averaging the individual PSANEXT loss values, in dB, for all four pairs in the disturbed (victim) link.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.22.

BB. PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. AFEXT loss is the coupling of crosstalk at the far-end from external link pairs into a disturbed (victim) pair of the 4-pair link under test. PS AACR-F is the calculated power sum from all external pairs into the disturbed (victim) pair.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz

3. The disturbed (victim) link shall have disturber links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links
5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.25.

CC. Average PS AACR-F (Power Sum Alien Attenuation to Crosstalk Ratio Far-End)

1. Is calculated by averaging the individual PS AACR-F values, in dB, for all four pairs in the disturbed (victim) link.
2. The frequency resolution shall be:
 - a. 1 – 31.25 MHz: 150 kHz
 - b. 31.25 – 100 MHz: 250 kHz
 - c. 100 – 250 MHz: 500 kHz
 - d. 250 – 500 MHz: 1000 kHz
3. The disturbed (victim) link shall have disturber links to the left and right of it and if present, links above and below it.
4. Disturber cables shall include all links within the same bundle as the disturbed (victim) link and adjacent links
5. Should be measured in both directions if the link is patch panel to patch panel. If the link is patch panel to telecommunications outlet, then it shall be measured from the patch panel end only.
6. Is not to exceed the Category 6A Permanent Link limits found in ANSI/TIA-568-C.2 Section 6.3.26.

DD. Administration

1. Test results documentation
 - a. The Permanent Link test results (excluding alien xtalk testing) shall be uploaded to LinkWare Live at the end of each working day for inspection by the Owner or the Owner's representative.
 - b. Test results uploaded to LinkWare Live shall be transferred into LinkWare PC to allow for the maintenance, inspection and archiving of the test records.
 - c. The database for the complete project shall be stored in LinkWare PC format (*.flw) and delivered on CD or DVD prior to Owner acceptance of the building. This CD or DVD shall include a copy of LinkWare PC to allow the inspection and printing of the test reports.
 - d. Circuit IDs reported by the test instrument should match the specified label ID (see 2.2 of this Section).
 - e. For Permanent Link testing, the detailed test results documentation data is to be provided in LinkWare PC for each tested balance twisted-pair and shall contain the following information
 - 1) Measured values of minimum requirements.
 - 2) The overall Pass/Fail evaluation of the link-under-test
 - 3) The date and time the test results were saved in the memory of the tester
 - 4) The identification of the customer site as specified by the end-user
 - 5) The name of the test limit selected to execute the stored test results
 - 6) The name of the personnel performing the test
 - 7) The version of the test firmware and the version of the test limit database held within the test instrument
 - 8) The manufacturer, model and serial number of the field-test instrument
 - 9) The adapters used
 - 10) The factory calibration date
 - 11) Wire Map
 - 12) Propagation Delay values, for all four pairs
 - 13) Delay Skew values, for all four pairs
 - 14) DC Resistance values, for all four pairs
 - 15) DC Resistance Unbalance within a pair, values for all four pairs

- 16) DC Resistance Unbalance between pairs, values for all four pairs
 - 17) Insertion Loss, worst case values for all four pairs
 - 18) NEXT, worst-case margin and worst-case values, both directions
 - 19) PS NEXT, worst-case margin and worst-case values, both directions
 - 20) ACR-N, worst-case margin and worst-case values, both directions
 - 21) PS ACR-N, worst case margin and worst-case values, both directions
 - 22) ACR-F, worst case margin and worst-case values, both directions
 - 23) PS ACR-F, worst case margin and worst-case values, both directions
 - 24) Return Loss, worst case margin and worst-case values, both directions
 - 25) TCL, worst case margin and worst-case values, both directions
 - 26) ELTCTL, worst case margin and worst-case values, both directions.
 - 27) Time Domain Crosstalk data if the link is marginal or fails
 - 28) Time Domain Reflectometer data if the link is marginal or fails
- f. For Alien Crosstalk testing, the detailed test results documentation data is to be provided in AxTalk Analyzer for each tested balance twisted-pair and shall contain the following information
- 1) The overall Pass/Fail evaluation of the link-under-test
 - 2) The date and time the measurements were made
 - 3) The identification of the customer site as specified by the end-user
 - 4) The name of the test limit selected to execute the stored test results
 - 5) The name of the personnel performing the test
 - 6) The version of the test software
 - 7) PS ANEXT, worst case margin for all four pairs
 - 8) Average PS ANEXT, worst case margin
 - 9) PS AACR-F, worst case margin for all four pairs
 - 10) Average PS AACR-F, worst case margin

END OF SECTION 27 0800

SECTION 27 1100 - COMMUNICATIONS EQUIPMENT ROOM FITTINGS AND GROUNDING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division-01 Specification sections, apply to work of this section.
- B. Requirements of the following Division 27 Sections apply to this section:
 - 1. Division 27 Section 27 0100 "Basic Communications System Requirements".

1.02 SUMMARY

- A. This section includes the following:
 - 1. Racks
 - 2. Cabinets
- B. This Section includes solid grounding of communications systems and equipment. It includes basic requirements for grounding for protection of life, equipment, circuits, and systems. Grounding requirements specified in this Section may be supplemented in other sections of these Specifications.
- C. The Electrical Contractor shall be responsible for grounding equipment provided in the Electrical Contract, HVAC Contract, Plumbing Contract, and General Contract.
- D. The Communication Contractor shall be responsible for proper grounding of all racks, cabinets, and active components as shown on the Drawings and as specified herein.

1.03 SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Product data for connectors and connection materials, and grounding fittings.
- C. Field testing organization certificate, signed by the Contractor, certifying that the organization performing field tests complies with the requirements specified in Quality Assurance below.
- D. Report of field tests and observations certified by the testing organization.

1.04 QUALITY ASSURANCE

- A. Manufacturers: Firms regularly engaged in manufacture of electrical connectors, terminals and fittings of types and ratings required, and ancillary grounding materials, including stranded cable, copper braid and bus, whose products have been in satisfactory use in similar service for not less than 3 years.
- B. Installer: Qualified with at least 3 years of successful installation experience on projects with communications grounding work similar to that required for project.

- C. Listing and Labeling: Provide products specified in this Section that are listed and labeled. The terms "listed" and "labeled" shall be defined as they are in the National Electrical Code, Article 100.
 - 1. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" (NRTL) as defined in OSHA Regulation 1910.7.
- D. Field Testing Organization Qualifications: To qualify for acceptance, the independent testing organization must demonstrate, based on evaluation of organization-submitted criteria conforming to ASTM E 699, that it has the experience and capability to conduct satisfactorily the testing indicated.
- E. Electrical Component Standard: Components and installation shall comply with NFPA 70, "National Electrical Code" (NEC).
- F. UL Compliance: Comply with applicable requirements of UL Standards Nos. 467 and 869 pertaining to grounding and bonding.
- G. IEEE Compliance: Comply with applicable requirements of IEEE Standard 142 and 241 pertaining to grounding.

1.05 DESCRIPTION OF WORK

- A. The Communications Contractor shall furnish and supply all equipment, including but not limited to, equipment racks, cabinets, mounting hardware, and all associated equipment necessary to provide a complete and operating system.
- B. All bids shall be based on equipment as specified herein. All alternate equipment must be approved ten (10) days prior to bid date. Adequate information must be made available for a evaluation and approval of alternate equipment.
- C. Contractor shall furnish a manufacturer's manual of the completed system including individual specification sheets, schematics, inter-panel and intra-panel wiring diagrams. In addition, all information necessary for the proper maintenance and operation of the system must be included. Any bidder using other than the specified equipment must provide this information prior to bidding. All published specifications of the manufacturers of equipment specified shall be considered as being a part of this specification, even though they have not been included in detail.
- D. As-built drawings that include any changes to wiring, wiring designations, junction box labeling and any other pertinent information shall be supplied upon completion of project. Refer to Section 270100 "Basic Communications System Requirements" for additional requirements.
- E. Wire management shall be in accordance with the recommended practices as established by BISC1.
- F. All equipment installation and wiring shall meet all requirements of manufacturer.

1.06 COORDINATION

- A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and services suppliers. Coordinate service entrance arrangement with local exchange carrier.
 - 1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
 - 2. Record agreements reached in meetings and distribute to other participants.
 - 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in in rooms to accommodate and optimize arrangement and space requirements of the telephone switch and LAN equipment.

4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.
- B. Coordinate location of power raceways and receptacles with location of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.01 COMMUNICATION ROOM EQUIPMENT

- A. Manufacturers: Provide products manufactured by Panduit or one of the following approved manufacturers.
1. Panduit
 2. Legrand
 3. Cooper B-Line
 4. Hoffman nVent
- B. Provide the following equipment, including but not limited to, the purchase, delivery, unpacking, installation, connection, testing, and operation of the same.
- C. The quantities of items required shall be as shown on the drawings, or as stated below. Where a conflict exists between the quantities shown on the drawings, and the quantities stated hereinafter, the greater of the two quantities shall be used.
- D. 4 Post Floor Rack
1. Manufacturer/Model No.: Hoffman E4SDR19FM45U or approved equal.
 2. Requirements:
 - a. Unit shall be standard 24" width by 84" high with adjustable depth
 - b. Unit shall be painted black
 3. Accessories:
 - a. Include all accessories shown on details and the following:
 - 1) Vertical Cable Management: WMPV45E
 - 2) Horizontal Cable Management: WMPFSE
 - 3) Vertical PDU: P16B08M
 - 4) Stationary shelf: RSHLF36
 - 5) Anchoring Kit: RFAKIT
 - 6) Cage Nuts & Screws (100 count): CNWS1223-C
 - 7) Provide engraved label at top center of rack indicating rack number.
- E. Electrostatic Discharge Kit
1. Manufacturer/Model No.: Panduit Corporation, part no. RGESE-1 approved equal.
 2. Description: One-hole barrel lug, angled at 45-degrees, permanently marked with protective earth (ground) symbol, designated to accommodate a 4mm ESD wrist strap plug. Kit shall include an antioxidant compound, and one #12-24x 1/2" threaded-forming screw.
 3. Quantity: Provide one kit for each Telecommunications Closet or wall cabinet.

F. Ladder Rack

1. Description: 12" wide ladder rack.
2. Manufacturer/Model No.: B-Line, SB17T12B or approved equal.
3. Requirements:
 - a. Provide ladder rack extending from cable tray to each equipment rack or wall cabinet.
 - b. Provide ladder rack extending from cable tray to each free-standing rack.
 - c. Ladder Rack shall have 9" rung spacing. Secure ladder rack to rack and cable tray.
 - d. Ladder rack shall be painted black.
4. Accessories:
 - a. Hardware
 - 1) Provide mounting and wire management accessories for a complete and neat installation.

PART 3 - EXECUTION

3.01 GENERAL

- A. Except as otherwise indicated, provide electrical grounding systems indicated; with assembly of materials, including, but not limited to, cables/wires, connectors, terminals (solderless lugs), bonding jumper braid, surge arresters, and additional accessories needed for complete installation. Where more than one type unit meets indicated requirements selection is Installer's option. Where materials or components are not indicated, provide products complying with NEC, UL, IEEE, and established industry standards for applications indicated.

3.02 INSPECTION

- A. Installer must examine areas and conditions under which grounding connections are to be made and notify the Architect in writing of conditions detrimental to proper completion of work. Do not proceed with work until unsatisfactory conditions have been corrected in an acceptable manner.

3.03 APPLICATION

- A. Provide grounding systems where shown, in accordance with applicable portions of NEC, with NECA's "Standard of Installation" and in accordance with recognized industry practices to ensure that products comply with requirements and serve intended functions.

3.04 INSTALLATION

- A. General: Ground communications systems and equipment in accordance with NEC requirements except where the Drawings or Specifications exceed NEC requirements.
- B. Coordinate with other electrical work as necessary to interface installation of communication system grounding system with other work.
- C. Route grounding conductors along the shortest and straightest paths possible without obstructing access or placing conductors where they may be subjected to strain, impact, or damage, except as indicated.

3.05 BACKBOARDS

- A. Equipment backboards shall be mounted on all walls from 6" AFF to 8'-6" AFF. Backboards shall be mated to each other so that no gap between boards is more than 1/4".
- B. Backboards shall be securely mounted to the existing walls. If attached to masonry walls, expandable anchors shall be used to secure the plywood to the walls. Backboards attached to studded walls shall have screws that penetrate the studs to provide secure attachment. If there is plywood backing in the wall, screws that penetrate the backing material can be used in lieu of penetrating the studs.

3.06 EQUIPMENT INSTALLATION

- A. Install equipment racks with manufacturer approved installation hardware. All equipment racks shall be securely bolted to the floor with four bolts.
- B. Equipment racks shall be supported at the top of the rack using cable tray, cable runway or supports attached to the wall. These supporting devices shall add rigidity to the rack for ease in working on equipment mounted in the rack.
- C. Equipment cabinets shall be assembled and secured as recommended by the manufacturer. All doors, panels and equipment shall be securely mounted to the equipment cabinet by means of fasteners designed to fasten these devices.
- D. All equipment cabinets and racks shall be grounded to the grounding bus bar with individual #6 AWG grounding conductors. Comply with requirements in Division 26 Section 260526 "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- E. Label all equipment racks and cabinets to meet the requirements of TIA/EIA-60

3.07 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. Comply with ANSI-J-STD-607-A.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum 3/0 AWG grounding electrode conductor from grounding bus bar to suitable
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.
- E. Fasteners for grounding lugs shall be machine screws with either nuts or tapped holes for securing the grounding lug to the equipment to be grounded. Self-tapping screws are not acceptable for grounding connections.
 - 1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.08 CONNECTIONS

- A. General: Make connections in such a manner as to minimize possibility of galvanic action or electrolysis. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact will be galvanically compatible.

1. Use electroplated or hot-tin-coated materials to assure high conductivity and make contact points closer in order of galvanic series.
 2. Make connections with clean bare metal at points of contact.
 3. Coat and seal connections involving dissimilar metals with inert material such as red lead paint to prevent future penetration of moisture to contact surfaces.
- B. Tighten grounding and bonding connectors and terminals, including screws and bolts, in accordance with manufacturer's published torque tightening values for connectors and bolts. Where manufacturer's torquing requirements are not indicated, tighten connections to comply with torque tightening values specified in UL 486A and UL 486B.

3.09 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems". Comply with requirements in Division 09 Interior Painting for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- B. See Division 27 Section 27 1500 "Communications Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section.

3.10 FIELD QUALITY CONTROL

- A. Upon Completion of installation of communications grounding systems, test ground resistance with ground resistance tester. Where tests show resistance to ground is over 3 ohms, take appropriate action to reduce resistance to 3 ohms, or less, by driving additional ground rods and/or by chemically treating soil encircling ground rod; then retest to demonstrate compliance.
- B. Independent Testing Organization: Arrange and pay for the services of a qualified independent electrical testing organization to perform tests described below.
- C. Tests: Subject the completed grounding system to a megger test at each location where a maximum ground resistance level is specified, at service disconnect enclosure ground terminal.
- D. Ground/resistance maximum values shall be as follows:
1. Equipment rated 500 kVA and less: 10 Ohms
- E. Deficiencies: Where ground resistances exceed specified values, and if directed, modify the grounding system to reduce resistance values. Where measures are directed that exceed those indicated the provisions of the Contract, covering changes will apply.
- F. Report: Prepare test reports, certified by the testing organization, of the ground resistance at each test location. Include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.

3.11 COMMUNICATION ROOM EQUIPMENT TESTING

- A. Before final acceptance of the installation, the contractor shall test in the presence of the Architect/Engineer/Owner or their representative's the complete installation and show that the system is completely operational and free from unwanted grounds, shorts, breaks, etc. The Contractor shall obtain all equipment required to test the final installation. The testing of the system shall be made under the direct supervision of the equipment manufacturers or their designated representative.

- B. The Contractor shall provide a one-year guarantee of the installed system against defects in material and workmanship. All labor and materials shall be provided at no expense to the Owner. Guarantee period shall begin on the date of acceptance by the Architect/Engineer/Owner.

END OF SECTION 27 1100

SECTION 27 1500 - COMMUNICATIONS CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- B. Requirements of the following Division 27 Sections apply to this section:
 - 1. Division 27 Section 27 0100 "Basic Communications System Requirements".

1.02 SUMMARY

- A. Section Includes:
 - 1. UTP cabling.
 - 2. Cable connecting hardware, patch panels, and cross-connects.
 - 3. Telecommunications outlet/connectors.
 - 4. Cabling system identification products.
- B. Related Requirements:
 - 1. Section 27 0800 "Commissioning of Communications" for testing requirements.
- C. Intent:
 - 1. It is the intent of this section for the Contractor to provide a complete workable cabling system ready for the Owner's use in accordance with TIA 568-C standards to support high speed data applications up to and in excess of 1000Mbps including IEEE system standards based on Twisted Pair Distributed Data Interface (TPDDI), Ethernet, Fast Ethernet, Gigabit Ethernet and Asynchronous Transmission Mode (ATM).
- D. Related Work to be provided by the Owner or their Representative:
 - 1. Installation of workstation devices: computers, terminals, telephones, and similar equipment.
 - 2. Installation of patch cords or cross connect wire to connect workstation devices to network equipment and backbones.

1.03 DEFINITIONS

- A. Utilize the following abbreviations for the Drawings and Specifications:
 - 1. "PROVIDE" means to supply, purchase, transport, place, erect, connect, test and turn over to Owner, complete and ready for regular operation, the work referred to.
 - 2. "FURNISH" means to purchase, procure, acquire, and deliver complete with related accessories.
 - 3. "INSTALL" means to move from property line, set in place, join, fasten, attach, set up or otherwise connect together before testing and turn over to the Owner. Installation is to be complete and ready for regular operation.
 - 4. "WIRING" or "CABLING" includes the furnishing of all fittings, conductors, connectors, grounding accessories, tape, connections, splices, labeling, and all other items necessary for such work.
 - 5. "CONDUIT" and "CABLE SUPPORTS" include furnishing of all fittings, hangers, supports, sleeves, grounding etc.,
 - 6. "AS DIRECTED" means as directed by the Owner or their representative.
 - 7. "ACCEPTED" means as accepted by the Owner or their representative.

8. "CONCEALED" means embedded in masonry or other construction, installed behind wall furring or within double partitions, or installed above hung ceilings.
9. "EXPOSED" means not installed underground or "CONCEALED" as defined above.
10. "EQUAL" means equivalent as approved by the Owner or their representative.
11. "CONSOLIDATION POINT" shall mean a location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.
12. "CROSS-CONNECT" shall mean a facility enabling the termination of cable elements and their interconnection or cross-connection.
13. "MUTOA" shall mean a grouping in one location of several telecommunications' outlet/connectors.
14. "OUTLET/CONNECTORS" shall mean a connecting device in the work area on which horizontal cable or outlet cable terminates.

1.04 ABBREVIATIONS

A. Utilize the following abbreviations for the Drawings and Specifications:

- | | | |
|-----|-------|--|
| 1. | ANSI | American National Standards Association |
| 2. | ASA | American Standards Association |
| 3. | ASTM | American Society of Testing Materials |
| 4. | BICSI | Building Industry Consulting Service International |
| 5. | EC | Electrical Contractor |
| 6. | EIA | Electronic Industries Association |
| 7. | EMI | Electromagnetic interference |
| 8. | FCC | Federal Communications Commission |
| 9. | ICEA | International Cable Engineers Association |
| 10. | IDC | Insulation displacement connector |
| 11. | IEEE | Institute of Electrical and Electronic Engineers |
| 12. | LAN | Local area network |
| 13. | NEC | National Electrical Code |
| 14. | NEMA | National Electrical Manufactures Association |
| 15. | NFPA | National Fire Protection Association |
| 16. | OEM | Original Equipment Manufacturers |
| 17. | OSHA | Occupational Safety and Health Act |
| 18. | RCDD | Registered Communications Distribution Designer |
| 19. | TDC | Teledata Contractor |
| 20. | TMGB | Telecommunication Main Ground Bus. |
| 21. | TGB | Telecommunication Ground Bus |
| 22. | TIA | Telecommunications Industries Association |
| 23. | UL | Underwriters' Laboratories, Inc. |
| 24. | UTP | Unshielded twisted pair |

1.05 ADMINISTRATIVE REQUIREMENTS

- A. Coordinate layout and installation of telecommunications cabling with Owner's telecommunications and LAN equipment and service suppliers.
- B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.06 ACTION SUBMITTALS

- A. General: Submit the following in accordance with Conditions of Contract and Division 01 Specification Sections.
- B. Submittals shall be made as complete systems including all required accessories and special installation tools (i.e., termination hardware).

- C. Provide information regarding all terminations that will be required to complete this installation. This information shall include complete specifications and installation instructions.
- D. Product data for each type of product.
 - 1. Provide manufacturer's product data sheets for the following equipment:
 - a. Patch Panels (UTP, etc.)
 - b. Data and Voice Jacks
 - c. Faceplates
 - d. Cable (UTP, etc.)
 - e. Patch cords
 - f. Cable Management Devices
 - g. Labeling
 - h. All other equipment identified or inferred. Submit complete list for Engineer/Owner approval.
 - 2. Provide manufacturer's installation data for all cabling, include the following for each type used:
 - a. Nominal OD.
 - b. Minimum bend radius.
 - c. Maximum pulling tension.
 - d. Recommended installation pulling points. (i.e. every 180 degrees of bend in the raceway, or every 100 feet of raceway)
 - e. Recommended pulling lubricants.
 - 3. Provide manufacturer's performance data for UTP cabling, include the following for each type used:
 - a. DC Resistance
 - b. Characteristic Impedance
 - c. Attenuation
 - d. Near-end Crosstalk (NEXT)
 - e. Far-end Crosstalk (FEXT)
 - f. Nominal Velocity of Propagation and Propagation Delay
 - g. Attenuation to Crosstalk Ratio (ACR)
 - h. Return Loss
 - i. Delay skew

1.07 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For installers, qualified layout technicians, installation supervisor, and field inspector.
- B. Source quality control reports.
- C. Field quality control reports.

1.08 CLOSEOUT SUBMITTALS

- A. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
- B. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
- C. Cabling administration drawings and printouts.
- D. Wiring diagrams to show typical wiring schematics, including the following:
 - 1. Cross-connects.
 - 2. Patch panels.
 - 3. Patch cords.
- E. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
- F. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.09 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. Patch-Panel Units: One of each type.
 - 2. Jacks: Ten of each type.
 - 3. Device Plates: One of each type.

1.10 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. A Certification Warranty shall provide a warranty to guarantee end-to-end high performance cabling systems that meet application requirements. The guarantee shall include cable and connectivity components and have one point of contact for all cabling system issues. The system shall be warranted for a period of at least 20 years. Unless otherwise noted all following sections, which describe such actions, tasks, and responsibilities refer to the Contractor.
 - a. A manufacturer trained and certified contractor shall complete network installation. A copy of the Contractor certification shall be submitted in the proposal.
 - b. A manufacturer trained and certified contractor shall have a Superintendent on the job with at least 10 years of experience.
 - c. A manufacturer trained and certified contractor shall have at least one BICSI RCDD on staff locally.
 - 2. Layout Responsibility: Preparation of Shop Drawings by an RCDD.
 - 3. Installation Supervision: Installation shall be under the direct supervision of Level 2 Installer, who shall be present at all times when Work of this Section is performed at Project site.
 - 4. Testing Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- B. Testing Agency Qualifications: A Nationally Recognized Test Laboratory (NRTL).
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- C. Comply with the following Electronic Industries Association (EIA) and Telecommunications Industry Association (TIA) Standards:

1. ANSI/TIA 568.1-D "Commercial Building Telecommunications Wiring Standard"
 2. ANSI/TIA568-C.2 "Balanced Twisted-Pair Telecommunications Cabling and Components Standard"
 3. ANSI/TIA 569-D, " Telecommunications: Pathways and Spaces "
 4. ANSI/TIA 606-B, " Administration Standard for Commercial Telecommunications Infrastructure "
 5. EIA 258, "Semi Flexible Air Dielectric Coaxial Cables and Connectors, 50 Ohms."
- D. UL Compliance: Comply with applicable requirements of UL Standard 910 "Test Method for Fire and Smoke Characteristics of Cables Used in Air Handling Spaces." Provide products that are UL listed and labeled for such use.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Deliver cable factory packaged in containers or reels. Store in clean dry space and protect products from damaging fumes and traffic. Handle wire and cable carefully to avoid damage.
- B. If cables are stored below 32°F bring cable indoors and store at room temperature 68°F for 48 hours prior to installation.
- C. The Telecommunications Contractor shall ensure that the General Contractor and Painting Contractor acknowledge that painting of or over spray any single or group of 4 pair horizontal telecommunications Category 5e, Category 6 or Category 6a or backbone cable is not allowed. Any painted or over sprayed cable(s) shall be replaced at the painting contractor's expense. Painted Cable will not be covered as part of an extended warranty. Painted cable in addition to obscuring the print legend may act as an accelerant or create an additional smoke hazard in the event of a fire and as such this is considered a life safety issue.
- D. Test cables upon receipt at Project site.
1. Test each pair of UTP cable for open and short circuits.

1.12 WARRANTY/WARRANTY MANUALS

- A. Warranty and Certification of the Structural Cabling System:
1. The Contractor shall provide a minimum twenty-year product and performance warranty that all cable, connectors, and connecting hardware shall be free from defects in material, workmanship and fabrication.
 2. The system shall be certified by the cable/component manufacturer and warranted for the specified performance for a minimum of twenty years. The Contractor shall conform to the manufacturer's certification program including submittal of all required documentation to the manufacturer.
 3. The Contractor shall obtain, from the manufacturer, a Registration Document and Certificate for the specific installation. Upon receipt of the Registration Document and Certificate, the Contractor shall forward a copy to the Engineer and deliver the original to the Owner.
- B. Provide complete warranty information for each item to include date of beginning of warranty, names, addresses, telephone numbers, and procedures for filing a claim to obtain warranty service.
- C. Within the warranty period, answer service calls within eight hours, and correct the deficiency within twenty-four hours.

PART 2 - PRODUCTS

2.01 HORIZONTAL CABLING DESCRIPTION

- A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called a "permanent link," a term that is used in the testing protocols.

1. TIA-568-D requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
 2. Horizontal cabling shall contain no more than one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
 3. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. A work area is approximately 100 square feet., and includes the components that extend from the telecommunications outlet/connectors to the station equipment.
- C. The maximum allowable horizontal cable length is 295 feet. This maximum allowable length does not include an allowance for the length of 16 feet to the workstation equipment or in the horizontal cross-connect.

2.02 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with transmission standards in ANSI/TIA-568.1-D when tested according to test procedures of this standard.
- 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. Grounding: Comply with ANSI/TIA-607-C.

2.03 UTP CABLE, PATCH CORDS, AND HARDWARE

- A. Products - subject to compliance with requirements, provide products by Panduit/General Cable, or one of the following approved manufacturers:
1. 2.5Gb/s 100W POE Category 6 Long Range Solution (Refer to Telecom Outlet Schedule for Long Range Category Cable Quantity and Location)
 - a. Paige Datacom Solution:
 - 1) Plenum Cabling: 258300336
 - 2) Indoor/Outdoor: N/A
 - 3) OSP Cabling: 258320804
 - 4) Jacks/Patch Panels/Patch Cords: Use standard product from approved manufactures mentioned in paragraphs below.
 2. 10Gb/s Category 6A Solution
 - a. Mohawk/Belden
 - 1) Plenum Cabling: GigaLAN 10 CMP M58646
 - 2) Indoor/Outdoor: N/A
 - 3) OSP Cabling: LAN-Trak M59198

- 4) Jacks: 10GX AX102xxx
 - 5) Patch Panels: AX103121 (Modular, Flat)
 - 6) Patch Cords: CA2110x0xx
- b. General Cable/Panduit
- 1) Plenum Cabling: GenSPEED 10 MTP CMP
 - 2) Indoor/Outdoor: N/A
 - 3) OSP Cabling: N/A
 - 4) Jacks: Mini-Com TX6A CJ6X88TGxx
 - 5) Patch Panels: CPPL48WBLY (Modular, Flat)
 - 6) Patch Cords: UTP6Axx
- c. Superior Essex/Ortronics
- 1) Plenum Cabling: 10GainXP – 6H Series CMP
 - 2) Indoor/Outdoor: N/A
 - 3) OSP Cabling: 04-001-A4
 - 4) Jacks: Clarity OR-TJ6A
 - 5) Patch Panels: OR-401045292 (Modular, Flat)
 - 6) Patch Cords: OR-MC6Axx-xx
- d. CommScope
- 1) Plenum Cabling: CS44P
 - 2) Indoor/Outdoor: N/A
 - 3) OSP Cabling: 1592A
 - 4) Jacks: USL10G
 - 5) Patch Panels: CPP-UDDM-SL-1U-24 (Modular, Flat)
 - 6) Patch Cords: UNC10G
- B. Cabling: 100-ohm, four-pair UTP, binder groups covered with a thermoplastic jacket.
1. Color: Coordinate cable colors with owner prior to sending submittals.
 2. Comply with ICEA S-90-661 for mechanical properties.
 3. Comply with ANSI/TIA -568-C.2 for performance specifications.
 4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:
 - a. Communications, Plenum Rated: Type CMP, complying with NFPA 262.
- C. General Requirements for Cable Connecting Hardware: Comply with ANSI/TIA-568-C.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher. Cables shall be terminated T-568-B.
- D. Modular Patch Panels: Flush mount modular patch panels in 24 port 1U or 48 port 2U configuration equipped with rear mounted faceplates to allow jack modules to be flush with front of patch panel.
- E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.
1. Color: Jack colors shall be selected by IDF the cable originates from. Coordinate IDF color scheme with owner.
- F. Wall plates:
1. Typical for use in interior, dry locations: single and combination, of types, sizes, and with ganging and cutouts as indicated. Provide .04 inch thick, Type 302 brushed stainless steel flush cover plates.
 2. Faceplates shall accept modular 8 position/8 conductor information jacks.
 3. Faceplates for wall-mounted telephones to be stainless steel with single jack and integral phone mounting tabs.

- G. Patch Cords: Factory-made, four-pair cables in various lengths; terminated with eight-position modular plug at each end.
 - 1. Patch cords shall have bend-relief-compliant boots.
 - 2. Patch cords shall have latch guards to protect against snagging.
 - 3. Patch cord lengths shall be no longer than required for the application.

2.04 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA-568-C.1.
- B. Workstation Outlets: Two or Four port-connector assemblies mounted in single or multi-gang faceplate.
 - 1. Metal Faceplate: Stainless steel, complying with requirements in Section 26 2726 "Wiring Devices."
 - 2. Legend: Factory labeled by silk-screening or engraving for stainless steel faceplates.

2.05 GROUNDING

- A. Comply with requirements in Section 27 0526 "Grounding and Bonding for Communications System" for grounding conductors and connectors.
- B. Comply with ANSI/TIA-607.

2.06 IDENTIFICATION PRODUCTS

- A. Comply with requirements in Section 26 0553 "Identification for Electrical Systems."
- B. Comply with ANSI/TIA-606-B and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.07 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cables.
- B. Factory test UTP cables on reels according to ANSI/TIA-568.1-D.
- C. Factory test UTP cables according to ANSI/TIA-568-C.2.
- D. Cable will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

- A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS

- A. Install cables in pathways and cable trays except within consoles, cabinets, desks, and counters. Conceal pathways and cables except in unfinished spaces.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements in Section 27 0528 "Cable Trays for Communications Systems."
- B. Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
- C. Wiring within Enclosures:
 - 1. Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radius.
 - 2. Install lacing bars and distribution spools.
 - 3. Install conductors parallel with or at right angles to sides and back of enclosure.

3.03 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with ANSI/TIA-568.1-D.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Install 110-style IDC termination hardware unless otherwise indicated.
 - 4. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminal TIAs, cross-connects, and patch panels.
 - 5. Cables may not be spliced.
 - 6. Secure and support cables at intervals not exceeding 30 inches and not more than 6 inches from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
 - 7. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 8. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
 - 9. Do not install bruised, kinked, scored, deformed, or abraded cable. Do not splice cable between termination, tap, or junction points. Remove and discard cable if damaged during installation and replace it with new cable.
 - 10. Cold-Weather Installation: Bring cable to room temperature 68°F for 48 hours before dereeling. Heat lamps shall not be used for heating.
 - 11. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
 - 12. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
 - 1. Comply with ANSI/TIA-568-C.2.
 - 2. Do not untwist UTP cables more than 1/2 inch from the point of termination to maintain cable geometry.
- D. Open-Cable Installation:
 - 1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
 - 2. Suspend UTP cable not in a wireway or pathway at a minimum of 8 inches above ceilings by cable supports not more than 60 inches apart.
 - 3. Cable shall not be run through structural members, on structural members (including bottom flange of joists), or in contact with pipes, ducts, or other potentially damaging items.

- E. Group connecting hardware for cables into separate logical fields.
- F. Separation from EMI Sources:
 - 1. Comply with BICSI TDMM and ANSI/TIA-569-BD for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
 - 2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches.
 - 3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches.
 - 4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:
 - a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
 - b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches.
 - c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches.
 - 5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
 - 6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.04 FIRESTOPPING

- A. Comply with requirements in Section 07 8413 "Penetration Firestopping."
- B. Comply with ANSI/TIA-569-BD, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" article.

3.05 GROUNDING

- A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" chapter.
- B. Comply with ANSI/TIA-607-C.
- C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.
- D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.06 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with ANSI/TIA-606-B. Comply with requirements for identification specified in Section 26 0553 "Identification for Electrical Systems."
 - 1. Administration Class: 3.
 - 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.
- C. Comply with requirements in Section 09 9123 "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- D. Paint and label colors for equipment identification shall comply with ANSI/TIA-606-B for **Class 3** level of administration, including optional identification requirements of this standard.
- E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.
- F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets, backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of ANSI/TIA-606-B. Furnish electronic record of all drawings, in software and format selected by Owner.
- G. Cable and Wire Identification:
 - 1. Label each cable within 4 inches of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
 - 3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet.
 - 4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular devices as shown.
 - b. Label each unit and field within distribution racks and frames.
 - 5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.
- H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in ANSI/TIA-606-B.
 - 1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.07 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 the following tests and inspections with the assistance of a factory-authorized service representative:
 - 1. Visually inspect UTP cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with ANSI/TIA-568.1-D.
 - 2. Visually confirm Category 6A marking of outlets, cover plates, outlet/connectors, and patch panels.
 - 3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 4. Test UTP backbone copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.
 - a. Test instruments shall meet or exceed applicable requirements in ANSI/TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - 5. UTP Performance Tests:
 - a. Test for each outlet. Perform the following tests according to ANSI/TIA 568.1-D and ANSI/TIA-568-C.2:
 - 1) Wire map.
 - 2) Length (physical vs. electrical, and length requirements).
 - 3) Insertion loss.
 - 4) Near-end crosstalk (NEXT) loss.
 - 5) Power sum near-end crosstalk (PSNEXT) loss.
 - 6) Equal-level far-end crosstalk (ELFEXT).
 - 7) Power sum equal-level far-end crosstalk (PSELFEXT).
 - 8) Return loss.
 - 9) Propagation delay.
 - 10) Delay skew.
 - 6. Final Verification Tests: Perform verification tests for UTP systems after the complete communications cabling and workstation outlet/connectors are installed.
 - a. Voice Tests: These tests assume that dial tone service has been installed. Connect to the network interface device at the demarcation point. Go off-hook and listen and receive a dial tone. If a test number is available, make and receive a local, long distance, and digital subscription line telephone call.
 - b. Data Tests: These tests assume the Information Technology Staff has a network installed and is available to assist with testing. Connect to the network interface device at the demarcation point. Log onto the network to ensure proper connection to the network.
- D. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.

- F. The General Contractor shall ensure that the painting contractor does not paint or over spray any single 4 pair horizontal telecommunications Category 6 or cable. Any painted or over sprayed cable shall be replaced at the painting contractor's expense. Painted Cable will not be covered as part of an extended warranty.
- G. Prepare test and inspection reports.

3.08 DEMONSTRATION

- A. Train Owner's maintenance personnel in cable-plant management operations, including changing signal pathways for different workstations, rerouting signals in failed cables, and keeping records of cabling assignments and revisions when extending wiring to establish new workstation outlets.

END OF SECTION 27 1500

SECTION 27 4115 - AUDIOVISUAL SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The Drawings, Specifications, General Conditions, Supplementary Conditions and other requirements of Division 1, apply to the work specified in Division 27, and shall be complied with in every aspect. The Contractor shall examine the documents, which make up the Contract Documents and shall coordinate them with the work on the Technology Drawings and Division 27 of these specifications.

1.02 SUMMARY

- A. Provide labor and materials required to design, procure, deliver, install, test, train, commission, program and place into operation the audio and video systems as called for in the contract documents, and according to applicable codes and regulations.
- B. Furnish and install all labor, materials, apparatus, and appliances essential to the complete functioning of the systems described and/or indicated herein, or which may be reasonably implied as essential whether mentioned in the Contract Drawings and Specifications or not.
- C. System components included herein, but not limited to, the following:
 - 1. Faceplates and Back boxes
 - 2. Assistive Listening Equipment
 - 3. Equipment Racks
 - 4. Audio Infrastructure
 - 5. Microphones
 - 6. Wireless Microphone Systems
 - 7. Audio Digital Signal Processors
 - 8. Amplifiers and Speakers
 - 9. Controls
 - 10. Network Equipment
 - 11. Video Infrastructure
 - 12. Projectors and Projection Screens
 - 13. Wires and Cabling

1.03 CONTRACTOR QUALIFICATIONS

- A. All AV systems shall be actualized, installed and configured by the Electrical Contractor or a single subcontractor directly to the Electrical Contractor. Multiple subcontractors shall not be allowed.
- B. Responsible contractor shall have the following certifications on staff at the project site during construction.
 - 1. RCDD
 - 2. CTS-I
- C. Manufacturer Qualifications: The Manufacturer or Supplier fabricating the material or equipment described in this Section must, within the last five (5) consecutive years, have successfully completed in a timely fashion at least two (2) projects similar in scope and type to the required work for this Section.

- D. Installer Qualifications: The Contractor performing the Work of this Section must, within the last five (5) consecutive years, have successfully completed in a timely fashion at least three (3) projects similar in scope and type to the required work for this Section.
- E. The Contractor performing the Work of this Section may demonstrate compliance with the above qualification requirements by demonstrating that it is certified or authorized as an installer by a manufacturer designated as acceptable in these Specifications. A copy of such manufacturer certification or authorizations must be submitted, or verified in writing by the manufacturer.

1.04 SUBMITTALS

- A. Submit shop drawings, wire markings, all manufacturer's data, samples and test procedure and reports as called for hereinafter. All submissions to be in English Language. All submittals require the approval of Owner/Engineer.
 - 1. Submit each AV system as independent submittals.
 - 2. Submittals that contain components from multiple AV systems will not be approved.
- B. Submit a single guarantee stating that all parts of the work are in accordance with Contract requirements. Guarantee work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term to apply. Within 24 hours after notification, correct any deficiencies, which occur during the guarantee period at no additional cost to the Owner, to the satisfaction of the Owner and Engineer. Obtain similar guarantees from subcontractors, manufacturers, suppliers and sub-trade specialists, if any.
- C. Indemnify the Owner and the Architect/Engineer against loss, liability, damage or expense, including attorneys' fees, in connection with any claim resulting from damage, which may be asserted by any third party.

1.05 OWNER'S MANUALS

- A. General:
 - 1. Submit 2 draft copies of owner's manuals for review. After review by authorized representative, the contractor shall incorporate review comments and submit 6 final copies.
 - 2. Update manuals with modifications made to system during guarantee period. Provide replacement pages or supplements in quantity stated above.
 - 3. Assemble owner's manuals into multi-volume sets as necessary and required by the Owner.
 - 4. Protect each volume with a heavy-duty vinyl plastic binder. Volumes to have plastic printed dividers between major sections and have oversized binders to accommodate up to 2-inch-thick set of additional information.
 - 5. Each binder to be silk-screened with project name and volume title on front cover and binder.
 - 6. On the first page of each manual identify with project name, manual title, owner's name, engineer's name, contractor's name, address and service phone number, and person who prepared manual.
- B. Operating manual to serve as training and reference manual for all aspects of day-to-day operation of the system. As a minimum include the following:
 - 1. Sequence of operation for on-line and off-line operating modes. The sequences shall cross-reference the system point names.
 - 2. System manufacturers complete operating manuals.
- C. Provide maintenance manual to serve as training and reference manual for all aspects of day-to-day maintenance and major system repairs. As a minimum include the following:
 - 1. Complete as-built installation drawings for each system.
 - 2. Photographs and drawings showing installation details and locations of equipment.

3. Routine preventive maintenance procedures, corrective diagnostic troubleshooting procedures, and calibration procedures.
 4. Parts list with manufacturer's catalog numbers and ordering information.
 5. Manufacturer's operating set up, maintenance and catalog literature for each piece of equipment.
 6. Maintenance and repair instructions.
 7. Recommended spare parts.
 8. Field test reports.
- D. Provide Programming Manual to serve as training and reference manual for all aspects of system programming. As a minimum include the following:
1. Complete programming manuals, and reference guides.
 2. Details of any special software packages supplied with system.
 3. Information required for independent programming of system.
 4. Software troubleshooting procedures.

1.06 QUALITY CONTROL

A. Quality Assurance:

1. Comply with current governing codes, ordinances and regulations, and all other applicable codes.
2. Comply with the requirements of agencies or authorities having jurisdiction over any part of the work and secure all necessary permits.
3. The products shall be compliant with test reports, such as ISO-9001, ISO-9014, UL1950, or CE conforming to the rigid EMC requirements for electromagnetic emissions, immunity and harmonics where applicable.
4. Where codes or standards are listed herein, the applicable portions apply.
5. Plans, specifications, codes, and standards are minimum requirements. Where requirements differ, apply the more stringent.
6. Should any change in plans or specifications be required to comply with governing regulations, notify the Architect/Engineer at the time of submitting the bid.
7. Execute work in strict accordance with the best practices of the trades in a thorough, substantial, workmanlike manner by competent workmen. Provide a competent, experienced full-time Superintendent who is authorized to make decisions on behalf of the Contractor.
8. Equipment and materials supplied shall be complete, model numbers accurate, and the performance shall conform to manufacturer's specifications.
9. All equipment and materials shall be new and shall conform to applicable codes.
10. Repair or replace any items damaged during installation.
11. Procure and pay for all necessary permits, licenses, inspections, and observe any requirements stipulated therein.
12. The installation shall conform to the latest safety codes and regulations. Where conflicts exist, the most stringent code or regulation shall apply.
13. Adhere to all Quality Assurance items in the Sub-Contract Agreement issued by the Construction Manager.

B. Assurance:

1. Comply with current governing codes, ordinances and regulations, and all other applicable codes.
2. Comply with the requirements of agencies or authorities having jurisdiction over any part of the work and secure all necessary permits.
3. The products shall be compliant with test reports, such as ISO-9001, ISO-9014, UL1950 or CE conforming to the rigid EMC requirements for electromagnetic emissions, immunity and harmonics where applicable.
4. Where codes or standards are listed herein, the applicable portions apply.
5. Plans, specifications, codes and standards are minimum requirements. Where requirements differ, apply the more stringent.

6. Should any change in plans or specifications be required to comply with governing regulations, notify the Architect/Engineer at the time of submitting the bid.
7. Execute work in strict accordance with the best practices of the trades in a thorough, substantial, workmanlike manner by competent workmen. Provide a competent, experienced full-time Superintendent who is authorized to make decisions on behalf of the Contractor.
8. Installer Qualifications: The Contractor performing the Work of this Section must, within the last five (5) consecutive years, have successfully completed in a timely fashion at least three (3) projects similar in scope and type to the required work for this Section.
9. The Contractor performing the Work of this Section may demonstrate compliance with the above qualification requirements by demonstrating that it is certified or authorized as an installer by a manufacturer designated as acceptable in these Specifications. A copy of such manufacturer certification or authorizations must be submitted, or verified in writing by the manufacturer.
10. Equipment and materials supplied shall be complete, model numbers accurate, and the performance shall conform to manufacturer's specifications.
11. All equipment and materials shall be new and shall conform to applicable codes.
12. Repair or replace any items damaged during installation.
13. Procure and pay for all necessary permits, licenses, inspections, and observe any requirements stipulated therein.
14. The installation shall conform to the latest safety codes and regulations. Where conflicts exist, the most stringent code or regulation shall apply.
15. Adhere to all Quality Assurance items in the Sub-Contract Agreement issued by the Construction Manager.

1.07 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products in factor containers. Store in clean, dry space in original containers. Protect products from fumes and construction traffic. Handle carefully to avoid damage.
- B. The work covered in this document consists of furnishing all labor, material and services necessary to install a complete audiovisual system as indicated on the project drawings and in these specifications.
- C. Deliverables:
 1. Prior to ordering materials or commencing any construction activities, the contractor shall provide the Owner with a complete bill of materials, including all quantities of components, devices, equipment, and wiring required to complete this work. Submit product data, including manufacturer's data sheets for all proposed system components. Submit three copies with all specific items that will be provided clearly indicated and any options highlighted.

PART 2 - PRODUCTS

2.01 SYSTEMS DESCRIPTION

- A. Refer to drawings for AV system details.
- B. Refer to Section 2.4 for AV System Operational Notes and Products.
- C. AV system include but are not limited to the following:
 1. Gathering

2.01 EQUIPMENT AND SYSTEM PERFORMANCE REQUIREMENTS

A. General Equipment Requirements

1. The contractor shall provide all options, accessories and hardware necessary to meet the intended function of the design even if they are not specifically listed. (i.e., mounting kits, separate or additional power supplies, input modules, transformers, media converters, media extenders, licensing, hard drives and memory cards etc.)
2. Deviations from this specification must be documented in writing to the Architect, Engineer and Owner at least ten business days prior to the bid date.
3. The System components shall all be listed and labeled by Underwriters Laboratories Incorporated (UL).
4. All products shall be new and under warranty at the time of installation. B-stock, previously installed, refurbished or used equipment shall not be provided on this project.
5. Where the specification lists several manufacturers for a major item, or group of items, the AV Integrator shall provide that entire item from one manufacturer only.

B. Faceplates and Back Boxes

1. Faceplates shall be stainless steel with laser engraved lettering. ProCo WPE series or equivalent.
2. Floor Boxes shall be as specified in Division 26. Unspecified floor boxes shall be Legrand Evolution series or equivalent with the following features: Sliding cable doors, floor material insert, minimum of 3¼" of wire space behind faceplates, 2-hour fire rated.
3. Custom Wall Boxes
4. Ceiling Enclosures shall
5. Standard Back Boxes shall be as specified in Division 26.

C. Assistive Listening Equipment

1. Provide rack mountable RF Transmitter with external antenna capable of covering the entire audience area, both seating and standing room.
 - a. All transmitter models shall comply to FCC Part 15 as of July 16, 2016.
 - b. Functions and Features:
 - 1) 17 wide band programmable channels / 8 simultaneous use channels (interpretation).
 - 2) Audio DSP Microprocessor capable of automatic gain control and limiting, EQ settings.
 - 3) Audio frequency response of 31 - 16000 Hz, ±3 dB.
 - 4) RJ-45 Ethernet Jack for Network Control
 - c. Accessories
 - 1) Provide the following:
 - a) Power Supply
 - b) Rack mount kit
2. External FM Antenna
 - a. Provide external antenna as recommended by the transmitter manufacturer that is the most appropriate for the coverage area.
 - b. Provide antenna mounting hardware or outdoor weather protection for antenna exposed to the elements as required.
 - c. Provide antenna cable as recommended by the manufacturer. If information is not available from the manufacturer, provide the following:
 - 1) RG-59/U low loss 75 Ohm for cable runs up to 25 feet.
 - 2) RG-6/U low loss 75 Ohm for cable runs up to 200 feet.

3. RF Receivers

- a. Provide pocket sized portable RF Receivers capable of being worn with a belt clip or lanyard. The lanyard shall have an integrated neck loop.
- b. RF Receivers shall be compatible with all channels of the transmitter.
- c. Provide over the ear required Headphones / Earbuds as needed.

4. Functions and Features

- a. Programmable OLED screen with screen timeout and display settings.
- b. 17 wide band programmable channels / 8 simultaneous use channels (interpretation).
- c. Audio frequency response of 200 Hz - 15 kHz, $\pm 3\text{dB}$.
- d. Field replaceable AA alkaline or NiMH rechargeable battery.
- e. Receiver shall be capable of at least 30 hrs. battery life w NiMH, 50 Hrs. with Alkaline

5. Accessories

- a. Charging Station/Carrying Case
 - 1) Provide receiver charging station/carrying cases capable of storing and charging all receivers simultaneously.
- b. Signage
 - 1) Provide signage. Quantity shall comply with ADA standards.

D. Equipment Racks

- 1. Provide full metal rack with welded joints. Wall racks shall be Middle Atlantic WRD series or approved equivalent. Floor racks shall be Middle Atlantic ERK series or approved equivalent.
- 2. Provide the following accessories:
 - a. Body Panels as listed below, unless noted otherwise on drawings and details.
 - 1) Vented front door
 - 2) Vented top
 - 3) Solid side panels
 - 4) Solid Rear with cable pass through
 - b. Power Strips
 - 1) Vertical for racks > 24 in tall.
 - 2) Horizontal or vertical for racks ≤ 24 tall.
 - 3) Integral switching capability. Unswitched power strips may be connected to switched power strips.
 - 4) Integral surge suppression
 - c. Lockable drawers with ball bearing runners for all accessories including but not limited to cables and microphones.
 - 1) Provide foam insert for microphones and other sensitive equipment.
 - d. Shelves for non-rack mountable AV equipment.
 - e. Wire management and raceway

E. Audio Distribution Equipment and Cabling

- 1. Audio shall be distributed using balanced signals. When receiving a signal from an unbalanced audio device, the signal shall be immediately converted to a balanced audio signal using an unbalanced input transformer Radio Design Labs TX series or equivalent.
- 2. All cabling shall be plenum rated.

F. Microphones

1. Speech Handheld microphones shall be Shure SM series or equivalent.
2. Theatrical vocal and instrumental microphones shall be Shure Beta Series or equivalent.
3. Over the Ear microphones shall be Shure Countryman or equivalent.
4. Lapel microphones shall be Shure Microflex or equivalent.
5. Athletic Headword microphones shall be Shure SM series or equivalent.

G. Wireless Microphone Systems

1. Wireless microphone systems shall be of the manufacturer and series indicated on the drawings and details or approved equivalent. Unspecified wireless microphone systems shall be Shure QLX-D series or approved equivalent with the features listed below.
 - a. 24-bit digital audio
 - b. AES-256 encryption
 - c. 120dB of dynamic range
2. Transmitters shall be of the same manufacturer and series as the receiver and shall have the following features:
 - a. Full metal construction
 - b. Lithium-Ion rechargeable battery
 - c. External charging contacts for docked charging
 - d. Backlit LCD display
 - e. Frequency band matching receiver
3. Antenna systems shall be provided to cover the intended use area with 100% reliable wireless device use.
 - a. Antennas shall be located in line of site of the transmitter use area. Multiple antennas may be required.
 - b. Antenna cable shall be as approved by the wireless microphone manufacturer. Antenna cable shall be pre-terminated. Multiple runs of cable shall have identical lengths.
4. Provide the following accessories:
 - a. Battery charger with capacity for every transmitter battery to charge simultaneously
 - b. Spare batteries - OEM batteries. (1) or 20% of system total, whichever is greater. Spare batteries shall not be considered when selecting battery charger size.

H. Audio Digital Signal Processors

1. Audio DSPs shall be of the manufacturer and series indicated on the drawings and details or approved equivalent.

I. Amplifiers, Speakers and Performance Requirements

1. Amplifiers and Speakers shall be provided to meet the audio performance requirements listed below based on application.
 - a. Basis of Design speakers and amplifiers are indicated in the AV details. Provide manufacture and series of those indicated or approved equivalent.
2. Speakers
 - a. Wall mounted speaker hardware shall allow for 3-axis of adjustment.
3. Amplifiers shall be provided in dual channel component to meet the audio performance requirements listed below.
 - a. Maximum Input Level: +21 dBu
 - b. Crosstalk: < -80dB (ref. 1 kHz, at 100 W/4 Ω)
 - c. Frequency Response: 10 Hz to 21 kHz (± 1 dB)

- d. Input Impedance: active balanced
- e. Signal-to-Noise Ratio (A-weighted): >104dB
- f. Output Noise, A-weighted: < -68dBu
- g. Output Stage Topology: Class AB
- h. Power Requirement
 - 1) As needed to provide System 3dB Headroom
- i. Signal Processing
 - 1) FIR Filters, Audio Limiters; Output delay per channel; 31 band GEQ per channel; PEQ per channel; Load impedance
 - 2) Stand-By Programmable power-on timer
- 4. Speaker and Amplifier selection, configuration and layout shall meet the following audio performance requirements across all listeners with +3dB headroom.

a. Auditorium/Theater:	106dB \pm 2dB	40Hz - 18kHz
b. Gymnasium:	106dB \pm 3dB	45Hz - 16kHz
c. Auxiliary Gym/Natatorium:	106dB \pm 3dB	60Hz - 16kHz
d. Misc. Multimedia:	90dB \pm 3dB	80Hz - 16kHz
e. Conference/Classroom:	80dB \pm 3dB	250Hz - 8kHz
f. Misc. speech reinforcement:	90dB \pm 3dB	80Hz - 16kHz

J. Controls

- 1. Provide User interface devices and control to every piece of equipment as indicated on the drawings. Controls processors and related equipment is not indicated on the drawings. The contractor shall provide a complete controls system by Crestron, Extron or approved equivalent with the following features:
 - a. Controls systems shall be serviceable by any controls integrator. Proprietary controls systems with limited integrator support will not be accepted.
 - b. Controls systems shall be Serial and Ethernet based.
- 2. Power Sequencers shall be provided as part of the controls system.
- 3. Controls system programing shall be the property of the owner and shall be provided to the owner at the completion of the project.

K. Network Equipment

- 1. A dedicated network switch shall be provided for every AV system which uses network controls, network audio protocols or network video protocols. Switches shall be Cisco SG300-MP series or equivalent with the features list below.
 - a. 30W POE power on all ports simultaneously
 - b. Non-Blocking layer 3 managed switch
 - c. VLAN and IGMP snooping support
 - d. 1 Gbps on all ports with total packet forwarding rate of at least 1.4 Mpps * port count.
 - e. Capability of switches Energy Efficiency Settings off.
 - f. DiffServ (DSCP) Quality of Service (QoS) with strict priority and 4 queues.
 - g. (2) SPF ports
 - h. Spare capacity of (4) ports or 20%, whichever is greater.
- 2. Fiber Media Converters shall be cut-through SPF or SPF+ modules in lieu of store-and-forward standalone converts.
- 3. Wi-Fi Routers shall be business class appliance with the following features:
 - a. 802.11B/G/N/AC

L. Video Distribution Equipment

1. Video distribution cabling shall support 4K/60 4:4:4 Chroma sampling.
2. Video distribution over 20 feet shall utilize HDBaseT. Proprietary protocols shall be allowable only if the equipment is dual compatible with HDBaseT.
3. All cabling shall be plenum rated.

M. Projectors

1. Specified model numbers establish a series of projector and basic performance requirements. The actual projector model number required may vary. Projector lenses shall be field coordinated.
2. It is the responsibility of the contractor to field verify the exact projector installation parameters and coordinate with the manufacturer to provide the correct lens, then confirm with the engineer.
 - a. Projector lenses that are not coordinated and that are deemed inadequate by the engineer will be replaced solely at the expense of the contractor.
3. Measure actual projection throw distance and provide lens or projector model that best suits the installation. Verify with the engineer after selection and prior to ordering.
4. Field coordinate all mounting hardware required. Provide blocking in walls as required.
5. Coordinate color of projector and projector mounting hardware, enclosure supports, etc. with the architect or engineer prior to ordering.
6. Provide structural engineering services as required for any device heavier than 200lbs, including the weight of mounting hardware, enclosures, etc.

N. Projection Screens

1. All projection screen shall be considered custom for the sake of model numbers and ordering. Specified model numbers establish a series of projection screen and basic requirements. The actual projection model number required may vary. Projection screens shall be field coordinated.
2. It is the responsibility of the contractor to field verify the exact projection screen requirements and coordinate with the manufacturer to provide the correct screen, then confirm with the engineer.
 - a. Projection screens that are not coordinated and that are deemed inadequate by the engineer will be replaced solely at the expense of the contractor.
3. Projection screens shall be installed at or recessed in the ceiling. If there is no ceiling, the screen shall be suspended from the structure or wall mounted at the elevation indicated on the drawings. If no elevation is provided, request an elevation from the engineer.
4. Measure actual black drop required for appropriate screen elevation. Inform the engineer of any obstructions or conflicts prior to ordering screen.
5. Provide structural engineering services as required for any screen heavier than 200lbs, including the weight of mounting hardware.

O. Wires and Cabling

1. Provide the following West Penn Wire part numbers or equivalent:
 - a. SUB-Loudspeakers WPHA210
 - b. Speaker 2 - 4 - 8 Ohms WP227
 - c. Speakers 70 V WP226
 - d. Speaker with VCP WP 245
 - e. Antennas WP810
 - f. Crestron Video DM Cable
 - g. Projector Screen WP 232
 - h. Telex Intercom per Channel WP 303
 - i. Line level cable WP291
 - j. Microphone Cable WP452
 - k. Microphone WP291
 - l. Control WP225

- P. Owner Furnished Equipment (OFE)
1. In each system, the video source equipment shall be furnished by the Owner (OFE). Portable source equipment such as DVDs, VCRs, laptop computers, microphone system, document cameras, etc. shall be owner furnished except where identified on the contract drawings.

2.02 GENERAL EQUIPMENT REQUIREMENTS

- A. Document deviations from this specification writing to the Architect and Owner at least ten business days prior to the bid date.
- B. The System components shall all be listed and labeled by Underwriters Laboratories Incorporated (UL).
- C. All products shall be new and under warranty at the time of installation. Do not provide B-stock, previously installed, refurbished or used equipment.
- D. Where the specification lists several manufacturers for a major item, or group of items, the AV Integrator shall provide that entire item from one manufacturer only.
- E. The contractor shall provide all options, accessories and hardware necessary to meet the function of the design even if they are not specifically listed (i.e., mounting kits, separate or additional power supplies, input modules, transformers, etc.).

2.03 MANUFACTURERS

- A. Refer to drawings and schedule for equipment part numbers.
- B. Provide products as indicated in drawings, schedules and specifications.
 1. The Engineer and/or Owner prefer the products specified, however substitution is considered. Substitute products shall only be acceptable if approved in writing by the engineer. Submit substitutions in accordance with Section 27 0100 "Basic Communications Systems Requirements".

2.04 SYSTEM SPECIFIC INFORMATION

- A. Gathering
 1. Operational Notes
 - a. The gathering AV system enables large group presentation.
 - b. A motorized projector screen permanently recessed in lay-in ceiling drops down at the presentation wall. The projector hangs from the ceiling via a fixed pole mount.
 - c. AV sources include a wall plate with HDMI input and a wireless presentation system. Audio sources include a mic wall plate with one XLR input, Bluetooth receiver wall plate, and one channel of wireless microphones.
 - d. The audio inputs mix through a DSP (Digital Signal Processor) into 2 output channels, Room left and Room right.
 - e. The wall mounted touch screen control shall control the system with the following functions: On, Off, Volume Up, Volume Down, and Source Select
 - f. A wall mounted av rack shall hold all of the av equipment. Sequenced power distribution strips shall serve all equipment with in the rack.

2. Products

- a. Refer to detail for more information.
- b. Provide the following products:

System Name			
Quantity	Model	Manufacturer	Description
1	ACSPR-RPC1-2009	Lowell	PDU with 9 (15A) Outlets, 20A Rating, Advanced Multi-Stage Surge Suppression, Over-Under Voltage Protection, Remote Circuitry
1	ACS-1506-WW	Lowell	12" Power Strip 6 (15A) Outlets, Wall Wart Spacing
1	TesiraFORTÉ AI	Biamp	Fixed I/O DSP with 12 analog inputs, 8 analog outputs, 8 channels con-figurable USB audio.
1	CP4	Crestron	4-Series™ Control System
1	HD-TX-301-C-E	Crestron	DM Lite® Transmitter and 3x1 Auto-Switcher for HDMI®, VGA, and Analog Audio Signal Extension over CATx Cable
1	HD-RXC-4KZ-101	Crestron	DM® Essentials 4K60 4:4:4 Receiver for HDMI®, RS-232, and IR Signal Extension over CATx Cable
1	AM-3200	Crestron	The AirMedia® Receiver
1	UD3	Middle Atlantic	3 RU Utility Rack Drawer
1	GSM4212P-100NAS	Netgear	Netgear 8-Port POE+ 2 Non-POE Gigabit Ethernet Managed
1	CG03974	C2G	4ft Cat6 Snagless Unshielded UTP Ethernet Network Patch Cable - Blue
6	CG04008	C2G	4ft Cat6 Snagless Unshielded UTP Ethernet Network Patch Cable - Yellow
1	SLXD4	Shure	Half-Rack, Single Channel Receiver
1	PX3	Yamaha	Dual-channel; 500W x 2 @ 4Ω; lightweight Class-D design; built-in DSP; 2RU
			Loudspeakers
2	Control 29AV	JBL	8" 2-WAY MONITOR SPEAKER
2	MTC-29UB	JBL	U-Bracket for Control 29
2	SAS-100-20	Adaptive Technologies	Wall Mounting Arm
			Projector
1	ACCESS E ULT: Ultimate Access E Screen 142032U	Draper	Ceiling recessed 165 " Diagonal 16:10, Matt White XT1000E, 110V, White case including flanges.
1	PT-FRZ60U	Panasonic	6,000 Lumens, Laser, WUXGA Resolution (1,920 x 1,200), 4K/60 Signal Input, 1DLP Projector, White
1	VMCA2b-01	Chief	I-Beam Adapter for ceiling mount
1	CMS0203W	Chief	2-3' Adjustable Extension Column, Pole
1	CMA348W	Chief	Large Venue Vibration Isolating Coupler, White
1	VCMUW	Chief	Heavy Duty Universal Projector Mount
1	HD-RXCA-4KZ-101	Crestron	DM® Essentials 4K60 4:4:4 Receiver for HDMI®, RS-232, and IR Signal Extension over CATx Cable, Wall Plate, Black
1	ACSP-2002-VTE	Lowell	Advanced Multi-Stage Surge Suppression with 2 (20A) Outlets, Over-Under Voltage Protection
1	CBL-8K-HD-3	Crestron	Certified HDMI® 2.1 Cable, 48 Gbps, 3 ft
1	CG27191	C2G	3 ft Cat6 Snagless Unshielded UTP Ethernet Network Patch Cable - Yellow

System Name			
<u>Quantity</u>	<u>Model</u>	<u>Manufacturer</u>	<u>Description</u>
1	CG27151	C2G	3 ft Cat6 Snagless Unshielded UTP Ethernet Network Patch Cable - Black
			System Antennas
1	DFINW	RF Venue	Diversity Fin Antenna - White
1	LA-122	Listen	Antenna Kit
3	LA-304	Listen	ALS Notification Signage Kit
			Touch Panel
1	Custom	Proco	1 Gang Metal Painted White w (1) XLRF Labeled Mic 1
1	HD-TXC-4KZ-211-2G-W	Crestron	DM® Essentials 4K60 4:4:4 Transmitter and 2x1 Auto-Switcher for HDMI® and USB-C® DisplayPort™ Signal Extension over CATx Cable, Wall Plate, White
1	TSW-770-W-S	Crestron	7 in. Wall Mount Touch Screen, White Smooth
1	TSW-UMB-70	Crestron	Universal Mounting Bracket for TSW-70 Series
1	DB-BT1A	RDL	Bluetooth Audio to Dante Interface, White
1	TX-TPR2A	RDL	Active Two-Pair Receiver - Twisted Pair Format-A
1	PS-24AS	RDL	24 Vdc Switching Power Supply, North American AC Plug, 500 mA, dc Plug
			Microphone - Stand - Audio Cable
2	SM58S	Shure	Cardioid Dynamic, On-Off Switch
2	MS-10E	Atlas	All-Purpose Mic Stand Ebony
2	HOGM-25.K	Rapco / Proco	RoadHog 25' Mic Cable
1	SLXD1--G58	Shure	Bodypack Transmitter
1	SLXD2/SM58--G58	Shure	Handheld Transmitter with SM58® Microphone
4	SB903	Shure	Shure Lithium-Ion Rechargeable Battery
2	SBC203	Shure	Dual Docking Station for SLX-D transmitters and SB903 battery
1	CBL-HD-20	Crestron	Crestron® Certified HDMI® Interface Cable, 18 Gbps, 20 ft (6.1 m)

PART 3 - EXECUTION

3.01 GENERAL

- A. All equipment and enclosures described in this specification shall be installed plumb and square per manufacturer's instructions.
- B. All equipment, except that designated as movable, portable or loose equipment, shall be secured and permanently attached to the permanent structure in a manner which will require the use of a tool (e.g.: screw driver, nut driver, etc.) for removal.
- C. All supports shall meet or exceed the load requirements of the intended application with a minimum safety factor of five.

- D. Provide blocking in the walls as required to support equipment and devices. If a general contractor is present on the project, coordinate required blocking with the general contractor prior the installation of walls.
- E. Provide support structure and hardware with a SAE Grade 8 load rating (min.).

3.02 EXAMINATION

- A. Site Verification of Conditions: Verify that related conditions, including equipment that has been previously installed under other sections, are acceptable for product installation in accordance with manufacturer's instructions.
- B. All devices connected to equipment specified in this section shall bear the UL label and comply with the applicable National Electrical Code (NEC) standards.

3.03 INSTALLATION

- A. Contractor shall furnish all equipment, labor, system setup, and other services necessary for the proper installation of the products/system as indicated on the drawings and specified herein. System setup information shall include each components proper mounting and alignment and properly verified signal pathways and operation. Proper operational control functions shall be verified.
- B. Install in accordance with manufacturer's handling and installation instructions.
- C. Install in accordance with all local and pertaining codes and regulations
- D. Utilize an installer with demonstrated experience in projects of similar size and complexity.
- E. Equipment shall be ready for use to condition at the end of installation.
- F. Energize equipment in accordance with manufacturer's instructions.
- G. All equipment must be labeled, inventoried, and asset tagged using the owner's templates and asset tags.
- H. Mount system components securely within the rack.
- I. Mount external antenna outside of rack within the area it serves.
- J. Assistive Listening
 1. Unbox all receiver and headsets. Fully charge all receivers. Place receiver and headset into charging/storage case for owner's use.
 2. Install all assisted listening ADA compliant signage in required areas per ADA standards.

3.04 WIRING METHODS

- A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters. Conceal raceway and cables except in unfinished spaces.
 1. All cabling shall be plenum rated.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- D. Support cables not enclosed in raceways on J-Hooks. Install, size, and space J-Hooks to comply with TIA/EIA-568-B.
- E. Cable Management
 - 1. Verify tie wraps are snug yet allow the cable to slide. Unshielded twisted pair (UTP) cables shall only be laced and bound with Velcro ties.
 - 2. Verify terminations have sufficient service loop to allow for re-terminating without having to open a cable bundle or a pathway to lay a new cable.
 - 3. Verify that cables have been dressed appropriately and bundled according to type. Cables should also have appropriate separation according to signal type and level.
 - 4. Verify all cables have clearly legible, unambiguous labels that are visible without having to take apart the system or the cable bundles. Cable labels shall be permanent and non-slipping.

3.05 ELECTRICAL CONNECTIONS

- A. Splices shall not be used anywhere in the system.
- B. Ground rack mounted equipment and conductor and cable shields to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

3.06 IDENTIFICATION

- A. Comply with Section 270553 "Identification of Communication Systems."
- B. Color code wires, and apply wire and cable marking tape to designate wires and cables so they are uniformly identified and coordinated with wiring diagrams throughout the system.

3.07 SYSTEM TESTING AND PERFORMANCE VERIFICATION

- A. Audio Performance
 - 1. Harmonic Distortion and Noise
 - a. Measure and record the total harmonic distortion + noise (THD+N) of the audio system from 20-20kHz.
 - b. THD+N shall be less than 0.01%, +4 dBu, 20-20 kHz, unity gain, 20kHz BW
 - 2. Signal-to-Noise
 - a. Measure and record the signal-to-noise ratio (SNR) of the audio system from 20-22kHz.
 - b. SNR shall be greater than 90 dB re +4 dBu, 22 kHz BW, unity gain
 - 3. Frequency Response
 - a. Measure and record the system's frequency response for speech sound reinforcement and for program sound amplification.
 - b. Frequency Response shall be "C" weighted

1)	Auditorium/Theater	106dB ± 2dB	40Hz - 18kHz
2)	Gymnasium	110dB ± 3dB	45Hz - 16kHz
3)	Auxiliary Gym/Natatorium	106dB ± 3dB	60Hz - 16kHz

- | | | | |
|----|----------------------------|----------------|--------------|
| 4) | Misc. Multimedia | 90dB \pm 3dB | 80Hz - 16kHz |
| 5) | Conference/Classroom | 80dB \pm 3dB | 250Hz - 8kHz |
| 6) | Misc. speech reinforcement | 90dB \pm 3dB | 80Hz - 16khz |
- c. Any variance from the specifications above must be approved by the engineer.
4. Audio Input Calibration
- a. Calibrate audio system inputs so that all input signal levels are equal.
- b. Adjust the microphone input gain to demonstrate that a standard talker, positioned at each talker position in the room, produces a dBu level of zero at the output bus of the digital signal processor. Verify signal levels for both transmitting and receiving normal speech.
5. Amplifiers
- a. Verify no power amplifier exceeds its rated load. Measure and record the impedance at a specific frequency for each loudspeaker line of each power amp. If available, 63, 250, and 1,000 Hz are recommended.
6. Speaker Polarity
- a. Program loudspeakers in the same system shall produce consistent polarity for a mono input signal across all channels.
- b. Polarized speech reinforcement sound systems so that positive acoustic pressure on a microphone result in positive acoustic pressure at all loudspeakers.
7. Assistive Listening
- a. Tests and Inspections:
- 1) Perform operational system tests to verify compliance with the Specifications and make adjustments to bring system into compliance. Include operation of all channels of RF transmission, all input sources and all functions.
- a) Perform operational systems tests on wireless systems only after all wireless systems are operational and online.
- b) All assistive listening systems shall be tested simultaneously to check for interference across systems.
- 2) Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
- b. The Assistive Listening Systems will be considered defective if it does not pass tests and inspections.
- c. Prepare test and inspection reports.
- d. Adjusting
- 1) Program system according to Owner's requirements. Set system so RF transmissions operate on Owner-required frequencies and do not interfere with other radio frequencies in use.
- 2) Set RF transmission power to the lowest signal strength selectable that maintains 100% reliability for the intended use of the system.
- 3) Adjust sound-output level of adjustable signal devices to suit Owner's requirements.
- 4) Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

B. Video Performance

1. Video Infrastructure

- a. For digital video infrastructure, use a test signal generator to demonstrate that digital video transport provides a reliable signal of 4K/60 4:4:4. Record the results.
- b. For NTSC sources, demonstrate that a consistent, 1-volt, peak-to-peak test signal at each source produces a 1-volt, peak-to-peak to each destination. Verify at each destination using SMPTE color bars, peak white and five-step multi-burst.
- c. Demonstrate consistent 700 mV from each source to each destination. Observe results using a flat-field pattern signal at 1,024x768 resolution. Measure peak-to-peak voltage using a 200 MHz oscilloscope.

2. Projected Displays

- a. Verify image is in focus and in the center of the projection surface.
- b. Measure and record the projector brightness at 9 points across the image using an incident-light meter.
- c. Measure and record the contrast ratio with ambient lighting in normal operating mode.

3. Multiple Resolutions

- a. Demonstrate that the video system is able to display stable, properly scaled images with no artifacts when switching between various resolutions and aspect ratio. At a minimum, the following resolutions shall be used: 3840x2160, 1920x1200, 1920x1080, 1,024x768, 1280x1024, and 1280x720 sources, plus all sources in the performance criteria.

3.08 PROTECTION AND CLEANING

- A. Storage and Protection: Store materials protected from exposure to harmful environmental conditions and at temperature and humidity conditions recommended by the manufacturer.
- B. Repair or replace damaged components before Substantial Completion of the project.
- C. Remove temporary tags, coverings, and construction debris from interior and exterior surfaces of the equipment. Remove construction debris from equipment area and dispose of properly.

3.09 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain system components.

END OF SECTION 27 4115

SECTION 27 5120 - INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. The drawings and general provisions of the Contract Documents apply to this Section.

1.02 SUMMARY

- A. This section includes a fully operational IP platform for a district-wide internal and school Critical Communications Solution, incorporating school safety notifications and general communications including but not limited to the following:
1. The platform shall provide complete internal communications and employ state of the art IP Technology including the minimum functions listed.
 - a. Two-way internal intercommunications between staff locations and classrooms.
 - b. Scheduled bell events.
 - c. Emergency announcements that will override any pre-programmed audio, assuring that all Emergency/Lockdown etc. are audible at every speaker location.
 - d. Capability of prerecording emergency announcements that can be activated by a Soft Key on an administrative console, panic button, dial string, or Web UI.
 - e. NTP with Class Change Tones utilizing multiple, programmable schedules for each zone.
 - f. District-wide, Emergency, Group, All School and Zone live voice paging.
 - g. District-wide, Emergency, Group, All School and Zone paging for pre-recorded audio – tones, music and voice.
 - h. Single sign on web-based user interface for multi school functionality.
 2. The system shall support a minimum of 1000 level priorities that shall be user-definable, allowing each end point to place a minimum of 5 different priority calls at the same time.
 3. Any authorized administrator shall be able to call from outside the school into any classroom, zone, or entire school directly via the School District supplied SIP enabled Telephone Network. This shall allow remote monitoring, call-in annunciation, and two-way conversation from outside the facility as well as paging into the system. (Compliance with NEMA Standard SB-40 for emergency communications in K-12 Schools).
 4. Authorized system users shall be able to create a minimum of 100 automated sequences with voice instructions, tones, emails, and relay activations and replay them.
 5. Automated message strings shall be manually initiated from a single-button access on the console, from a mobile APP, on a SIP connected telephone, a panic button, from the web-based user interface or via interface with third party systems.
 6. Paging and two-way intercom features shall be accessible from any system console or SIP connected telephone for each campus.
 7. The platform shall synchronize its system time to the network timeserver or a web-based time server.
 8. Each single campus installation shall be locally survivable for intercom, paging, bells, and emergencies such as lockdown, even when the district connection is unavailable.
 9. This specification establishes a minimum level of quality, features, and performance for individual components as well as the integrated system.
 10. Systems that do not comply with the feature-sets highlighted in this Specification will not be considered.
 11. Included in the emergency procedures is the ability to send specific messages and or instructions. These features can be added to the emergency sequences.
 12. The ability to require an access code to initiate or clear an emergency from the administrative console.

13. An App that can be installed on either Android or Apple phones. This App will give a person to initiate one of 19 emergency procedures programmed into the App. This App will also allow the user to view all classrooms that have not checked in. This process will update during the emergency to make sure all information is current.
14. The ability to allow the fire alarm system to annunciate through the TCU. This shall include visual messaging, play an audio message, with the addition of tones. TCU will be programmed to change status if the systems get an emergency sequence. Both fire and emergency will be displayed on the console and App.
15. Any system that requires more than one Data drop to a classroom to control an IP speaker, up to 5 call-in switches, status lights (up to 2) and message board/digital clock will not be considered equal to the specified system.

1.03 DEFINITION OF TERMS

- A. Installer(s): Shall refer to the person, persons, or company who or which actually contracts to perform the work specified herein.

1.04 SUBMITTALS

- A. Product data for each component.
- B. Shop Drawings: Prior to proceeding with the work: Provide detailed equipment assemblies and indicate dimensions, weights, required clearances, method of field assembly, components, location of each field connection, and a complete schedule of all equipment and materials with associated manufacturer's cuts sheets which are to be used.
 1. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring. Identify terminals to facilitate installation, operation, and maintenance. Include a single-line diagram showing cabling interconnection of components and levels throughout system and impedances.
 2. Artwork drawings and lists indicating proposed nameplate nomenclature and arrangements for control panels and plug panels prior to fabrication reflecting equipment used.
 3. Each drawing shall have a descriptive title and all sub-parts of each drawing shall be labeled. All drawings shall have the name and locations of the project, Systems Contractor's name in the title block.
 4. Details and descriptions of any other aspect of the system, which must differ from the contract documents due to field conditions or equipment, furnished.
- C. FCC Approval: The system shall be approved for direct interconnection to the telephone utility under Part 68 of FCC rules and regulations. Systems, which are not FCC approved or utilize an intermediary device for connection, will not be considered. Provide the FCC registration number of the system being proposed as part of the submittal process.
- D. Product Certificates: Signed by manufacturers certifying that products furnished comply with specified requirements.
- E. Installer Certificates: Signed by manufacturers certifying that Installers comply with specified requirements.
- F. Manufacturer Certificates: Signed by manufacturers certifying that they comply with specified requirements.
- G. Field Test Reports: Indicate and interpret test results for compliance with performance requirements. Include record of final matching transformer-tap settings, and signal ground-resistance measurement certified by Installer.
- H. Maintenance Data: For equipment to be included in maintenance manuals specified in Division 1.
 1. Record of Owners equipment-programming option decisions.
 2. All instructions necessary for proper operation and manufacturer's instructions.
 3. "Proof of Performance" information.
 4. Manufacturer's maintenance information.

5. Copies of non-proprietary computer programs and system set up disks documenting all programmable features of the installed system.
- I. Record Drawings: Prior to final acceptance, provide three (3) complete sets of drawings indicating all cable numbers and construction details in accordance with the actual system installation. Revise all shop drawings to represent actual installation conditions. These Record Drawings will be used during "Final Acceptance Testing".
- J. System Training: Submit the following information describing the training programs and system trainers as outlined in paragraph 1.6 of this specification and in accordance with Division 1 specifications.
 1. Include with the submittal a preliminary staff development training program in outline form for review and approval by the owner's representative.
 2. Include with the submittal a current copy of the trainer's certification from the manufacturer that certifies and identifies the trainer(s) who are eligible to provide training and support for the project.
 3. Include with the submittal a current copy of trainer's needs assessment form which will be reviewed with the owner's designated representative for the system's preliminary system programming and configuration.
 4. Include with the submittal copies of all documentation used to identify for the owner those participants attending and completing the training programs.
- K. A copy of the manufacturer's standard statement of warranty proving all equipment provided for the school communications network is covered with the required **five-year** warranty shall be included with the project submittal. This statement of warranty shall be provided on the manufacturer's stationary.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced Installer who is an authorized representative of equipment manufacturer for both installation and maintenance of equipment required for this Section. Provide the following within thirty (30) days after notification to proceed:
 1. Provide a list of installations that the Installer has specifically installed for verification by the Owner. Random installations from other vendors and/or Installers shall not be accepted. The Installer, not its employees, must meet these qualifications.
 2. The Installer shall be bondable.
 3. The Installer shall demonstrate to the satisfaction of the Owner or his representative that he has:
 - a. Adequate plant and equipment to pursue the work properly and expeditiously.
 - b. Adequate staff and technical experience to implement the work.
 - c. Suitable financial status to meet the obligations of the work.
 - d. Technically capable and factory trained service personnel at a local service facility to provide routine and emergency service for all products used in this project.
- B. Any Contractor, who intends to bid on this work and does not meet the requirements of the "Quality Assurance" paragraph(s), shall employ the services of an "Installer" who does meet the requirements and who shall provide the equipment, make all connections and continuously supervise the installation. A subcontractor so employed as the "Installer" must be acceptable to the Architect/Engineer. The "Installer" shall be identified within thirty (30) days of notification to proceed for acceptance by the Architect/Engineer.
- C. Each major component of equipment shall have the manufacturers name, address and model number on a plate securely affixed in a conspicuous place. NEMA code ratings, UL Label, or other data that is die-stamped into the surface of the equipment shall be easily visible.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.

- E. Comply with NFPA 70
- F. Comply with NEMA Standard SB-40 for Emergency Communications in K-12 schools.
- G. Comply with UL 60950.

1.06 IN-SERVICE TRAINING

- A. The contractor shall provide and implement a complete and comprehensive staff training program for all administrators, facility staff members, and teachers. This mandatory training program will provide school staff a complete understanding of how to utilize and properly operate all functions.
- B. The training program shall be implemented by a staff member/trainer employed by the contractor. The trainer must be factory certified to provide training on their product.
- C. All staff development training is to be coordinated through the owner's designated representative. As training sessions are completed, the trainer will provide the school's administrative staff and school district's staff a document listing all of the staff and faculty members who attended, received, and completed the training program.

1.07 WARRANTY

- A. Provide a manufacturer's five-year warranty of the intercommunication and program system equipment against defects in material and workmanship. This warranty will cover all electronic system components. Additional warranties cover clocks, speakers, and call-in switches. If any defects are found within the warranty period, the defective equipment shall be replaced at no cost (equipment only); a one-year warranty shall be provided for labor.
- B. A copy of the manufacturer's standard statement of warranty proving all equipment provided for the school communications network is covered with the required five-year warranty shall be included with the project submittal. This statement of warranty shall be provided on the manufacturer's stationary. The standard five-year warranty is an important element in establishing a standard in quality. Manufacturers who circumvent the five-year warranty by offering special "extended warranties" that are not part of their normal published warranty will not be accepted.
- C. Contractor shall respond, excluding weekends and holidays, within 24 hours to any warranty service calls. If equipment cannot be repaired within 24 hours of service visit, the contractor shall provide "loaner" equipment to the facility at no charge.
- D. Make available a service contract offering continuing factory authorized service of the system after the initial warranty period.

1.08 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide the following system:
 - 1. Telecenter manufactured by Rauland-Borg Corp
 - a. Authorized Rauland-Borg Distributor contact:
Open Systems Pittsburgh
Contact: Phil Thompson
Email: pthompson@ospittsburgh.com

PART 2 - PRODUCTS

2.01 SYSTEM REQUIREMENTS

- A. The platform shall utilize state of the art IP Technology for Call-in Notification, School Safety Paging and Evacuation tones, Time Synchronization, Class Change Tones utilizing multiple, programmable schedules for each zone, Two-way hands-free Internal Communications and Paging, and Program Distribution. The system shall be easy to learn and operate. All standard programming shall be web based and user friendly to allow the system administrator the ability to easily program system features.
- B. Provide complete and satisfactorily operating district/school communications and district/school safety as described herein, using materials and equipment of types, sizes, ratings, and performances as indicated. Use materials and equipment that comply with referenced standards and manufacturers' standard design and construction, in accordance with published product information. Coordinate the features of all materials and equipment so they form an integrated system, with components and interconnections matched for optimum performance of specified functions.
- C. The platform shall be a single electronic system consisting of a minimum of 10 audio channels for each campus, (classroom) IP Speaker Modules and call switches, IP Zone Modules connecting corridor speakers, inside and outside horns, IP Administrative Consoles, SIP enabled PBX integration and district-wide integration for paging, emergency notifications, calendar scheduling and configuration.
- D. Each Classroom shall be provided with a Speaker Module interface and a minimum of 5 different call switches, a small message board (3.75" x 12.91"), a status light in the room with an optional status light in the hall, each with their own annunciation path and priority.
- E. Call-ins may automatically annunciate (display of priority and location) to administrative consoles, SIP enabled phones, and outside phones.
- F. Call-ins shall be programmed to automatically change priority and annunciation route based on age of call-in and original priority.
- G. Call-ins may have priority (and annunciation route) changed by user action from a console or SIP enabled phone.
- H. Call-in annunciation route shall include playing pre-recorded audio over speakers, sending a pre-configured email, and activating relays.
- I. The platform shall lend itself to expansion by simple addition of hardware modules.
- J. The platform shall connect directly to an existing, standard protocol WAN/LAN network, without the need for a separate server at each school location. Configuration, including bell schedules, calendars, and emergency sequences can be remotely created, changed, stored and downloaded to the system by an authorized user from a web-based user interface.
- K. The platform shall provide the ability to initiate school safety paging announcements, evacuation tones and take cover tones from any telephone or connected web browser within the facility or outside the facility to any other location within the facility or district.
- L. The platform shall provide the ability to selectively communicate or monitor individual classrooms in emergency situations from any telephone within the facility or outside the facility to any other location within the facility; all communication within the classroom shall be hands-free and will not require any interaction by the classroom user.

- M. The platform shall provide classroom users the ability to confirm that they have safely secured their classrooms during lockdown with a single button press. The front office administrator will receive confirmation that the classroom is safely secured via an administrative console, web-based user interface or mobile App. The front office administrator shall be able to initiate two-way communication, without a pre-announcement tone, to the classroom during an emergency via the administrative console. Web-based user interface will still identify that a school is in an emergency, even if all classrooms are safely secured. Individual classroom check-in and school emergency status shall be viewed from the web-based user interface or Mobile App, both on-site and remotely.
- N. IP Addressable and POE powered Speaker Modules for individual rooms shall be system programmable and may be assigned any two-, three-, four-, five- or six-digit number as well as name and description. Any extension may be reassigned at any time.
- O. IP-enabled two-way voice communication shall be available from any provided telephone or administrative console through any speaker in a campus. This shall allow hands-free communication to any classroom or any individual loudspeaker unit. A programmable pre-announce tone shall sound immediately before the intercom path is opened and a supervisory tone shall continue to sound at regular intervals when speaker monitoring is active, complying fully with all privacy legislation. Pre announce tone and supervisory tones shall be disabled during designated emergencies automatically.
- P. The platform shall allow users to configure multiple schedules per school, with a minimum of 500 unique events per schedule, and automatic Daylight Savings time correction. Schedules can be programmed to occur once, daily, weekly, monthly, or in any combination of the preceding recurrences. Each school may have a minimum of 20 unique bell schedules, with a minimum of 5 active schedules on any given day for each campus. User shall be able to select from 25 standard included tones as well additional user created and uploaded audio files for class change signaling and messaging. In addition, scheduled events shall include relay actions, email notifications, and paging exclusions as system configuration changes. The platform shall allow control of the bell schedules via the district WAN/LAN without the need for a separate server at each school location. Bell schedules can be remotely created, changed, stored and assigned to calendar days for the local school by an authorized user from a web-based user interface.
- Q. The platform shall be able to integrate with an existing PA system or operate as a fully independent IP solution. The platform shall be able to function in combination of said configurations, and allow for seamless communication within a school or district-wide, regardless of the type of configuration used. The platform shall be scalable, with the ability to easily add, install, and configure additional equipment to a system.
- R. The platform allows for customization of preprogrammed sequences, used for emergencies, events, and everyday communications. Preprogrammed sequences can be activated from the push of a relay button, soft key of an administrative console, a dial string of a SIP phone, or a web browser configured to the district network. Sequences can be initiated automatically as part of a schedule or on the fly. Preprogrammed sequences can be customized to utilize any combination of audio tones, emails, relays, tone exclusions, swings, delays, SIP phone notifications, and program distribution. Audio tones can include customized audio files and voice messages, recorded in any language. Uploaded audio tones and messages can be preprogrammed to announce repeatedly or individually, as part of a scheduled sequence or on the fly. Each school in a district can have its own customized sequences, and can be activated individually, in groups, or district-wide.
- S. The platform allows for emergencies to be initiated in a drill environment, separate from real emergencies. Drill emergencies can be initiated from panic buttons, consoles, SIP phones, or a web browser.
- T. The platform shall provide status lights that will display the status of individual classrooms and school emergency status at the same time. Status lights will be customizable in color and flash rate based on events.
- U. Visual message boards are available in 2 sizes. Small message boards have 8 by 40 LED display with 3 color LED's. the large message board will have 2 lines with 16 by 80 LED display with 3 color LED's. During idle time the message boards can display date and time. They can also display countdowns for class change or status of an emergency. The user will have the ability to change the messages on the fly to display instructions or directions. Status lights can be

tied to message boards to give more information as to status of classrooms that checked in or groups of rooms that checked in.

- V. POE zone page amplifier module. This component will give the schools the ability to place an amp to drive groups of speakers where local power is not available. Each amplifier on the network will send notification for any reason that it is offline or powered down. Depending upon configuration the amplifier will have 14 or 35 watts of output. The module can be either wall or rack mounted.
- W. First Responders Notification. This feature can be initiated so the status lights do not display the rooms that checked in until the first responders are on site. This will not have an effect on any of the other check-in notifications. The App, console and computers can still display the rooms that have checked in.
- X. TCU App. This app can be installed on either Android or Apple devices. The App can process up to 18 different emergencies. The App will update in real time rooms that have checked in OK. It can also display a Fire emergency is in effect during an emergency.

2.02 EQUIPMENT AND MATERIAL

A. Server Software

1. Provides district-wide paging, bell event scheduling, emergency notification and configuration for entire district.
2. Ability to configure system and initiate system features, per school and district-wide via web-based user interface.
3. The software has the ability to sync system time to the Atomic Clock Signal or to the school's or district's network time server.
4. The software will provide a web browser to deliver district-wide emergency paging, pre-recorded messages and tones from any authorized computer in the facility or the district. The software must be capable of automatically notifying district personnel via the WAN/LAN of an alarm condition.
5. The software can automatically broadcast emergency instructions via associated system hardware throughout an entire district when an alarm (e.g., lockdown, lockout, security, fire) is initiated via the web-based user interface. The emergency instructions are preprogrammed and require no user intervention. Bell tones are able to be halted during an emergency. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.
6. The software allows for user-uploaded pre-recorded messages and tones. Software supports the upload of MP3 and WAV file types. User-uploaded pre-recorded messages and tones can be part of emergencies, sequences, and bell schedules.
7. The software can be installed in cloud, virtual or physical server environments.
8. The web-based user interface supports secure HTTP browsing.
9. The software supports encryption to ensure secure access.
10. The system shall monitor itself if devices go offline and system actions are not received. Specified users shall receive email notifications when devices go offline. The software shall be able to keep a log and report on system activity within a school or all schools district-wide for a minimum of one year. These reports can be exported to excel spreadsheets.
11. The software will support a minimum of 20 bell schedules per school, with 5 schedules assignable to a specific school day. Bell schedules can be programmed to annunciate tones, activate relays, send emails, activate program distribution, and notify SIP phones.
12. The system allows programmable end points to be automatically included or excluded for live paging, bell tones, or prerecorded audio, depending on the time or day or day of the week. These inclusions/exclusions can be applied manually or automatically depending on their schedule.
13. The software can automatically send an email, as part of a programmed sequence of events, to district administrators alerting them of an emergency within the district.
14. The software provides the ability to view schools that are in an emergency status, using any web browser on the district's network. The software shall identify the name of the school in an emergency as well the type of emergency that school is in.

15. The system has a minimum of 5 customizable emergencies, one of them being an All-Clear with the ability to return the system from an emergency to normal status. Each emergency shall have a minimum of 500 unique events.

B. Campus Controller

1. Provides call routing for paging and intercom for a single facility.
2. System shall connect to the district provided Telephone Network via a SIP connection.
3. Support a flexible numbering plan allowing two-, three-, four-, five-, or six-digit extensions.
4. SIP interface to a district provided Telephone Network shall be capable of allowing connected phones to display classroom call-ins, answer internal intercom call-ins, make pages and change priorities of call-ins in progress.
5. Direct dialing, two-way amplified voice intercom between any provided telephone or admin console and speaker without the use of a press-to-talk or talk-listen switch.
6. Ability to upgrade priority level from individual call switch.
7. The ability to answer intercom call-ins registered at administrative consoles and pre-selected telephones.
8. The ability to automatically escalate incoming call-ins to an alternate telephone or group of telephones if they remain unanswered for a predetermined amount of time.
9. The ability to manually upgrade an intercom call-in to an alternate telephone or group of telephones.
10. The ability for classrooms to "check-in" via push button when they have successfully secured their location during emergency.
11. Administrative console shall display locations that have not checked in to confirm their secured location and provide hands-free audio monitoring and communication to unsecured locations.
12. The controller shall not need direct connection to any classroom via home run or distributed wiring. It shall communicate solely through the IP network.
13. Single button access from any console on the system to distribute emergency announcements within the facility to all or select locations equipped with speakers. Emergency announcements originating from any assigned administrative console shall have priority over all regular system functions.
14. Ability for administrative consoles and connected phones to selectively monitor audio at any two-way speaker during an emergency.
15. Stores a minimum of 48 hours' worth of Bell Event Schedules, all emergency notification sequences as well as facility wide configuration.
16. System has the ability to sync system time to the Atomic Clock Signal or to the school's or districts network time server.
17. System's SIP Interface shall provide:
 - a. Audio paging access from any telephone to any single intercom speaker, zone (group) of intercom/paging speakers, or all speakers/paging horns throughout the entire facility.
 - b. Ability to answer a call-in directed to that SIP extension.
 - c. Ability to upgrade a call-in directed to that SIP extension.
 - d. Single button access from any telephone on the system to initiate alarm signals within the facility to all or select locations equipped with speakers. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative telephone shall have priority over all regular system functions.
 - e. Ability to initiate a school-wide emergency including lockdown and evacuate sequences.
 - f. SIP device shall display call-in information from call in switch. Information will include a minimum of Classroom Name, Number, and Priority Level.
18. The system will have the ability to utilize a web browser and a USB microphone connected to the PC to deliver district-wide live emergency paging, pre-recorded messages and tones from any authorized computer in the facility or the district. The system must be capable of automatically notifying district personnel via the WAN of an alarm condition.

19. The system can automatically broadcast emergency instructions throughout an entire campus when an alarm (e.g., lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. Bell tones are able to be halted during an emergency. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.
20. The system will have the ability to utilize a desktop microphone to deliver school-wide live emergency paging and zone paging throughout the facility.
21. The system can integrate with emergency weather radios to generate live emergency broadcasts notification throughout a facility.

C. IP Addressable Modules

1. System shall provide multiple IP Addressable Modules for intercom, paging and relay activation.
 - a. All Modules are POE 802.3af compliant
 - b. All Modules support DHCP.
 - c. All Modules connect to network with a single RJ45 connector (PoE Required)
2. IP Addressable Speaker Module
 - a. Shall interface to school's data network, a classroom speaker, and multiple call switches.
 - b. A minimum of 5 levels of call-in can be placed from an IP Speaker Module. The call-ins are routed to administrative consoles and select SIP connected telephones and can only be cleared from the system once answered. If a call-in is not answered within a preprogrammed time the call-in may reroute to other telephones, consoles, and speakers.
 - c. An option for Privacy call in switches is supported. When the Privacy switch is activated, it prevents administrative or classroom telephones from monitoring the specific classroom/location intercom speaker.
 - d. The ability to belong to one or more of a minimum of 100 independent zones for zone paging, program/music distribution zones and class change tone zones; this assignment is a programmable function, changeable by time of day. Each IP Speaker Module's location shall be programmed in software to belong to any combination of software zones. IP Speaker Modules shall be designed to mount near ceiling and wall speakers and in the plenum space.
 - e. Intercom and paging volume adjustable from Software interface.
 - f. Module will support and power a status light that displays individual classroom information including call-ins placed, testing status and emergency check-in status.
3. IP Addressable Zone Paging Module
 - a. Zone Paging Module shall connect multiple speakers for district all page, all page, zone paging, bells, audio events and, emergency notification.
 - b. Zone Paging Modules shall be rack and wall mountable.
 - c. Zone Paging Modules shall be able to belong to one or more of 100 independent zones for live paging, bells, pre-recorded audio and emergency notification.
4. IP Addressable Aux I/O Module
 - a. Aux I/O Module shall have two input contacts and two output contacts.
 - b. Input and output contacts are individually addressable.
 - c. Aux I/O Module shall be wall and rack mountable.
 - d. User can program relays to be activated manually, through an event/bell schedule, or during emergency notification.
 - e. Aux I/O Module can perform school lockdown from a single press of a panic button.
5. IP Addressable Program Line Input Module
 - a. Program Line Input Module shall provide line level audio program distribution into system.
 - b. Program Line Input Module shall have a 3.5mm cable jack.
 - c. Program Line Input Module shall be configured via web-based user interface.

- d. User can configure program distribution to be activated manually or automatically through an event/bell schedule.
 - e. Program Line Input Module will have a system priority level such that emergency communications override program distribution.
- 6. IP Addressable Microphone Input Module
 - a. The system shall support a minimum of five (5) Microphone Input Modules per school.
 - b. Microphone Input Module shall support dynamic and condenser style microphones.
 - c. Microphone Input Module shall support microphones with or without Push-To-Talk functionality.
 - d. Microphone Input Module shall support configurable paging priorities.
 - e. Microphone Input Module shall provide user feedback for paging activity.
 - f. Microphone Input Module shall have adjustable microphone gain levels.
 - g. Microphone Input Module shall be configurable from the web-based user interface.
 - h. Live pages from the Microphone Input Module can automatically increase audio priority during an emergency.
- D. IP Addressable Administrative Console
 - 1. A full color screen with 64 soft keys, 3 line select, volume control, push to talk, speakerphone mode and left/right and up/down scrolling.
 - 2. Audio paging access from any Console to any single intercom speaker, zone (group) of intercom/paging speakers, or all speakers/paging horns throughout the entire school.
 - 3. Programmable soft key access from any console on the system to initiate alarm signals within the school to all or select locations equipped with speakers. A minimum of 25 separate distinct alarm signals shall be provided. Alarm signals originating from any assigned administrative console shall have priority over all regular system functions.
 - 4. Programmable soft key access from any console to automatically broadcast page emergency instructions throughout an entire school when an alarm (e.g., lockdown, lockout, security, fire) is tripped or manually activated. The emergency instructions are preprogrammed and require no user intervention. The system provides redundant alarm annunciation over intercom/paging speakers and is not meant to replace primary fire alarm or security systems.
 - 5. Ability to perform intercom to any single IP Addressable Speaker Module.
 - 6. Ability to display 3 call-ins at a time on the screen while other call-ins are annunciating and the ability to scroll to view all call-ins.
 - 7. Ability to upgrade a call-in via soft key.
 - 8. Programmable soft key access from any console for activating relays, campus wide.
 - 9. Ability to maintain, along with controller and other IP Modules system functions, including intercom, bells and paging for the local campus in the event of district-wide connection loss.
 - 10. Classrooms that have not 'checked-in' during an emergency are listed on the Administrative Console's screen.
 - 11. The time duration of an emergency is shown on the screen of the administrative console. The check-in timer is shown on the screen of the administrative console.
- E. Audio Paging/Program Amplifiers
 - 1. Power amplifier(s) shall be provided to provide a minimum of 2 watts of power to all paging speakers, and 15 watts of power to all paging horns.
 - 2. The maximum load on the paging/program amplifiers shall be 80% of the rated maximum output of the amplifiers.
 - 3. Amplifier(s) output shall be 150 Watts @ 25 Volts, 4 Channel Industrial Grade with no fans - Ashley TRA4150. One Channel per Zone.

F. Zone Page Amplifier Module

1. Depending on configuration the amp output is either 14 or 35 watts.
2. Can be wall or rack mounted.
3. Powered with either a wall wort or POE+.
4. Supervised via network connection.

G. Visual message boards.

1. Can be powered by either POE or POE+ depending on size and features.
2. Comes in two sizes:
 - a. Large, 2 lines (16 by 80 LED) display
 - b. Small, 1 line (8 by 40 LED) display
3. Three color LED's.
4. Static or scrolling message display.
5. Instant visual messaging to any or all locations.
6. Idle mode can be various formats of time/date display.

H. Input/Output Module

1. Provides dual input and dual output contact closure points to control external devices such as Alert Lights, Strobes, Fire Alarm Panels or Security systems.
2. Provides the ability to connect panic buttons to the system. Digital encryption of all control signals for excellent security.
3. Compliant with IEEE 802.3af Power over Ethernet (PoE) Standard.
4. Independent relay outputs: 2 Dual Pole, Single throw (DPST), 30 VDC at 5 Amperes, 125 VAC at 5 Amperes.
5. Network compliant with one RJ-45 Network Socket, 24 AWG Minimum Category 5e or better.

I. Interior Ceiling Speakers (IP Addressable)

1. Provide Ceiling Speaker Assembly consisting of 8 Ohm, speaker mounted in a 2 foot by 1 foot, lay-in baffle, with an integrated back box that covers the full area of the baffle.
2. The speaker shall be connected by inserting an 8-pin RJ45 terminated CAT 5e or Cat 6 cable.
3. The speaker shall include provisions to allow attachment of a safety cable if required.
4. Rauland model BAFKIT1X2S8RJ.

J. Interior Ceiling Speakers

1. Provide Ceiling Speaker Assembly consisting of 25/70 Volt, speaker mounted in a 2 foot by 1 foot, lay-in baffle, with an integrated back box that covers the full area of the baffle.
2. The speaker shall be connected by tapping the speaker transformer at 1/4, 1/2, 1, 2 or 5 watts.
3. The speaker shall include provisions to allow attachment of a safety cable if required.
4. Rauland model BAFKIT1X2S.

K. Wall Surface Mounted Interior Speakers

1. Provide wall mount interior speaker with an 8" O.D., dual cone loudspeaker and a 5W, 25/70V transformer mounted on a square, screw mount, steel baffle with a slanted, steel, vandal resistant, surface mount enclosure with four (4) 8-32 threaded inserts, a single 1/2" conduit entrance on the back, and two (2) Wiremold knockouts and a white, powder coat finish.
2. Provide Part Number: Quam System 2

L. Wall Surface Mounted Interior Paging Horn

1. Provide a Vandal Resistant horn assembly featuring a double re-entrant, compression horn with and integrated 16W,25/70V, multi-tap transformer that is mounted on a vandal resistant baffle. It also includes a square, heavy gauge steel surface mount enclosure with 4 threaded inserts for baffle attachment, a single ½" conduit entrance and wire mold entrance on the top and bottom. It is a high durability, white, powder coat finish.
2. Provide Part Number: Quam System 6VP

M. Exterior Wall Mounted Horn

1. Provide heavy duty type horn loudspeakers with integral driver. The horn loudspeaker shall be impervious to weather and vandalism. Horn shall be constructed of 14 – gauge, carbon steel. Horn loudspeaker drivers shall be rated at 16 watts with a frequency response of 350 Hz to 10,000 Hertz. Sensitivity shall be 108 dB 1 watt, 1 meter. Transformer assembly shall be dual voltage multi-tap type suitable for 25 or 70-volt installations.
2. The surface mount back box shall vandal resistant with tamper resistant screws.
3. The baffle shall be vandal proof, square, two-piece construction, 14-gauge carbon steel, baked white epoxy finish. Dimensions 11.7" square with a 4.0" depth.
4. Provide Part Number: Quam H16/SVPS Compression horn with Stainless Steel Baffle with an ES-85 back box for flush mount or a SE1WVPS stainless steel surface mount back box.

N. Volume Control

1. The Area Speaker Volume Control is designed to control the volume of either one or several speakers in a commonly wired group for up to 10 watts of total power. It provides 10 steps of attenuation plus an Open Circuit position, and is designed for use with either 25V or 70V lines. Attenuation is accomplished in 6dB steps at positions 1 and 2, and in 3dB steps at positions 3 through 10. To prevent damage to the control, there is not stop between position "10" (Max) and "0" (Off). The unit features silver plated switch contacts and a brushed stainless steel single gang wall plate with a black knob. Unit installs in a standard single gang electrical box.
2. Rauland model ACC1300.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine conditions, with the Installer present, for compliance with requirements and other conditions affecting the performance of the School Communications and School Safety Network.
- B. Do not proceed until unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. General: Install system in accordance with NFPA 70 and other applicable codes. Install equipment in accordance with manufacturer's written instructions.
- B. Furnish and install all material, devices, components and equipment for a complete operational system.
- C. Impedance and Level Matching: Carefully match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

- D. Control Circuit Wiring: Install control circuits in accordance with NFPA 70 and as indicated. Provide number of conductors as recommended by system manufacturer to provide control functions indicated or specified.
- E. All housings are to be located as indicated.
- F. The contractor shall provide necessary transient protection on the AC power feed, all copper station lines leaving or entering the building, and all central office trunks. All protection shall be as recommended by the equipment supplier and referenced to earth ground.
- G. Wiring within Enclosures: Provide adequate length of conductors. Bundle, lace, and train the conductors to terminal points with no excess. Provide and use lacing bars.
- H. Provide physical isolation from speaker-microphone, telephone, line-level wiring, and power wiring. Run in separate raceways, or where exposed or in same enclosure, provide 12-inch minimum separation between conductors to speaker-microphones, telephone wiring and adjacent parallel power. Provide physical separation as recommended by equipment manufacturer for other system conductors.
- I. Identification of Conductors and Cables: Use color coding of conductors and apply wire and cable marking tape to designate wires and cables so all media are identified in coordination with system wiring diagrams.
- J. Weatherproofing: Provide weatherproof enclosures for items to be mounted outdoors or exposed to weather.

3.03 GROUNDING

- A. Provide equipment grounding connections for Integrated Electronic Communications Network systems as indicated. Tighten connections to comply with tightening torques specified in UL Standard 486A to assure permanent and effective grounds.
- B. Ground equipment, conductor, and cable shields to eliminate shock hazard and to minimize to the greatest extent possible, ground loops, common mode returns, noise pickup, cross talk, and other impairments. Provide 5-ohm ground at main equipment location. Measure, record, and report ground resistance.
- C. Provide all necessary transient protection on the AC power feed and on all copper station lines leaving or entering the building. Note in system drawings, the type and location of these protection devices as well as all wiring information.

3.04 FIELD QUALITY CONTROL

- A. Manufacturer's Field Services: Provide services of a duly factory authorized service representative for this project location to supervise the field assembly and connection of components and the pre-testing, testing, and adjustment of the system.
- B. Inspection: Make observations to verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Provide a list of final tap settings of paging speaker line matching transformers.
- C. Testing: Rectify deficiencies indicated by tests and completely re-test work affected by such deficiencies at Contractor's expense. Verify by the system test that the total system meets the Specifications and complies with applicable standards.

3.05 FINAL ACCEPTANCE TESTING

- A. The Final Acceptance Testing shall be provided to the Owner or the Owners designated representative only. Final acceptance testing to any other trade or service provider for the project will not comply with the requirements of this section.
- B. The contractor will provide a Final Acceptance Test record document signed by both the contractor and the Owner or designated Owner's Representative establishing the "In Warranty" date. The warranty period will not commence until the Final Acceptance Test is completed.
- C. Be prepared to verify the performance of any portion of the installation by demonstration, listening and viewing test, and instrumented measurements. Make additional adjustments within the scope of work and which are deemed necessary by the Owner because of the acceptance test.

3.06 COMMISSIONING

- A. The contractor shall train the Owner's maintenance personnel in the procedures and schedules involved in operating, troubleshooting, servicing, and preventative maintenance of the system. This training will be in accordance with the training as outlined in Section 1.6 of these specifications. In addition to the Training Materials provided, the contractor will also furnish Operators Manuals and Users Guides at the time of this training.
- B. Schedule training with Owner through the owner's representative, with at least seven days advance notice.

3.07 OCCUPANCY ADJUSTMENTS

- A. The contractor shall provide Occupancy Adjustments in accordance with Section 1.6 of these specifications. A response scenario amenable to both the owner and the contractor will be established and followed for the first year of service.

3.08 CLEANING AND PROTECTION

- A. Prior to final acceptance, the contractor shall vacuum and clean all system components and protect them from damage and deterioration. All blank spaces in equipment cabinets will be covered with blank panels. Top and side panels, and all cabinet doors will be installed. All general areas within and around all equipment rack/cabinets in the facility will be swept, vacuumed, and cleaned up. No cabinets will be left unlocked and all cabinet keys will be turned over to the owner or designated owner's representative.

END OF SECTION 27 5120

SECTION 27 5319 - DISTRIBUTED ANTENNA SYSTEM

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. This specification describes the technical and performance criteria for deploying a Neutral-Host Basic Distributed Antenna System (DAS) to support Wireless Service Providers (WSP) for Cellular Telephones.
 - 1. The professional scope of work includes, but may not be limited to, the following:
 - a. Design, construct, install, operate, and maintain a neutral host solution to support RF-based telecommunications applications to a DAS at the System Location.
 - b. Provide commercial mobile radio service providers with access to the DAS for purposes of receiving and transmitting radio frequency signals to portable wire-less devices used by persons using, visiting, and/or attending events at the System Location.
 - c. Responsibility for all DAS operations that commercial mobile radio service providers are currently authorized by the FCC to implement, as well as a licensed spectrum that may be implemented for wireless service in the future, the negotiation of multiple wireless carrier sub-license agreements, carrier installation and access supervision, DAS monitoring, repair and maintenance, and radio frequency interference management.
- B. Bidder Qualifications:
 - 1. All bidders shall have demonstrated experience with projects of similar size and complexity within the past 5 years. References to be made available upon request.
 - 2. All bidders shall have design experience on projects of similar size and complexity with the proposed manufacturer.
 - 3. All bidders shall be design certified with the manufacturer.
 - 4. All bidders shall be both RF design and commissioning certified by the Original Equipment Manufacturer (OEM) for the system proposed in their bid submission.

1.02 RELATED DOCUMENTS

- A. American National Standard ANSI/TIA/EIA Telecommunications Building Wiring Standards.
- B. Drawings and general provisions of the Contract, including General and Supplemental Conditions and other Division 1 Specification Sections, apply to this Section.

1.03 RELATED SECTIONS

- A. Refer to the following sections for additional requirements for the Communications Distribution System (CDS):
 - 1. Section 27 0100 - Basic Communications Systems Requirements
 - 2. Section 27 0529 - Hangers and Supports for Communications Systems
 - 3. Section 27 0553 - Identification for Communications Systems
 - 4. Section 27 1500 - Communications Cabling

1.04 SECTION INCLUDES

- A. This specification describes technical and performance criteria for deploying a Neutral-Host Distributed Antenna System (DAS) capable of supporting Wireless Service Providers (WSP). The DAS components specified in this document include:
1. Donor Antennas
 2. Network Unit (NU)
 3. Coverage Unit (CU)
 4. Fiber Hubs (FH)

1.05 SYSTEM DESCRIPTION

- A. The DAS shall provide coverage throughout the entire building.
- B. The DAS shall be carrier neutral and support every commercial mobile radio service provider independent of the wireless frequencies and format used.
- C. The DAS and all its subsystems shall be designed to operate 24 hours per day, 7 days per week, 365 days per year.
- D. The DAS will be subject to periodic reviews and upgrades as technologies evolve and must be able to expand to accommodate additional interested carriers at later intervals.
- E. The DAS design must use modular architecture.
- F. Prior to any installation, all equipment and antenna-mounting locations are to be reviewed and approved by the engineer.
- G. Services: Upon commissioning, the DAS shall provide coverage for the WSP's. Listed below are the frequencies currently being used by the designated WSP's in the given market.
1. AT&T Wireless
 2. T-Mobile
 3. Verizon
- I. Expansion: Without replacing the Passive DAS Infrastructure, the DAS shall have expansion capabilities to support the following WSP technologies/frequency bands deployed in a SISO antenna environment. Any additional components required for system expansion shall comply with all specifications of this Section.

Service	Uplink, MHz	Downlink, MHz
Cellular	824 - 849	869 - 894
PCS	1850 - 1920	1930 - 2000
AWS	1710 - 1780	2110 - 2180
WCS	2305 - 2315	2350 - 2360
Commercial 700 Bank	698 - 716, 776 - 787	728 - 746

- J. WSP Approval: The Contractor shall propose and deploy a DAS System capable of receiving WSP Approval for interconnection to the WSP's macro networks.
- K. Broadband Active Distribution: CAT5e (minimum) cable will be used for Active distribution.

L. Network Management:

1. NMS: The DAS shall have a Network Management System (NMS) capable of alarm, monitor, configuration and control of all Active Components.

1.06 ALTERNATIVES

- A. No alternative component(s) shall be accepted as equal to the components and manufacturers specified in this document unless the Contractor proves that the alternative component(s) are of equal or superior specifications and quality, and that they have been used in similar projects of size and complexity for no less than 3-years. The following information shall be required for each alternative component with submittal of the bid response:

1. Passive Components:
 - a. Product samples
 - b. Detailed product specifications
 - c. Independent test results verifying the productspecifications
 - d. Written documentation from the manufacturer guaranteeing that the alternative component(s) shall remain available for new purchase for a period of 7-years from the date of system acceptance.
2. Active Components:
 - a. Hardware and software manuals
 - b. Detailed product specifications
 - c. Mean Time Between Failure (MTBF) data for each Active Component
 - d. Independent test results verifying the productspecifications
 - e. Written documentation from the manufacturer guaranteeing that the alternative component(s) shall be supported for a period of 7-years from the date of system acceptance.
 - f. For Active Components serving the WSPs, written documentation from the WSPs that the alternative component(s) are approved for use within the WSP's network and that interconnection of the DAS to the WSP's network will not be withheld due to the alternative component being used in the DAS.

1.07 CODES, STANDARDS AND CERTIFICATIONS

- A. All work, including but not limited to: cabling, pathways, support structures, wiring, equipment, installation, workmanship, maintenance and testing shall comply with the latest editions of the National Electrical Code, National Electrical Safety Code, all applicable local rules and regulations, equipment manufacturer's instructions, and the National Electrical Contractors Association (NECA) Standard of Installation. In case of discrepancy or disagreement between the documents noted above, the contractor shall satisfy the most stringent requirements.

1.08 ABBREVIATIONS AND ACRONYMS

- A. ACG: Automatic Gain Control
- B. ATP: Acceptance Test Plan
- C. AWS: Advanced Wireless Service
- D. BOM: Bill-of-Material
- E. BRS: Broadband Radio Service
- F. BTS: Base Transceiver Station

- G. DAS: Distributed Antenna System
- H. EBS: Educational Broadband Service
- I. ESMR: Enhanced Specialized Mobile Radio
- J. FCC: Federal Communications Commission
- K. GUI: Graphical User Interface
- L. LTE: Long Term Evolution
- M. MTBF: Mean Time Between Failure
- N. NFPA: National Fire Protection Association
- O. NMS: Network Management System
- P. PCS: Personal Communications System
- Q. RoF: Radio-over-Fiber
- R. RoHS: Restriction of Hazardous Substances BB. RSL: Received Signal Level
- S. SISO: Single-Input, Single-Output DD. SMR: Specialized Mobile Radio EE. SMS: Short Message Service
- T. SNIR: Signal-to-Noise Interference Ratio
- U. SNMP: Simple Network Management Protocol HH. SOW: Statement of Work
- V. VSWR: Voltage Standing Wave Ratio JJ. WSP: Wireless Service Provider
- W. WSP: Wireless Service Provider

1.09 DEFINITIONS

- A. Acceptance: Expressed approval by the customer
- B. Active: DAS components that require AC/DC power for operation
- C. Carrier Approval: Expressed approval to interconnect to the WSP macro network
- D. Channel: A path for an RF transmission between two points
- E. Component: A main system element of the DAS
- F. Contractor: The prime contractor bidding the project
- G. Passive: DAS components that do not require AC/DC power for operation

1.10 PERFORMANCE REQUIREMENTS

A. WSP DAS:

1. On a per channel basis, the downlink RSRP for each frequency band shall meet or exceed the criteria in Table 1.

Table 1 - System Parameters

Parameters	Unit	Cellular, PCS, AWS,	700, 800 MHz
Minimum downlink Reference Signal Re- ceive Power (RSRP)	dBm	-100	-100

2. Contractor shall state the assumed channel loading and frequency bands for the proposed WSP in-building coverage. Prior to installation, contractors shall confirm the channel loading and frequency use in the serving area, and shall guarantee coverage for these channels per the criteria in Table 1.
3. The DAS shall deliver coverage per the criteria in Table 1 throughout 95% of the building. The coverage areas shall include the stairwells, elevators, basement, and garage.
4. The contractor shall explain the method used to avoid downlink and uplink interference.

1.11 ADDITIONAL REQUIREMENTS

- A. WSP Approval: The Contractor shall be responsible for providing the WSP with the information each WSP requires to approve interconnection of the DAS to the WSP's macro network.

1.12 SUBMITTALS

A. Submittal Requirements Prior to Start of Construction

1. Final RF link budget
2. Overlay of system Components on floor plans
3. Drawings for Donor Antenna and grounding
4. RF propagation modeling
5. Signal to Noise Interference Ratio (SNIR) Map
6. Bill-of-Material (BOM)
7. Maintenance Service Contract
8. Statement of Work (SOW): The contractor shall submit a SOW that has been accepted by the customer or customer's designated representative.
9. Acceptance Test Plan (ATP): The contractor shall submit an ATP that has been accepted by the customer or customer's designated representative.

B. Submittal Requirements at Close Out

1. Drawings - submit as-built drawings indicating:
 - a. Donor antenna, grounding and lightning protection details
 - b. Cable routing, splitters, couplers and coverage antenna locations
 - c. Active component locations, layout and configuration
2. Test Reports
 - a. WSP DAS: Submit accepted ATP reports confirming the requirements of Section 1.07 A have been met.

- b. PSN: Submit Accepted ATP reports confirming the requirements of Section 1.07 B have been met.
- 3. Field Reports: Submit sweep-testing results for all cable runs.
- 4. Field Reports: Submit OTDR test results for all fiber runs.
- 5. Operation and Maintenance Data: Submit hardware and software manuals for all Active Components.
- 6. Warranty Documents:
 - a. Submit for all manufactured components specified in this Section.
 - b. Submit Contractor's System Warranty.
 - c. Submit Manufacturer's Extended Warranty.

1.13 QUALITY ASSURANCE

- A. Qualifications: Contractor, and/or Sub-Contractors, shall have a minimum of 5-years full-time experience executing work of similar scope and complexity.
- B. Certifications:
 - 1. Passive Components: Contractor or Sub-Contractor shall provide manufacturer certification that their personnel have been trained on the components being installed.
 - 2. Active Components: Contractor or Sub-Contractor shall provide manufacturer certification that their personnel have been trained on the components being installed.

1.14 WARRANTY

- A. Manufacturer Warranty
 - 1. Splitters, Couplers and Coverage Antennas: 1-year limited warranty from date of system acceptance.
 - 2. Coaxial Cable and Connectors: 10-year limited warranty from date of system acceptance.
 - 3. Fiber Optic Cable: 20-year limited warranty from date of system acceptance.
 - 4. Active Components: The earliest of 1-year limited warranty from date of system installation or 15 months from date of shipment.
- B. Contractor Warranty: Contractor shall warrant the system performance as specified in Section 1.09 for 1-year.
- C. Manufacturers Extended Warranty:
 - 1. The DAS shall be covered by a two-part certification program provided by a single manufacturer and that manufacturer's certified contractor. The certification program covers a certified system defined as a DAS installation performed by a certified contractor using components conforming to section 2.01 following all the manufactures recommendations, installation instructions and bestpractices.
 - 2. Manufacturer shall administer a follow-on program through the contractor to provide support and service to the purchaser. The first part is an assurance program, which provides that the certified system will support current and future modulation formats in the frequency bands for which it is designed, during the 20-year warranty of the certified system.
 - 3. The second portion of the certification is a 20-year warranty provided by the manufacturer and the contractor on all cable products within the system (UTP cable, Fiber Optic cable, coaxial riser cable, plenum coaxial cable and associated connectors, etc.).
 - 4. In the event that the certified system ceases to support the certified application(s), whether at the time of ATP, during normal use or when upgrading to additional frequency bands, the manufacturer and Contractor shall commit to promptly implement corrective action.
 - 5. Manufacturer shall maintain ISO Quality Control registration for the facilities that manufacture the products used in the DAS.

1.15 MAINTENANCE

- A. The Contractor shall provide an optional maintenance service contract, covering for a period of one-year: preventative maintenance, system monitoring, spares, fault mitigation, equipment repair, and response time.

1.16 SYSTEM SUMMARY

- A. The following are feature of the Nextivity CEL-Fi Quatra 4000C system.
- B. System Features
 - 1. Enterprise-class, carrier-grade, small footprint active DAS
 - 2. RF inputs for ultra-high gain parabolic antenna (BT974822)
 - 3. Network Unit (NU) (Head End) attaches to Coverage Unit (CU) (Remote Unit) via Cat 5e (minimum) cable
 - 4. A single NU and up to six (6) CUs may be attached (hub and spoke architecture) in a Cel-Fi QUATRA 4000C system
 - 5. Multiple Cel-Fi QUATRA 4000C systems may be deployed to increase coverage footprint
 - 6. Up to 325 ft (100 m) range from NU to CU
 - 7. Cel-Fi QUATRA Range Extender (QRE) (optional) may be used to increase NU-to-CU distance to 650 ft (200 m)
 - 8. Remote Management through Nextivity's Cel-Fi WAVE cloud platform
 - 9. Easiest installation in its class
 - 10. Glanceable LED User Interface (UI)
- C. Wireless Features
 - 1. Supports up to three bands simultaneously from three operators
 - 2. 5G/4G/LTE support (/ WCDMA / HSPA+ / LTE)
 - 3. Supports FDD
 - 4. Up to 100dB system gain per band (in Off-Air mode)
 - 5. Peaceful coexistence with adjacent Wi-Fi (2.4 GHz & 5 GHz), femtocells, and cellular devices
 - 6. Advanced digital echo-cancellation (>30dB) and channel select filtering algorithms
 - 7. Active management of the cellular link between the Base Station and user devices
 - 8. Automatic Gain Control (AGC) based on fast real-time echo-cancellation
 - 9. Linear RF front end
 - 10. Adaptive signal equalization
 - 11. Uses Nextivity's proprietary IntelliBoost® chip
- D. Mobile Network and Network Protection Features
 - 1. Triple-carrier combinations available: AT&T and Verizon; and T-Mobile Integration, handover, and handoff with the macro network
 - 2. Supports multiple channels with bandwidths of 3.84/5/10/15/20 MHz per channel
 - 3. Works with any user equipment (UE) for the configured networks (no whitelist/blacklist)
 - 4. Up to 75 MHz system total relay bandwidth
 - 5. Support for 3GPP Release 10 features
 - 6. Provider-specific operation: Cel-Fi QUATRA 4000C distributes and boosts service only for the Operator PLMNIDs for which the device is authorized and configured
 - 7. Secure and ciphered provisioning
 - 8. System intelligence accurately establishes proper safe uplink power in real time
 - 9. Uplink Muting Mode automatically shuts down uplink cellular transmissions when no active user equipment is detected

E. Benefits

1. Easiest to deploy Active DAS Hybrid
2. Distribute and boost cellular coverage indoors
3. 4G and 5G support, Voice and Data, network safe
4. Coverage footprint provided via Power over Ethernet (PoE); no requirement for additional power source at CU (RU)

F. Donor Signal

1. Simplest Installation: NU (Head End) and CU (RU) connect with Cat 5e-rated (or better) cable
2. Scalable architecture allows multiple Cel-Fi QUATRA systems to be deployed in the same environment for larger footprint
3. LED cues provides visual feedback for ease of setup and status
4. Works with any subscriber device from the configured carrier
5. System management locally or from the cloud through the Cel-Fi WAVE platform
6. Wall and ceiling mounting options

G. Wireless Benefits

1. Clear and reliable cellular connections within coverage area up to 75,000 ft² per system, and beyond
2. Highest gain (100dB) provides best coverage footprint on location
3. Advanced Echo-Cancelation allows Cel-Fi QUATRA 4000C to transmit more power without feedback interference
4. Subscriber devices require less transmit power for improved battery life
5. Linearity eliminates IMD desense issues
6. Dynamic gain control ensures maximum gain—best coverage—at all times in ever changing RF environments, without user intervention

H. Mobile Network Benefits

1. Flexibly deploy in LTE, VoLTE, LTE-Advanced, and WCDMA networks, with multiple cellular bands, simultaneously
2. Automatically adjusts channel bandwidths from 3.84 MHz to 20 MHz
3. Sufficient relay bandwidth (75 MHz) to support SISO in multiple bands
4. Off-load the macro network, or use to improve macro capacity and building propagation/penetration
5. Cel-Fi QUATRA 4000C system improves users' cellular experience while remaining invisible to networks and UEs: no gateways or third-party software needed
6. UE control is transparent and remains centralized in the network core (no gateways or third-party software)

I. Variants

1. Model Numbers: Q44-1M34
2. Band Supported: 2,4,5,12,13,25,30*,48**,71*
3. Carrier Configuration Available:
 - a. AT&T & Verizon & T-MOBILE

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. Active Components DAS: Nextivity or approved equal.
- B. Cabling and Connectors: As defined in Section 27 1500 "Communications Cabling".

- C. Passive Components (Antennas): CommScope, JMA, Mars, or approved equal.
- D. Uninterruptable Power Supplies (UPS): APC, Alpha or Equivalent
- E. Fiber Optic cable and associated hardware: As defined in section 271500.

2.02 COMPONENTS

- A. Quatra Range Extender (#Q40-0E)
 - 1. The Cel-Fi QUATRA Range Extender is a Power over Ethernet (PoE) device that allows Cel-Fi QUATRA 4000C Network Unit
 - 2. (NU) to Coverage Unit (CU) interconnect cable lengths up to 650 ft. Plug and Play installation.
 - 3. Power over Ethernet+ (PoE+)
 - 4. Extends NU to CU cable to 650 ft (200 m)
 - 5. Supports Cel-Fi QUATRA 4000C proprietary protocols
 - 6. Intuitive LED interface
 - 7. Note: Will not support other (non Cel-Fi QUATRA 4000C) PoE+ devices
- B. Indoor Omni Antenna (#A11-V43-121)
 - 1. The Wideband Indoor Dome Server Antenna receives and transmits signal in a 360° pattern
 - 2. Compatible with the 698 - 2700 MHz frequency ranges that include 3G and 4G signals
 - 3. Omni-Directional
 - 4. N-Type Female connector
- C. Ultra-High Gain Parabolic Antenna (#BT974822)
 - 1. The Ultra High Gain Parabolic Antenna is perfect for use as an outdoor cellular donor signal source
 - 2. 600 - 6500 MHz
 - 3. N-type Female
- D. Attenuator (AN-20N)
 - 1. Frequency Range: DC-3GHz
 - 2. RF Connectors: N Male/Female
 - 3. Maximum Power: 5W
 - 4. Attenuation: 20dB
 - 5. RF Connectors: N Male/Female
- E. Coax Lighting Protector (Tessco Technologies 354405)
 - 1. Frequency Range: 0-6 GHz
 - 2. Connector: N Female
- F. Termination Load (TER-E-3800-2W):
 - 1. Frequency Range: 0-3.800 MHz
 - 2. Impedance: 50Ω
 - 3. Max VSWR: 1.25dB
 - 4. Return Loss: 19dB
 - 5. Total Input Power: 2W
 - 6. Input Connector: N male

- G. 2-Way Splitter (D2-76FN)
 - 1. Frequency Range: 617-5925 MHz
 - 2. Power: 50W avg., 1kW peak
 - 3. Reverse Power: 0.2W as a combiner
 - 4. Impedance: 50Ω nom.
 - 5. PIM: -153 dBc (-110 dBm) min.
 - 6. Connector: N-type
 - 7. Environment: IP65

- H. Wideband Directional Coupler (DC-H05-ON300C(I))
 - 1. Frequency Range: 555-3800MHz
 - 2. Available in 5, 6, 7, 8, 10, 13, 15 & 20dB values
 - 3. Insertion Loss: ≤ 2.4dB
 - 4. Coupling Tolerance (dB): ±1.0dB
 - 5. PIM: ≤-161dBc @ 2 x 43dBm
 - 6. Max Reflection Power: 35W
 - 7. Max Average Power: 300W
 - 8. Max Peak Power: 1000W
 - 9. Impedance: 50Ω
 - 10. Connector: N Female
 - 11. Environment: IP65

- I. HELIAX Plenum Rated Air Dielectric Coaxial Cable (HL4RPV-50)
 - 1. Corrugated Aluminum
 - 2. Off White PVC Jacket

- J. Leviton CAT 6 Cable (LM1000)
 - 1. 23 AWG min

- K. Coaxial Jumper Cable 0.141 (JA-10TN)
 - 1. Length: 1.0m
 - 2. Frequency: DC to 6GHz
 - 3. PIM: <-158 dBc
 - 4. Straight N-Male to Straight N-Female

- L. Coaxial Jumper Cable 0.141 (JA-10MN)
 - 1. Length: 1.0m
 - 2. Frequency: DC to 6GHz
 - 3. PIM: <-158 dBc
 - 4. Straight N-Male to Straight N-Female

- M. Generic RJ45 Connector

- N. CommScope 1/2in N-Male Positive Stop 50 Ohm Connector (L4TNM-PSA)

- O. Non-penetrating Roof Mount (FRM225HC)
 - 1. Item Height: 60"
 - 2. Item Width: 34-3/4"
 - 3. Item Width: 34-3/4"
 - 4. Mounting Pipe 2-1/4"

2.03 NETWORK UNIT AND COVERAGE UNIT (Q44-1M34CNU AND Q41-RECU)

A. Power

1. Input voltage: 100-240 V
2. Power consumption: 321.3 W max.
3. Power cable: Type B (US) to IEC C13
4. Network Unit provides power to Coverage Units over ethernet (PoE+)
5. Bands

Band	Downlink (MHZ)	Uplink (MHZ)	Technology/Bandwidth	Uplink Power(dBm)
2	1930-1990	1850-1910	5G/4G/20 MHz	22
4	2110-2155	1710-1755	5G/4G/20 MHz	22
5	869-894	824-849	5G/4G/HSPA/20 MHz	20
12	729-746	699-716	5G/4G/10 MHz	22
13	746-756	777-787	5G/4G/10 MHz	22
25	1930-1995	1850-1915	5G/4G/20 MHz	22
30*	2350-2360	2305-2315	5G/4G/10 MHz	19
48**	3550-3700	3550-3700	5G/4G/10 MHz	22
71*	617-652	663-698	5G/4G/20 MHz	22

Band	Network Unit Port
2	ATT, VZW, TMO
4	ATT, VZW, TMO
5	ATT only
12	ATT & TMO
13	VZW only
25	ATT, VZW, TMO
30*	ATT only
48**	PVT only
71*	TMO only

6. Specification:
 - a. Network Selection: Automatically best available (WAVE Portal for manual setting)
 - b. Duplex Modes: FDD & TDD
 - c. Number of Relay Bands: 6 max.
 - d. Independent Operators Supported: 3 max.
 - e. Relay Bandwidth per NU Donor Port (ATT/TMO/VZW): 20 + 20 MHz max.
 - f. CU DL Power (All Public Bands): 16 dBm max.
 - g. CU DL Power (PVT Port Band 48): 20 dBm max.
 - h. System Gain: 100 dB max.
 - i. Enterprise-Grade Echo Cancellation: 30 dB min.
 - j. Noise Figure (All Bands): 7 dB max. at ambient (8 dB max. for Band 13 only)
 - k. Return Loss: -8 dB max.
 - l. UL Transmit EVM: 8.5 %, 16-QAM with full RB allocation
 - m. DL Transmit EVM: 8.5%, E-TM3.1
 - n. DL Input Level: -120 to -40 dBm
 - o. RF Interface Impedance (All Ports): 50 Ω
 - p. NU to CU Cable: 2x Category 5e or better Cables ANSI/TIA/EIA 568-B Compliant
 - q. NU to CU Cable Distance: 328 feet (656 feet) (with CEL-FI QUATRA Range Extender) max. with Cat5e. 492 feet (984 feet) (with CEL-FI QUATRA Range Extender) max. with Cat6a 23 AWG.
 - r. Product Settings & SW Updates: WAVE Portal for Desktop

7. Network Unit Interface
 - a. Donor Port RF Connectors: 4x N-type (f) (ATT|TMO|VZW|PVT)
 - b. Power Port: IEC C13
 - c. Power Control: ON/OFF Switch
 - d. Cellular Modem Antenna Connector: 1x SMA (f)
 - e. Cellular Modem GPS Antenna Port: 1x SMA (f)
 - f. Cellular Modem SIM: Nano SIM (Included with 1-year free service)
 - g. Status LED (Power/LAN/Modem): Bi-Color Green/Red
 - h. Status LED (6x CU Link/SFP+): Green
 - i. CU Interface: 2x RJ45 per CU
 - j. Number of CU max. per NU: 6
 - k. NU-Hub Expansion: SFP+
 - l. Number of CU max per CEL-FI QUATRA 4000 Fiber Hub (Q40-1234FNU): 6
 - m. Monitoring & Management: LAN RJ45
 - n. COMPASS XR and Factory Debug: USB 2.0 Micro-B
8. Coverage Unit Interface
 - a. Server Antenna RF Connector: N-type(f)
 - b. NU Connectivity: 2 x RJ45
 - c. Status LED (Power): Bi-Color Green/Red
 - d. Status LED (NU Link/Cable Link): Green
 - e. Factory Debug Only: USB 2.0 Micro-B
9. Compliance
 - a. FCC: Part 15, Part 20, Part 22, Part 24, Part 27, Part 90, Part 96
 - b. UL: Yes
 - c. ISED: Yes (for Q44-1M34CNU & Q41-RECU only)
10. Power
 - a. Input Voltage: 100V-240V
 - b. Power Consumption: 321.3W
 - c. Power Cable: Type B (US) to IEC C13
 - d. Power Supply Cable: 18 AWG execution
 - e. Power Supply Cable Length: 4.5 ft (1.37m)
 - f. Coverage Unit Power: Power over Ethernet

PART 3 - EXECUTION

3.01 INSTALLATION

- A. The contractor shall design, install, commission and test the DAS in accordance with the manufacturer's instructions and recommendations.
- B. The contractor shall install the DAS in accordance with the accepted SOW.

3.02 ACCEPTANCE TESTING

- A. Acceptance testing will be performed confirming the requirements of Section 1.09 have been met.
- B. The contractor shall complete the acceptance testing as prescribed in the approved Acceptance Test Plan (ATP) submittal.

END OF SECTION 27 5319

SECTION 28 0100 - BASIC ELECTRONIC SAFETY AND SECURITY SYSTEMS REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 28.
- B. This section is a Division 28 Electronic Safety and Security Systems section, and is a part of each Division 28 Section.
- C. Requirements of the following Division 28 Sections apply to this section:
- D. Division 28 Section 28 0500 "Common Work Results for Electronic Safety and Security".

1.02 SUMMARY

- A. This Section includes general administrative and procedural requirements for electrical installations. The following administrative and procedural requirements are included in this Section to expand the requirements specified in Division 01 - reference individual sections for further expansion of these requirements:
 - 1. Abbreviations and Definitions
 - 2. Permits, Codes, and Inspections
 - 3. Visiting Premises
 - 4. Submittals
 - 5. Project Drawings and Specifications
 - 6. Cooperation and Coordination with Other Trades
 - 7. Product Listing
 - 8. Nameplate Data
 - 9. Record Documents
 - 10. Maintenance Manuals
 - 11. Warranty
 - 12. Delivery, Storage, and Handling
 - 13. Sequence of Work
 - 14. Electrical Installations
 - 15. Cleaning
 - 16. Testing
 - 17. Instructions to the Owner

1.03 ABBREVIATIONS

- A. General: Utilize the following abbreviations and definitions for discernment within the Drawings and Specifications.
 - 1. Abbreviations:
 - a. ANSI American National Standards Institute
 - b. ASA American Standards Association
 - c. ASTM American Society of Testing Materials
 - d. BICSI Building Industry Consulting Services International
 - e. CBM Certified Ballast Manufacturers

f.	EC	Electrical Contractor
g.	EIA	Electronic Industries Association
h.	ETL	Electrical Testing Laboratories, Inc.
i.	GC	General Contractor
j.	HVAC	Heating, Ventilating, Air Conditioning Contractor
k.	ICEA	International Cable Engineers Association
l.	IEEE	Institute of Electrical and Electronics Engineers
m.	MC	Mechanical Contractor
n.	NEC	National Electrical Code
o.	NEMA	National Electrical Manufacturers Association
p.	NFPA	National Fire Protection Association
q.	OEM	Original Equipment Manufacturer
r.	OSHA	Occupational Safety and Health Act
s.	PC	Plumbing Contractor
t.	TIA/EIA	Telecommunications Industry Association/Electronic Industries Association
u.	UL	Underwriters' Laboratories, Inc.

1.04 DEFINITIONS

- A. PROVIDE means to furnish, place, erect, connect, test, and turn over to Owner, complete and ready for the regular operation, the particular work referred to.
- B. INSTALL means to join, unite, fasten, link, attach, set up or otherwise connect together before testing and turning over to Owner, complete and ready for regular operation, the particular work referred to.
- C. FURNISH means to supply all materials, labor, equipment, testing apparatus, controls, tests, accessories, and all other items customarily required for the proper and complete application for the particular work referred to.
- D. WIRING means the inclusion of all raceways, fittings, conductors, connectors, tape, junction and outlet boxes, connections, splices, and all other items necessary and/or required in connection with such work.
- E. CONDUIT means the inclusion of all fittings, hangers, supports, sleeves, etc.
- F. AS DIRECTED means as directed by the Architect or their representative.
- G. CONCEALED means embedded in masonry or other construction, installed behind wall furring or within double partitions or installed within hung ceilings.
- H. ACCEPTED means as accepted by the Architect or their representative.
- I. APPROVED means as approved by the Architect or their representative.
- J. EQUAL means equivalent as approved by the Architect or their representative.
- K. CONTRACTOR as stated herein shall mean Electronic Safety and Security Contractor.

1.05 PERMITS, CODES, AND INSPECTIONS

- A. General: Contractor shall obtain and pay for all permits and inspections required by laws, ordinances, rules, and regulations having jurisdiction for work included under this Contract, and shall submit approval certificates to the Architect.
- B. Codes: The installation shall comply fully with all local, county, and state laws, ordinances and regulations applicable to local area network and related communication installations.
- C. The installation shall be in compliance with the requirements of the latest revisions of:
 - 1. Building Communication International (BISCI)
 - 2. Telecommunications Industry Association/Electronic Industries Association (TIA/EIA)
 - 3. Occupational Safety and Health Act (OSHA)
 - 4. Institution of Electrical and Electronic Engineers (IEEE)
 - 5. National Electric Code (NEC)
 - 6. Underwriter's Laboratories, Inc. (UL)
 - 7. National Electrical Manufacturer's Association (NEMA)
 - 8. National Electrical Contractors Association (NECA)
 - 9. National Safety Code
 - 10. Legislative Act 235 (1965) - Handicapped
 - 11. Legislative Act 287 (1974) - Excavation
 - 12. International Building Code (IBC) 2003
 - 13. Americans with Disabilities Act (ADA)
 - 14. All approved published instructions set forth by equipment manufacturers.
- D. The installation shall be in compliance with the requirements of:
 - 1. Middle Department Inspection Agency (MDIA)
 - a. Exception: Where the regulations of the local municipality require inspection services by an agency other than MDIA.
 - 2. All local codes and ordinances in effect and having jurisdiction.
 - 3. All requirements of electrical power utility companies.
 - 4. All requirements of telephone utility companies.
 - 5. All requirements of cable television utility companies.
- E. Submit certificates issued by approved authorized agencies to indicate conformance of all work with the above requirements, as well as any additional certificates as may be required for the performance of this contract work.
- F. Should any change in Drawings or Specifications be required to comply with governmental regulations, the Contractor shall notify Architect prior to execution of the work. The work shall be carried out according to the requirements of such code in accordance with the instructions of the Architect and at no additional cost to the Owner.
- G. Certificate of Inspection: The Contractor shall procure and pay for the Certificate of Inspection from MIDA, or other required inspection agency, and deliver it to the Architect before final payment is made.

1.06 VISITING PREMISES

- A. General: The Bidder shall visit the project site before submitting his/her bid, in order to familiarize him/herself with existing conditions that may affect the work. It is the Contractor's responsibility to analyze existing conditions. Sufficient allowances shall be provided in the Contractor's bid to cover work, due to existing conditions, that will be required to complete this contract work.

- B. By submission of a bid the Contractor is attesting that responsible personnel did, in fact, visit the site during the bidding period and verified all existing pertinent conditions.
- C. Contractor shall verify all measurements and dimensions at the site prior to submitting a bid.

1.07 SUBMITTALS

- A. General: Follow the procedures specified in Division 1 and as stated below.
- B. The Contractor shall submit a complete set of Project Documents and complete product data for the proposed system to the system vender for review prior to submission to the Architect/Engineer. The System Vender shall review the complete system package and provide documentation attesting to the system compliance with the extended system product and performance warranty. This documentation must accompany all submittals to the Architect/Engineer. Submittals will not be reviewed by the Architect/Engineer without the System Vender approval documentation.
- C. Submit for approval a complete Material Source of Supply and Subcontractor list for all work required under this project. Shop drawing submittals will not be reviewed until a complete Material Source of Supply and Subcontractor list is received.
- D. Submittal of shop drawings, product data, and samples will be accepted only when submitted by the Contractor. Data submitted from subcontractors and material suppliers directly to the Architect, will not be processed.
- E. Prepare and submit detailed shop drawings for materials, systems, and equipment as listed herein, including locations and sizes of all required openings in floor decks, walls and floors.
- F. The work described in any shop drawing submission shall be carefully checked for all clearances (including those required for maintenance and servicing), field conditions, maintenance of architectural conditions and proper coordination with all trades on the job. Each submitted shop drawing shall include a certification that all related job conditions have been checked and that no conflict exists.
- G. All shop drawings shall be stamped by the Contractor, indicating approval, and space shall be provided for the Engineer's stamp and the Architect's stamp.
- H. All drawings shall be submitted sufficiently in advance of field requirements to allow ample time for checking and re-submittal as may be required. All submittals shall be complete and contain all required and detailed information.
- I. Acceptance of any submitted data or shop drawings for material, equipment apparatus, devices, arrangement and layout shall not relieve the Contractor from responsibility of furnishing all items of proper dimensions, weight, capacities, sizes, quantity and quality as intended by the Contract. Such acceptance shall not relieve the Contractor from responsibility for errors, omissions or inadequacies of any sort on submitted data or shop drawings.
- J. Each shop drawing shall contain job title and reference to the applicable drawing and specification article, including the Contractor's drawings, specifications, and verification of compatibility with the systems involved.
- K. Individual shop drawing submittals shall be provided for each specific material, system or equipment as identified herein. Submittals provided in other than this manner will be return without review.
- L. All nameplate data shall be complete at time of equipment submittals - refer to other sections for identification requirements.
- M. For each room or area of the building containing telephone backboards, fire alarm control panels, consoles, etc., coordination drawings are required to be submitted for review and acceptance at the time of the equipment submittal.

- N. Equipment shall not be purchased until the shop drawing approval is received.
- O. Shop Drawings shall show conformance with specified equipment characteristics, or Contractor shall assume responsibility for all deviations including all additional costs involved for the deviations.
- P. The following is a list of some important material, equipment and systems that require shop drawing approval, refer to each section of this specification for additional submittal requirements:
 - 1. Outlet Boxes
 - 2. Fire Alarm System
 - 3. Video Surveillance
 - 4. Security System
 - 5. Wiring/Cables
- Q. Submittals shall include plan, riser and wiring diagrams complete with all wiring and required equipment.
- R. Product Options:
 - 1. The product manufacturers listed in each section are either the product the design is based on or a product that the Engineer feels would be an acceptable substitution if that product can meet the intent of the written specifications and the scheduled capacities. The Electronic Safety and Security Systems Contractor are responsible for ensuring that the substituted product complies with the intent of the specifications, the scheduled capacities and the drawings. Substitutions of manufacturers not listed are not permitted unless prior approval is obtained from the Engineer as required by Part 2.2, SUBSTITUTIONS, of this specification section.
 - 2. It will be the responsibility of the Contractor to pay any and all costs associated with any approved substitutions that impact the architectural layout, structure, electrical system(s), mechanical systems, and/or the plumbing systems, due to an increase in physical dimensions, weight, electrical requirements, connection sizes, etc., between the approved substitution item and the equipment item scheduled and/or indicated as the basis of design.

1.08 PROJECT DRAWINGS AND SPECIFICATIONS

- A. Contractor shall carefully examine the Drawings and Specifications of all trades and report all discrepancies to the Architect in writing to obtain corrective action. No departures from the Contract Documents will be made without prior written approval from the Architect.
- B. Questions or disputes regarding the intent or meaning of Contract Documents shall be resolved by the interpretation of the Architect. The Architect's interpretation is final and binding.
- C. The Drawings and Specifications are not intended to define all details, finish materials, and special construction that may be required or necessary. The Contractor shall provide all installations complete and adequate as implied by the project documents.
- D. Drawings are diagrammatic only and do not show exact routes of cabling and locations of equipment. The Contractor shall verify the work of all other trades and shall arrange his work to avoid conflicts. In the event of a conflict, the Contractor shall obtain corrective action from the Architect.
- E. All work shall be considered new, unless noted otherwise.

1.09 COOPERATION AND COORDINATION WITH OTHER TRADES

- A. This Contractor shall cooperate completely and coordinate work with the contractors of other trades. Due to the Project Schedule this Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.
- B. Prepare floor plans, elevations, sections, and details to conclusively coordinate and integrate all installations. Indicate locations where space is limited, and where sequencing and coordination of installations are of importance to the efficient flow of the Work, including (but not necessarily limited to) the following:
 - 1. Specific equipment installations, including, but not limited to control cabinets for fire alarm, security, video surveillance systems.
 - 2. Where additional conduit sleeves are required in order to limit cable lengths.
 - 3. Wiring diagrams: Indicating field installed wiring and cabling layouts, equipment, and equipment connections.

1.10 PRODUCT LISTING

- A. Prepare a listing of equipment and materials for the project.
- B. Submit this listing as a part of the submittal requirement specified in Division 01.
- C. When two or more items of same material or equipment are required, they shall be of the same manufacturer. Product manufacturer uniformity does not apply to raw materials, bulk materials, fasteners, and similar items used in work, except as otherwise indicated.
- D. Provide products that are compatible within systems and other connected items.

1.11 NAMEPLATE DATA

- A. Provide permanent operational data nameplate on each item of power operated equipment, indicating manufacturer, product name, model number, serial number, capacity, operating and power characteristics, labels of tested compliances, and similar essential data. Locate nameplate in an accessible location.

1.12 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 01.
- B. When all work has been completed and before final acceptance, the Contractor shall furnish to the Architect a complete set of reproducible contract drawings clearly showing all contract work "as-built". Prior to delivery each drawing shall be signed and dated by the Contractor's project manager attesting to the accuracy of the as-built drawing.
- C. In addition to the above referenced reproducible contract drawings, the Electronic Safety and Security Contractor shall furnish to the Architect a CD-ROM containing all of the floor plans. The floor plans shall be in AutoCAD 2017 format, and shall indicate the "as-built" conditions. A CD-ROM shall be provided to the Electronic Safety and Security Contractor prior the completion of the project, with the drawing files from the bid set of documents. The Electronic Safety and Security Contractor shall make changes to these files, indicating all changes made during construction, including tagging and room names. The Electronic Safety and Security Contractor shall make these changes or retain the services of a third party to make the changes.
- D. Mark up a clean set of Specifications to indicate approved substitutions, change orders and actual equipment and materials used.

1.13 OPERATION MANUALS

- A. Prepare operation manuals in accordance with Division 01. In addition to the requirements specified in Division 01, include the following information for equipment items:
 - 1. Description of function, normal operating characteristics and limitations, engineering data and tests, and complete nomenclature and commercial numbers of replacement parts.
 - 2. Manufacturer's data of each piece of equipment including:
 - a. Installation instructions.
 - b. Drawings and Specifications.
 - c. Parts list, including recommended items to be stocked.
 - d. Complete wiring diagrams.
 - e. Marked or changed prints locating all concealed parts and all variations from the original system design.
 - f. Test and inspection certificates.
- B. Format:
 - 1. Provide five (5) copies of each manual.
 - 2. Manuals to be 8-1/2 inches x 11 inches size in hard back 3-ring loose-leaf binders. Use more than one volume if required. Do not overfill binders.
 - 3. Submit one (1) copy to Architect. After review and acceptance, assemble other copies.
 - 4. Manuals to be completed and in Owner's hands prior to turning building over to Owner and at least 10 days prior to instruction to operating personnel.

1.14 WARRANTIES

- A. Refer to the Division 1 for procedures and submittal requirements for warranties and to individual equipment specifications for additional warranty requirements. If a contradiction exists, the most demanding requirements shall prevail.
- B. Compile and assemble the warranties specified in Division 28 into a separated set of vinyl covered, three-ring binders, tabulated and indexed for easy reference.
- C. Provide complete warranty information for each item to include date of beginning of warranty or bond; duration of warranty or bond; and names, address, and telephone numbers and procedures for filing a claim and obtaining warranty services.
- D. Submit a single warranty stating that all portions of the work are in accordance with Contract requirements. Warrant all work against faulty and improper material and workmanship for a period of one (1) year from date of final acceptance by the Owner, except that where guarantees or warranties for longer terms are specified herein, such longer term shall apply. Within 24 hours after notification, correct any deficiencies that occur during the warranty period at no additional cost to Owner, all to the satisfaction of the Owner. Obtain similar warranties from subcontractors, manufacturers, suppliers and sub-trade specialists.
- E. Any material, equipment or appurtenance whose operation or performance does not comply with the requirements of the Contract Documents or which are damaged prior to acceptance will be held as defective and shall be removed and properly replaced at no additional cost to the Owner.

PART 2 - PRODUCTS

- A. Major items of equipment shall have manufacturer's name, address and catalog number on a plate securely attached in a convenient place. All equipment or apparatus of any one system must be the product of one manufacturer, or approved equivalent products of a number of manufacturer's that are suitable for use in a unified system.
- B. All materials and equipment for which Underwriter's Laboratories have established standards shall bear a UL label of approval.
- C. In all cases where a device, function or item of equipment is herein referred to in the singular, such reference shall apply to as many such items as are required to complete the installation.
- D. All listed materials and equipment shown on drawings and/or specified herein, are indicative of complete and whole units and shall be furnished as such.
- E. In certain instances, specific manufacturer/model/type and catalog numbers are set out herein or on the drawings for the purpose of indicating required criteria for quality, function, and acceptable physical size. Specifications, performance data, and descriptive data published by the designated manufacturer shall be taken as minimum requirements for the item to be provided.
- F. Comply with manufacturer's printed instructions and recommendations as minimum criteria for the installation of equipment.
- G. Where proprietary names are used, whether or not followed by the words "or as approved", they shall be subject to substitution only as approved by the Architect.
- H. Where the contractor proposes substitute equipment, he shall submit acceptable evidence to indicate compliance with all requirements of the documents, including performance rating, equivalent to the specified item. In instances where substituted equipment requires additional material or work beyond that shown or required by the specified item, said additional material or work shall be the responsibility of this Contractor, regardless of the trade involved.
- I. All materials and equipment provided under this Contract shall be completely satisfactory and acceptable in operation, performance and capacity. No approval, either verbal or written, of any drawing, descriptive data or samples of such materials, equipment and/or appurtenances, shall relieve this Contractor of his responsibility to turn over all items in perfect working order at completion of the work.

PART 3 - EXECUTION

3.01 DELIVERY, STORAGE, AND HANDLING

- A. Deliver products to the project properly identified with names, model numbers, types, grades, compliance labels, and other information needed for distinct identification; adequately packaged and protected to prevent damage during shipment, storage and handling.
- B. Store equipment and materials at the site, unless off-site storage is authorized in writing. Protect stored equipment and materials from damage.
- C. Coordinate deliveries of materials and equipment to minimize construction site congestion. Limit each shipment of materials and equipment to the items and quantities needed for the smooth and efficient flow of installations.

3.02 SEQUENCE OF WORK

- A. Construct work in a sequence in accordance with Division 01.
- B. Due to current Project Schedule the Contractor will be required to phase the installation in accordance with the Electrical Contractor's work.

3.03 INSTALLATIONS

- A. General: Sequence, coordinate, and integrate the various elements of electrical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate electrical systems, equipment, and materials installation with other building components.
 - 2. Verify all dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for installations of cabling.
 - 4. Coordinate the installation of required supporting devices and sleeves to be set in poured-in-place concrete and other structural components, as they are constructed.
 - 5. Sequence, coordinate, and integrate installations of electrical materials and equipment for efficient flow of the Work. Give particular attention to large equipment requiring positioning prior to closing in the building.
 - 6. Where mounting heights are not detailed or dimensioned, install systems, materials, and equipment to provide the maximum headroom possible.
 - 7. Install systems, materials, and equipment to conform with approved submittal data, including coordination drawings, to greatest extent possible. Conform to arrangements indicated by the Contract Documents, recognizing that portions of the Work are shown only in diagrammatic form. Where coordination requirements conflict with individual system requirements, refer conflict to the Architect.
 - 8. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components.
 - 9. Coordinate the cutting and patching of building components to accommodate installation of equipment and materials.
 - 10. Coordinate the installation of materials and equipment above ceilings with suspension system, mechanical equipment and systems, and structural components.
 - 11. Install equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. Connect equipment for ease of disconnecting, with minimum of interference with other installations.

3.04 CLEANING

- A. Refer to the Division 01 for general requirements for final cleaning.

3.05 TESTING

- A. Contractor, at his own expense, shall make any and all tests directed by an inspection authority, or connector manufacturer, or the Architect, and shall provide all equipment, instruments and materials to make such tests.
- B. Unless otherwise approved, all terminations shall be made and all components shall be in place, complete and operational, at time of final inspection and tests.
- C. Time of such tests, the manner in which they are made and the results of the tests, shall be subject to approval.
- D. Upon completion of work, all component parts, both singularly and as a whole, shall be set, calibrated, adjusted, and left in satisfactory operating condition to suit load conditions, by means of instruments furnished by the Contractor.

- E. Complete testing of equipment and systems shall be provided throughout this project.
- F. Industry standards shall apply except as otherwise specified.
- G. Provide all labor, premium labor, and materials required by field testing as specified in the Contract Documents and as required.
- H. Notify the Architect seven (7) days prior to the testing dates. Upon completion of a test, a statement of certification shall be forwarded to the Architect for his approval.
- I. Conduct tests at a time agreeable to the Architect. Provide premium labor as necessary.
- J. Products that are found defective or do not pass such tests shall be removed and replaced at the Contractor's expense. Tests shall be repeated.

3.06 INSTRUCTIONS TO THE OWNER

- A. After the tests and adjustments have been made, approved factory-authorized system representatives and the Contractor shall fully instruct Owner in all details of operation and maintenance of equipment installed under this Contract. Dates and times of such instructions shall be as directed by Owner, including any necessary weekend or after-hours instruction.
- B. Additional instruction requirements are included in each section of the Specifications.
- C. The Contractor shall video tape all instruction sessions. Prepare a separate video tape for each system as shown on the schedule below. Clearly label the tape with the title "INSTRUCTIONS FOR THE USE OF ", on both the face and the spine, in typewritten letters. Two (2) copies of each video tape shall be given to the Owner at the completion of the Contract; one (1) set for the maintenance staff and one (1) set for the administrative staff.
- D. Prepare an instructional training form indicating the topic of instruction, the date, the time, the purpose of instruction and lines for signatures of attendees. Each person attending the instruction shall print their name and sign the form. Provide a copy of the completed form to the Owner in the O & M manual as proof of instructional training. The Contractor shall keep the original in the Contractor's project file.
- E. The attached schedule indicates the extent of training.

Minimum Instructions to Owner Requirements										
Topic	Spec. Sec. (4)	Session 1			Session 2			Session 3		
		F (1)	L (2)	A (3)	F (1)	L (2)	A (3)	F (1)	L (2)	A (3)
Access Control	28 1500	I	A/R	A, M	1F	A/R	M	-	-	-
Video Surveillance	28 2300	I	A/R	A, M	1F	A/R	M	-	-	-
Other Systems not listed above: Refer to individual Specification Section										

Notes:

Format: Provide training in the following format:

I = initial meeting to discuss system operation, safety issues, maintenance issues

1F = follow-up session, 1 month from initial session

2F = follow-up session, 2 months from initial session

Length: Provide the length of instruction as follows:

1, 2, 3, etc. indicates the number of hours of training; does not include travel time, setup time, question/answer time.

A/R = as required by Owner or the number of attendees

Attendees:

A = Administrative Staff, as determined by Owner's representative

M = Maintenance Staff, as determined by Owner's representative

T = Teaching Staff, schedule multiple sessions to limit instructional session size to 15 people

3.07 LIST OF INSTALLED EQUIPMENT

- A. Provide a list of all active devices installed under this contract. This list shall include both contractor furnished, contractor installed and owner furnished, contractor installed equipment.
- B. Active devices shall include, but not be limited to, the following:
 - 1. Access Control Panels
 - 2. Security Panels
 - 3. Cameras
 - 4. Servers
 - 5. Video Intercoms and Handsets
 - 6. Emergency Notification Stations
- C. In Microsoft Excel format, include the following information:
 - 1. Device Symbol as Indicated on As-Built Drawings
 - 2. Location (Room #)
 - 3. Manufacturer/Model
 - 4. Serial Number
 - 5. Manufacturer Warranty Valid Through Date
 - 6. Static IP address (provide address) or DHCP (address not required)
 - 7. MAC address
 - 8. Login Credentials
 - 9. Replacement Cost (for owner's insurance)

END OF SECTION 28 0100

SECTION 28 1500 - ACCESS CONTROL HARDWARE DEVICES

PART 1 - GENERAL

1.01 DESIGN INTENT

- A. The intention of this contract is to expand the owner's existing installation of Avigilon access control platform. This system utilizes proprietary hardware and software. Substitute manufacturers shall not be allowed.

1.02 GENERAL

- A. The complete access control system shall be provided by a single entity. This entity may be the Electrical Contractor (E.C.) or a single sub-contractor.
 - 1. Provision of components by both the E.C. and a subcontractor shall not be allowed.
 - 2. Provision of components by multiple subcontractors shall not be allowed.
 - 3. Exception:
 - a. Empty pathways may be installed by any entity; however, cabling shall be pulled by the same entity providing the complete access control system.

1.03 RELATED DOCUMENTS

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

1.04 SUMMARY

- A. Section Includes
 - 1. Credential Cards
 - 2. Card readers
 - 3. Request to Exit Sensors
 - 4. Door Position Switches
 - 5. Switches and Buttons
 - 6. Cables
 - 7. Transformers
 - 8. Integration of other electronic and electrical systems and equipment.

1.05 DEFINITIONS

- A. Credential: Data assigned to an entity and used to identify that entity.
- B. DTS: Digital Termination Service. A microwave-based, line-of-sight communication provided directly to the end user.
- C. Identifier: A credential card; keypad personal identification number; or code, biometric characteristic, or other unique identification entered as data into the entry-control database for the purpose of identifying an individual. Where this term is presented with an initial capital letter, this definition applies.

- D. Location: A Location on the network having a PC-to-controller communications link, with additional controllers at the Location connected to the PC-to-controller link with a TIA 485-A communications loop. Where this term is presented with an initial capital letter, this definition applies.
- E. PC: Personal computer. Applies to the central station, workstations, and file servers.
- F. RAS: Remote access services.
- G. RF: Radio frequency.
- H. ROM: Read-only memory. ROM data are maintained through losses of power.
- I. TCP/IP: Transport control protocol/Internet protocol.
- J. TWAIN: Technology without an Interesting Name. A programming interface that lets a graphics application, such as an image editing program or desktop publishing program, activate a scanner, frame grabber, or other image-capturing device.
- K. WMP: Windows media player.
- L. Wiegand: Patented magnetic principle that uses specially treated wires embedded in the credential card.
- M. WYSIWYG: What You See Is What You Get. Text and graphics appear on the screen the same as they will in print.

1.06 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Reference each product to a location on Drawings. Test and evaluation data presented in Product Data shall comply with SIA BIO-01.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Diagrams for cable management system.
 - 2. System labeling schedules, including electronic copy of labeling schedules that are part of the cable and asset identification system of the software specified in Parts 2 and 3.
 - 3. Wiring Diagrams. For power, signal, and control wiring. Show typical wiring schematics including the following:
 - a. Workstation outlets, jacks, and jack assemblies.
 - b. Patch cords.
 - c. Patch panels.
 - 4. Cable Administration Drawings: As specified in "Identification" Article.
 - 5. Battery and charger calculations for central station, workstations, and controllers.
- C. Product Schedules.

1.07 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.08 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For security system to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 7823 "Operation and Maintenance Data," include the following:
 - 1. Hard copies of manufacturer's specification sheets, operating specifications, design guides, user's guides for software and hardware, and PDF files on **USB** media of the hard-copy submittal.
 - 2. System installation and setup guides with data forms to plan and record options and setup decisions.

1.09 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. Credential card blanks, ready for printing. Include enough credential cards for all personnel to be enrolled at the site plus an extra 50 percent for future use.
 - 2. Fuses of all kinds, power and electronic, equal to 10 percent of amount installed for each size used, but no fewer than three units.

1.10 QUALITY ASSURANCE

- A. Installer Qualifications: An employer of workers trained and approved by manufacturer.
 - 1. Cable installer must have on staff an RCDD certified by Building Industry Consulting Service International.
- B. Source Limitations: Obtain central station, workstations, controllers, Identifier readers, and all software through one source from single manufacturer.

1.11 DELIVERY, STORAGE, AND HANDLING

- A. Store in temperature- and humidity-controlled environment in original manufacturer's sealed containers. Maintain ambient temperature between 50° and 85°F, and not more than 80% relative humidity, noncondensing.
- B. Open each container; verify contents against packing list; and file copy of packing list, complete with container identification, for inclusion in operation and maintenance data.
- C. Mark packing list with the same designations assigned to materials and equipment for recording in the system labeling schedules that are generated by software specified in "Cable and Asset Management Software" article.
- D. Save original manufacturer's containers and packing materials and deliver as directed under provisions covering extra materials.

1.12 PROJECT CONDITIONS

- A. Environmental Conditions: System shall be capable of withstanding the following environmental conditions without mechanical or electrical damage or degradation of operating capability:
 - 1. Control Station
 - a. Rated for continuous operation in ambient conditions of 60° to 85°F and a relative humidity of 20% to 80%, non-condensing.

2. Indoor, Controlled Environment
 - a. NEMA 250, Type 1 enclosure. System components, except the central-station control unit, installed in temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 36° to 122°F dry bulb and 20% to 90% relative humidity, non-condensing.
3. Indoor, Uncontrolled Environment
 - a. NEMA 250, Type 1 enclosures. System components installed in non-temperature-controlled indoor environments shall be rated for continuous operation in ambient conditions of 0° to 122°F dry bulb and 20% to 90% relative humidity, non-condensing.
4. Outdoor Environment
 - a. NEMA Type 4 enclosures. System components installed in locations exposed to weather shall be rated for continuous operation in ambient conditions of minus 30° to plus 122°F dry bulb and 20% to 90% relative humidity, condensing. Rate for continuous operation where exposed to rain as specified in NEMA 250, winds up to 85 mph and snow cover up to 24 inches thick.

PART 2 - PRODUCTS

2.01 OPERATION

- A. Security access system hardware shall use a single database for access-control and credential-creation functions.

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. Comply with NFPA 70, "National Electrical Code."
- C. Comply with SIA DC-01, SIA DC-03 and SIA DC-07.

2.03 CREDENTIAL CARDS

- A. The owner shall utilize existing Prox cards.

2.04 CARD READERS

- A. Basis of Design
 1. HID model 40-NKS-00-000: Wall mounted
- B. General Requirements
 1. Card-Reader Power: Powered from its associated controller, including its standby power source, and shall not dissipate more than 5 W.
 2. Response Time: Card reader shall respond to passage requests by generating a signal that is sent to the controller. Response time shall be 800 ms or less, from the time the card reader finishes reading the credential card until a response signal is generated.

3. Enclosure: Suitable for surface, semi-flush, pedestal, or weatherproof mounting. Mounting types shall additionally be suitable for installation in the following locations:
 - a. Indoors, controlled environment.
 - b. Indoors, uncontrolled environment.
 - c. Outdoors, with built-in heaters or other cold-weather equipment to extend the operating temperature range as needed for operation at the site.
 4. Display: Digital visual indicator shall provide visible **and audible** status indications and user prompts. Indicate power on or off, whether user passage requests have been accepted or rejected, and whether the door is locked or unlocked.
- C. 2.4 GHz (Bluetooth) Credential Compatibility: Mobile Credentials powered by Seos (HID Mobile Access)
 - D. 13.56 MHz (NFC) Credential Compatibility: Seos, iCLASS SE, iCLASS SR, iCLASS, MIFARE Classic, MIFARE DESFire EV1/EV2/EV3, FeliCa & Contactless e-Purse Application Specification (CEPAS), Mobile Credentials powered by Seos (HID Mobile Access)
 - E. 125 kHz Credential Compatibility: HID Proximity®, Indala® Proximity, AWID Proximity, and EM Proximity
 - F. Typical Read Range: Seos, iCLASS SE, iCLASS SR, iCLASS, MIFARE Classic, MIFARE DESFire EV1/EV2/EV3 & ISO14443A Single Technology Cards – 1.6 to 4 in (4 to 10 cm); HID /AWID Proximity, Indala Proximity, EM Proximity & 125 kHz Single Technology Cards – 2.4 to 4 in (6 to 1cm)

2.05 DOOR CONTROLLER

- A. Basic of Design
 1. AC-MER-CONT-LP1502
- B. Device Feature:
 1. Embedded crypto memory chip and data at rest encryption provides secured layer of protection of sensitive data
 2. OSDP Protocol: Secure channel communications for reader connectivity
 3. Host communications protected by TLS 1.2/1.1
 4. FIPS 140-2 user of OpenSSL.
 5. Supports multiple card formats, paired and alternate readers, elevator, turnstile and biometric devices.
 6. Anti-pass back support (area, reader and time based), programmable keypad user commands, threat level and operating modes

2.06 PANEL ENCLOSURES

- A. Basic of Design
 1. Altronix Trove T1MK1F4
- B. Features
 1. 12VDC or 24VDC power supply/charger.
 2. Accommodates the following Mercury controller:
 3. LP1501, LP1502, LP2500, LP4502, MR16IN, MR16OUT, MR50, MR52, MR62e, MUX8

4. Convenient knockout configuration:
 - a. One (1) double knockout
1.948" (1-1/2" Conduit) / 1.701" (1-1/4" Conduit)
 - b. Nine (9) double knockouts
 - c. 1.362" (1" Conduit) / 1.115" (3/4" Conduit)
5. 16 AWG galvanized steel backplane simplifies board layout and wire management
6. Enclosure accommodates up to two (2) 12VDC/7AH batteries
7. Supervision
 - a. AC Fail
 - b. Low Battery and Battery Presence
 - c. Low power shutdown
8. UL: UL294 - Access Control System
9. cUL: CAN/ULC - s319-05 - Electronic Access Control Systems
10. Lifetime Warranty
11. Provide TMV2 backplane to mount devices on backside of door.
12. Accessories
 - a. One (1) cam lock, one (1) tamper switch and mounting hardware.
13. Enclosure
 - a. Wall mount enclosure for indoor use.
 - b. Accommodates up to four (4) 12VDC/12AH batteries.
 - c. Dimensions 27.25"H x 21.75"W x 6.5"
 - d. 3/4" and 1" combination knockouts
 - e. Screw Covers: Where enclosures are readily accessible, secure with security fasteners of type appropriate for enclosure.

2.07 CABLES

- A. General Cable Requirements: Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and as recommended by system manufacturer for integration requirement.
- B. Plenum-Rated TIA 232-F Cables:
 1. **Three**, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. PE insulation.
 3. Aluminum foil-polyester tape shield with 100 percent shield coverage.
 4. Fluorinated ethylene propylene jacket.
 5. Conductors are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 6. Flame Resistance: Comply with NFPA 262.
- C. Plenum-Rated TIA 485-A Cables:
 1. Paired, two pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 2. Fluorinated ethylene propylene insulation.
 3. Unshielded.
 4. Fluorinated ethylene propylene jacket.
 5. NFPA 70 Type: Type CMP
 6. Flame Resistance: NFPA 262, Flame Test.

- D. Paired, Plenum-Type, Reader and Wiegand Keypad Cables:
 - 1. Three pairs, No. 22 AWG, stranded (7x30) tinned copper conductors, plastic insulation, individual aluminum-foil/polypropylene-tape shielded pairs each with No. 22 AWG, stranded tinned copper drain wire, 100 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 - 2. NFPA 70, Type CMP.
 - 3. Flame Resistance: NFPA 262 flame test.
- E. Multiconductor, Plenum-Type, Reader and Wiegand Keypad Cables:
 - 1. Six conductors, No. 20 AWG, stranded (7x28) tinned copper conductors, fluorinated-ethylene-propylene insulation, overall aluminum-foil/polyester-tape shield with 100 percent shield coverage plus tinned copper braid shield with 85 percent shield coverage, and fluorinated-ethylene-propylene jacket.
 - 2. NFPA 70, Type CMP.
 - 3. Flame Resistance: NFPA 262 flame test.
- F. LAN Cabling:
 - 1. Comply with requirements in Section 27 1500 "Communications Cabling."

2.08 TRANSFORMERS

- A. NFPA 70, Class II control transformers, NRTL listed. Transformers for security access-control system shall not be shared with any other system.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine pathway elements intended for cables. Check raceways, cable trays, and other elements for compliance with space allocations, installation tolerances, hazards to cable installation, and other conditions affecting installation.
- B. Examine roughing-in for LAN and control cable conduit systems to PCs, controllers, card readers, and other cable-connected devices to verify actual locations of conduit and back boxes before device installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PREPARATION

- A. Comply with recommendations in SIA CP-01.
- B. Comply with TIA 606-B, "Administration Standard for Commercial Telecommunications Infrastructure."
- C. Product Schedules: Obtain detailed product schedules from manufacturer of access-control system or develop product schedules to suit Project. Fill in all data available from Project plans and specifications and publish as Product Schedules for review and approval.
- D. In meetings with Architect and Owner, present Product Schedules and review, adjust, and prepare final setup documents. Use approved, final Product Schedules to set up system software.

3.03 CABLING

- A. Comply with NECA 1, "Good Workmanship in Electrical Construction."
- B. Install cables and wiring according to requirements in Section 26 0519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters. Conceal raceway and wiring except in unfinished spaces.
- D. Wiring Method: Install wiring in raceway and cable tray except within consoles, cabinets, desks, and counters and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Use NRTL-listed plenum cable in environmental airspaces, including plenum ceilings. Conceal raceway and cables except in unfinished spaces.
- E. Install LAN cables using techniques, practices, and methods that are consistent with Category 6 rating of components and optical fiber rating of components, and that ensure Category 6 and optical fiber performance of completed and linked signal paths, end to end.
- F. Boxes and enclosures containing security-system components or cabling, and which are easily accessible to employees or to the public, shall be provided with a lock. Boxes above ceiling level in occupied areas of the building shall not be considered accessible. Junction boxes and small device enclosures below ceiling level and easily accessible to employees or the public shall be covered with a suitable cover plate and secured with tamperproof screws.
- G. Install end-of-line resistors at the field device location and not at the controller or panel location.

3.04 CABLE APPLICATION

- A. Comply with TIA 569-D, "Commercial Building Standard for Telecommunications Pathways and Spaces."
- B. Cable application requirements are minimum requirements and shall be exceeded if recommended or required by manufacturer of system hardware.
- C. TIA 232-F Cabling: Install at a maximum distance of 50 feet between terminations.
- D. TIA 485-A Cabling: Install at a maximum distance of 4000 feet between terminations.
- E. Card Readers and Keypads:
 - 1. Install number of conductor pairs recommended by manufacturer for the functions specified.
 - 2. Unless manufacturer recommends larger conductors, install No. 22 AWG wire if maximum distance from controller to the reader is 250 feet and install No. 20 AWG wire if maximum distance is 500 feet.
 - 3. For greater distances, install "extender" or "repeater" modules recommended by manufacturer of the controller.
 - 4. Install minimum No. 18 AWG shielded cable to readers and keypads that draw 50 mA or more.
- F. Install minimum No. 16 AWG cable from controller to electrically powered locks. Do not exceed **250 feet** between terminations.
- G. Install minimum No. 18 AWG ac power wire from transformer to controller, with a maximum distance of **25 feet** between terminations.

3.05 GROUNDING

- A. Comply with Section 27 0526 "Grounding for Communications System."
- B. Comply with IEEE 1100, "Recommended Practice for Power and Grounding Electronic Equipment."
- C. Ground cable shields, drain conductors, and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.
- D. Bond shields and drain conductors to ground at only one point in each circuit.
- E. Signal Ground:
 - 1. Terminal: Locate in each equipment room and wiring closet; isolate from power system and equipment grounding.
 - 2. Bus: Mount on wall of main equipment room with standoff insulators.
 - 3. Backbone Cable: Extend from signal ground bus to signal ground terminal in each equipment room and wiring closet.

3.06 INSTALLATION

- A. Install card readers, keypads, push buttons, and biometric readers.

3.07 IDENTIFICATION

- A. In addition to requirements in this article, comply with applicable requirements in Section 27 0553 "Identification for Communications System" and with TIA 606-B.
- B. Using software specified in "Cable and Asset Management Software" Article, develop cable administration drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable, and label cable and jacks, connectors, and terminals to which it connects with the same designation. Use logical and systematic designations for facility's architectural arrangement.
- C. Label each terminal strip and screw terminal in each cabinet, rack, or panel.
 - 1. All wiring conductors connected to terminal strips shall be individually numbered, and each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with the name and number of the particular device as shown.
 - 2. Each wire connected to building-mounted devices is not required to be numbered at the device if the color of the wire is consistent with the associated wire connected and numbered within the panel or cabinet.
- D. At completion, cable and asset management software shall reflect as-built conditions.

3.08 SYSTEM SOFTWARE AND HARDWARE

- A. Develop, install, and test software and hardware, and perform database tests for the complete and proper operation of systems involved. Assign software license to Owner.

3.09 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. LAN Cable Procedures: Inspect for physical damage and test each conductor signal path for continuity and shorts. Use tester approved for type and kind of installed cable. Test for faulty connectors, splices, and terminations. Test according to TIA 568-C.1, "Commercial Building Telecommunications Cabling Standards - Part 1: General Requirements." Link performance for balanced twisted-pair cables must comply with minimum criteria in TIA 568-C.1.
 - 2. Test each circuit and component of each system. Tests shall include, but are not limited to, measurements of power-supply output under maximum load, signal loop resistance, and leakage to ground where applicable. System components with battery backup shall be operated on battery power for a period of not less than 10 percent of the calculated battery operating time. Provide special equipment and software if testing requires special or dedicated equipment.
 - 3. Operational Test: After installation of cables and connectors, demonstrate product capability and compliance with requirements. Test each signal path for end-to-end performance from each end of all pairs installed. Remove temporary connections when tests have been satisfactorily completed.
- C. Devices and circuits will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports.

3.10 STARTUP SERVICE

- A. Engage a factory-authorized service representative to supervise and assist with startup service.
 - 1. Complete installation and startup checks according to approved procedures that were developed in "Preparation" article and with manufacturer's written instructions.
 - 2. Enroll and prepare badges and access cards for Owner's operators, management, and security personnel.

3.11 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain security access system. See Section 01 7900 "Demonstration and Training."
- B. Develop separate training modules for the following:
 - 1. Computer system administration personnel to manage and repair the LAN and databases and to update and maintain software.
 - 2. Operators who prepare and input credentials to man the control station and workstations and to enroll personnel.
 - 3. Security personnel.
 - 4. Hardware maintenance personnel.
 - 5. Corporate management.

END OF SECTION 28 1500

SECTION 28 2300 - VIDEO SURVEILLANCE SYSTEM (VSS)

PART 1 - GENERAL

1.01 GENERAL REQUIREMENTS

- A. The intent of this specification is to expand upon the owner's district wide Avigilon's surveillance camera installation. This system uses Avigilon management software to communicate with local camera. All camera feed is recorded and saved in network video recorder. Substitute manufacturers shall not be allowed.
- B. All bids shall be based on the equipment as specified herein.
- C. Performance Statement: This specification section and the accompanying CCTV specific Contract Documents are performance based, describing the minimum material quality, required features, and operational requirements of the system. These documents do not convey every wire that must be installed and every equipment connection that must be made. Based on the equipment constraints described and the performance required of the system, as presented in these documents, the vendor and the Contractor are solely responsible for determining all wiring, programming and miscellaneous equipment required for a complete and operational system.

1.02 RELATED DOCUMENTS

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this and the other sections of Division 28.
- B. This section is a Division 28 Electronic Safety and Security Systems section, and is a part of each Division 28 Section.
- C. Requirements of the following Division 28 Sections apply to this section:
 - 1. Conduits, Raceway, and Cable Trays - Division 27 and Division 28.
 - 2. Cabling and Wiring - Division 27.

1.03 REFERENCES

- A. NFPA 70: National Electrical Code
- B. Electronic Industries Association (EIA) Video Surveillance Equipment Standards
- C. UL 2044: Standard for Commercial Closed Circuit Television Equipment
- D. UL 3044: Standard for Safety for Surveillance Closed Circuit Television Equipment

1.04 SYSTEM DESCRIPTION

- A. This specification section describes the furnishing, installation, commissioning and programming of a complete, turnkey, closed circuit television system.
 - 1. Video Servers Recording and Storage
 - 2. Cameras and Accessories

1.05 SUBMITTALS

- A. General: Submit all product data and/or shop drawings bound in a single, soft-cover binder. Incomplete submittals, i.e., missing cameras, computers, racks, equipment, software, Contractor's signatures, etc. will be returned to the sender without any action being taken. The Digital VSS submittal shall comply with the following:
 - 1. Complete listing of ALL equipment, materials, and services that are to be furnished for the work.
 - 2. Typewritten cover page that includes the Contractor's and Supplier's name, addresses, and telephone numbers, and the name of the Project.
 - 3. Organized and physically divided into sections for each group of items, i.e., separate sections for Image Server, Cameras, etc.
 - 4. Clearly identify each component item by highlight marker or arrow to define that specific component, all associated characteristics, and all hardware.
- B. Product Data for each component, including detailed manufacturer's specifications.
- C. Wiring diagrams detailing planned wiring for power, signal and control systems.
- D. Qualification data for firms and persons bidding on and expected to work on the project. Describe capabilities and experience, and provide references when requested.

1.06 QUALITY CONTROL

- A. For compatibility with the existing system, provide only the product specified.
- B. The manufacturer shall have five (5) years documented experience.
- C. Installer: The installing dealer must be a factory authorized service and support company specializing in the selected manufacturer's product, with demonstrated prior experience with the selected manufacturer's system installation and programming. The installing dealer must be able to reference at least 3 projects of similar nature with the video surveillance software and hardware. The installer shall retain a Microsoft MCSE or equivalent technician for the purposes of server deployment, software configuration and system integration. All certifications and integrations must be verified and included with submittals.
- D. Servicing Contractor: The manufacturer of the system must have local service representatives within 60 miles of the project site. The Servicing Contractor shall carry a complete stock of parts. Must have 24/7 available technical support for onsite service. Servicing Contractor must have at least two factory training technicians. Provide all certifications with bid.
- E. All components (DVSS, Computer Hardware, cameras and accessories) must be certified to work in with each other.
- F. Servers and storage capacity shall be configured to provide 30 days of storage at 10 IPS at 1920x1080 resolution and 30% motion using the highest quality compression setting.
- G. Bidder shall include software license for each camera identified on the project drawings and schedules.

PART 2 - PRODUCTS

2.01 VIDEO MANGAEMENT SOFTWARE

- A. Platform
 - 1. Avigilon Control Center - Existing installation

2.02 VIDEO APPLIANCE PLATFORM - STORAGE COMPONENT

A. Manufacturers

1. Provide products by one of the following:
 - a. AINVR2-PRM-FORM-D-96TB

B. Performance

1. The minimum throughput rate of each server shall be 200 Mb/s.
2. Each server shall be able to accept a minimum of 64 cameras.
3. Provide multiple video servers to share the processing load and to create redundancy.

C. Hardware Configuration

- | | |
|-----------------------------|---|
| 1. Processor | 2 x Intel 8 Core Xeon |
| 2. Operating System | Avigilon hardened OS |
| 3. Manufacturer | Avigilon |
| 4. Memory | 4 x 16 GB (DDR5) |
| 5. Data Storage | 96TB (RAID 6) |
| 6. Video Outputs | No video outputs - Web-based administration only |
| 7. Networking | 4x10 GbE SFP+ ports, 6X1 GbE RJ-45 port |
| 8. USB | Front: 2 x USB 2.0 Rear: 2 x USB 3.0 |
| 9. RAID | Operating System: 2 x 480GB M.2 SSD Drives, RAID 1
Data RAID Level: RAID 6 |
| 10. NVR Hardware Monitoring | Web-based administration |
| 11. Warranty | 5-years, Next Business Day (NBD) with onsite parts delivery service. |
| 12. Form Factor | 2U Rackmount |
| 13. OS Drive Bays | 2 x M.2 BOSS PCIe Card |
| 14. Data Drive Bays | 5 x 3.5" Hot Swappable |
| 15. Power Supply | Dual (1+1) 1400 W redundant |

D. Client Software - The NVR system shall be furnished with the specified VMS as the only client application installed.

2.03 IP CAMERAS

A. Manufacturers:

1. Provide cameras by the following manufacturers:
 - a. Avigilon

B. Camera Types:

1. 4 Mega Pixel Dome Camera:
 - a. Base Design: 4.0C-H6A-D1, fixed dome, 4 MP, WDR, 3.3-9mm lens, onboard analytics.
2. 8 Mega Pixel Dome Camera:
 - a. Base Design: 8.0C-H5A-D1, fixed dome, 8 MP, WDR, 4.9-8mm lens, onboard analytics.
3. Bi-Directional Camera:
 - a. Base Design: 10.0C-H5DH-DO1-IR, surface mount, 2x5 MP, 3.35-7mm varifocal lens.

4. Multi-sensor (3 Lens):
 - a. Base Design: 15C-H5A-3MH-270, 3x5 MP, WDR, with 2.8mm lenses.
 - b. Ceiling Mount Accessories:
 - 1) 15C-H5A-3MH
 - 2) H5AMH-AD-DOME1
 - 3) H5AMD-DO-COVR1
 - 4) H4AMH-AD-IRIL-1
 - c. Pole Mount Accessories:
 - 1) 32C-H5A-4MH
 - 2) H5AMH-AD-DOME1
 - 3) H5AMD-DO-COVR1
 - 4) H4AMH-AD-IRIL-1

C. General Requirements of all IP Cameras

1. General
 - a. Cameras located in areas susceptible to physical damage shall be provided with a wire guard which shall be affixed to a permanent structure.
 - 1) Wire guards shall be required in all gymnasiums and mechanical spaces.
2. Electrical
 - a. The camera shall be capable of accepting power from a POE power source and a low voltage ac power source.
3. Video
 - a. The camera shall have a video output for image preview during installation.
 - b. The camera lens shall be adjustable so that when the camera is installed with the dome facing the ground, the camera is able to capture an image at or above the horizon.
4. Features and Functions
 - a. Camera Title
 - b. Day & Night Modes
 - c. Backlight Compensation
 - d. Digital Noise Reduction
 - e. Privacy Masking
 - f. Adjustable Gain Control
 - g. Adjustable White Balance
 - h. Adjustable Electronic Shutter Speed
 - i. Flip / Mirror
 - j. Intelligent Video Analytics: Tampering, Motion Detection
 - k. Alarm Triggers: Tampering, Motion Detection
 - l. Alarm Events:
 - 1) File upload via FTP and E-mail
 - 2) Local storage recording at event
 - 3) Notification via E-mail
5. Network
 - a. Ethernet: RJ-45 (10/100Base-T)
 - b. Video Compression: H.264, MJPEG
 - c. Resolution: Adjustable from maximum down to 320 x 240.

- d. Frame rate: 30fps at indicated resolution unless otherwise noted.
- e. Video Quality Adjustment
 - 1) H.264, MPEG-4: Compression level, Target bit rate level control
 - 2) MJPEG: Quality level control
- f. Bitrate Control
 - 1) H.264, MPEG-4: VBR or CBR
 - 2) MJPEG: VBR
- g. Streaming: Multiple, minimum of 3 profiles.
- h. IP: IPv4, IPv6
- i. Network Protocol
 - 1) TCP/IP, UDP/IP, RTP (UDP), RTP (TCP), RTSP, NTP, HTTP, HTTPS, SSL, DHCP, PPPoE, FTP, SMTP, ICMP, IGMP, SNMPv1, v2c, v3 (MIB-2), ARP, DNS, DDNS, ONVIF
- j. Streaming Method: Unicast, Multicast
- k. User Access: 6 users at Unicast
- l. ONVIF Conformance: ONVIF Profile S, G, SUNAPI (HTTP API)
- m. Web Viewer
 - 1) Supported OS
 - a) Windows XP / VISTA / 7 / 8 / 8.1/10
 - b) MAC OS X 10.7 ~ 10.10
 - 2) Supported Browsers
 - a) Microsoft Internet Explorer (Ver. 8 ~ 11),
 - b) Mozilla Firefox (Ver. 9 ~ 35),
 - c) Google Chrome (Ver. 15 ~ 40),
 - d) Apple Safari (Ver. 8.0.2(Mac OS X 10.10),
- 6. Operational Temperature/Humidity
 - a. Indoor Cameras:-10°C ~ +55°C / Less than 90% RH
 - b. Outdoor Cameras: -40°C ~ +55°C / Less than 90% RH
- 7. Color: White
- 8. Certifications: CE mark; FCC mark
- 9. Warranty: 3 years; parts and labor.

PART 3 - EXECUTION

3.01 INSTALLATION

- A. Installing Surge Suppressors: Where AC power operated devices are not protected against voltage transients by integral surge suppressors specified in UL 1449, install surge suppressors at the device's power-line terminals.
- B. Network connections shall be made only after notification to the Owner's network and/or telecommunications personnel. Network access lines and service shall be provided under Division 27.
- C. Exterior cameras shall be installed using a mount which directs the dome towards the ground. Exterior cameras shall not be mounted directly to a vertical surface with the dome pointed towards the horizon.

D. Programing

1. Confirm the following with Owner:
 - a. Field of View for all cameras
 - b. Camera Name and Number
 - c. Camera IP Address
 - d. User Names and Passwords for Servers, Cameras & End User Software
2. All cameras, unless otherwise noted, shall be setup to record using the following parameters:
 - a. Resolution: Maximum possible
 - b. Recording Speed: 10 FPS minimum
 - c. Compression: Best Quality Video
 - d. Motion Detection: On
 - e. WDR: On (if available)
 - f. Bitrate Control VBR
 - g. Privacy Masking
 - 1) Windows of adjacent buildings (except other buildings on Owner's campus)
 - 2) Computer Screens
 - 3) Per owner direction
3. All cameras shall record at the maximum resolution. Cameras shall not have views cropped by reducing resolution.
4. All cameras shall have motion detection recording turned on in the camera. Server-side motion detection shall not be used.
5. The contractor shall verify analytical features, including motion detection, function as intended at 9 points in the field of view for every camera.

3.02 GROUNDING

- A. Connect equipment-grounding connections as recommended by the manufacturer.
- B. Tighten connection to comply with tightening torques specified in UL 486A to assure permanent and effective grounds.

3.03 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: Provide appropriate services of an authorized service representative to supervise the field assembly and connection of components and the testing and adjustment of the system.
- B. Inspection: Verify that units and controls are properly installed, connected, and labeled and that interconnecting wires and terminals are properly identified.
- C. Pretesting: Align and adjust the system and pretest all components, wiring and functions to verify that they conform to specified requirements. Replace malfunctioning or damaged items with new items. Retest until satisfactory performance and conditions are achieved.
- D. Acceptance Test: Schedule tests after pretesting and system has been in normal function operation for at least 5 days.

3.04 CLEANING

- A. Prior to final acceptance, clean system components using methods and materials recommended by manufacturer.

3.05 DEMONSTRATION

- A. Demonstration: Arrange for the services of a factory authorized training representative to demonstrate server features and functions and train key Owner's technical personnel as appropriate.
- B. Training: Conduct a minimum of two (4 hours total) training Sessions for Owner's employees and authorized users of the Digital Video Security System.

3.06 ON-SITE ASSISTANCE

- A. Occupancy Adjustments: When requested within 1 year of the date of Substantial Completion, provide an on-site adjustment of system components and features to optimize performance and customize video capture programs for changing Owner needs. Remote customization shall be provided under the Service Agreement package.

END OF SECTION 28 2300

SECTION 31 1000 - SITE CLEARING AND PREPARATION

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Coordination with the public utility companies for existing and new utility service.
 - 2. Environmental Protection.
 - 3. Material Stockpiling.
 - 4. Removal of surface debris trees, brush, etc., within the approximate limit of work.
 - 5. Topsoil stripping and stockpiling
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Clearing: The removal of trees, brush, topsoil and other vegetation, and surface debris.
- B. Grubbing: The complete removal of all stumps and the removal from reusable fill materials of all roots whose diameter is larger than 1-inch and organic matter.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 02 4113 – Site Demolition.
- E. Section 31 2500 – Erosion and Sediment Control.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Control Manual, latest edition.

1.05 SUBMITTALS

- A. Not used.

1.06 REGULATORY REQUIREMENTS

- A. Obtain required approvals/permits from the appropriate authorities for clearing and grubbing activities.
- B. Do not close or obstruct emergency entrances, roadways, fire lanes, sidewalks, or hydrants without approval from the Owner or his representative.
- C. Conform to applicable regulatory procedures when discovering hazardous or contaminated materials.
- D. Conform and coordinate with any utility company requirements when site preparation activities affect utility service.
- E. Conform to the applicable regulatory requirements of the local conservation district and PADEP with regards to erosion and Sediment control. Maintain adjoining streets and roads free of mud and debris that are deposited from vehicles traveling to and from the work site.
- F. It shall be the Contractor's responsibility to contact utility companies prior to any construction, as the locations of utilities shown on the plans are approximate and possibly incomplete. Contractors shall call 1-800-242-1776 (PA One-Call) a minimum of three and no more than ten working days prior to the start of work.
- G. The Contractor shall comply at all times with applicable Federal, State, and local laws, provisions, and policies governing safety and health, including the Federal Construction Safety Act (Public Law 91-54), Federal Register, Chapter XVII, Part 1926 of Title 29 Code of Federal Regulations, Occupational Safety and Health Regulations for Construction, and subsequent publications updating these regulations.

1.07 COORDINATION

- A. Coordinate site preparation activities with utility companies and the Owner or his representative. Notify affected utility companies when it will be necessary to disconnect or shut off their utilities during site clearing at least three working days in advance. Temporary utility connections shall be made to maintain service.
- B. Route vehicular and pedestrian traffic away from Work at all times during site preparation and construction activities. Temporary facilities shall remain in effect until all outside construction activities have been completed.
- C. Notify municipality and the county conservation district of the location of any offsite borrow and/or disposal site(s) that will be used during construction prior to site preparation. The Contractor shall identify the erosion and Sediment control measures which will be implemented at the disposal/borrow sites, and any applicable permit numbers. If the borrow area/disposal site is not permitted, an erosion and Sediment control plan must be prepared by the Contractor and approved by the regulatory agency having jurisdiction prior to its use.
- D. Notify the Owner or his representative after identifying any existing utilities that are not shown on the drawings.
- E. The removal of minor obstructions shall be anticipated and accomplished even though not shown or specifically mentioned. Major obstructions encountered shall immediately be identified to the Owner. The Owner or his representative shall make a determination for proceeding with the work of the major obstruction encountered. Any work performed by the Contractor before the Owner or his representative has made a determination will be made at the Contractor's own risk and at no additional cost to the Owner. The removed materials shall be disposed of in an approved waste site or other location as directed by the Owner or his representative. The quantity of each major obstruction that is removed to accommodate the proposed construction shall be measured by the Owner or his representative prior to or during the removal.
- F. The Contractor responsible for the site preparation shall coordinate with other contractors on site during such operations.

1.08 PROJECT RECORD DOCUMENTS

- A. Not Used.

PART 2 - PRODUCTS

2.01 FILL MATERIALS

- A. Not Used.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that all existing landscaped areas to be removed are tagged or identified and their removal has been approved by the Owner or his representative.
- B. Verify existing grades prior to beginning site preparation. If the existing grades are at variances with the drawings, notify the Owner and receive instructions prior to proceeding. No additional compensation will be considered resulting from grade variances once site clearing has commenced.
- C. Verify that erosion and Sediment control measures have been properly installed in their proper locations prior to commencing with clearing and grubbing activities.
- D. Verify that survey benchmarks and intended elevations for the work are as shown on the drawings.

3.02 PREPARATION

- A. Locate, identify, and protect any and all structures, slabs, utilities and appurtenances to remain from damage.
- B. Protect trees, plant growth and other site features designated to remain as final landscaping.
- C. Protect benchmarks and existing structures from damage or displacement.
- D. Construction stakeout shall be performed by a licensed surveying firm provided by the Contractor.
- E. Protect areas outside limits of construction from encroachment by construction personnel or equipment, regardless of property ownership. Access shall be specific, written permission or easement only.
- F. Existing utilities are indicated on the drawings as approximate locations and not all the above or below grade structures and utilities may be shown. It is the Contractor's responsibility to locate and verify the extent and location of above or below grade site utilities and structures.

3.03 CLEARING AND REMOVAL

- A. Remove surface debris, trees, brush, rubbish, and other objectionable matter within the approximate limit of work. Dispose of off-site brush, stumps, roots, etc., cleared and grubbed from the site in an approved and permitted waste site. Burning will not be permitted unless the Contractor obtains written approval from the local jurisdictional authority. If burning is permitted by local jurisdiction, all burn pits shall be monitored by the Contractor at all times, local

jurisdictional containment and emergency procedures followed, and residual matter from closed burn pits excavated and disposed of off-site in an approved waste facility.

- B. Topsoil shall be stripped, segregated, and stockpiled in areas identified on the Erosion and Sediment Control Plans. Stripping of topsoil shall be performed to such depths as required to remove soils with significant organic matter.
- C. Erect and maintain a temporary fence around drip line of individual trees or around perimeter drip line of groups of trees identified to remain. Remove fence when construction completed. Do not excavate within drip line of trees, unless otherwise noted.
- D. Coordinate with the appropriate utility company on the disconnection and removal of site utilities, which are identified for removal, in accordance with Section 02 4113.

3.04 ENVIRONMENTAL QUALITY PROTECTION

- A. Landscape Preservation: The Contractor shall exercise care to preserve the natural landscape beyond the limits of the work and shall conduct his construction operations in a manner which prevents any unnecessary destruction, scarring, or defacing of the natural surroundings in the vicinity of the work. Except where clearing and grubbing is required for permanent construction, stockpile areas and earthwork activities, all trees, shrubbery, and vegetation shall be preserved and shall be protected from damage, which may be caused by the Contractor's construction operations and equipment. Movement of crews and equipment within the property shall be performed in a manner that prevents damage to roads or adjacent properties. Where unnecessary destruction, scarring, damage, or defacing may occur as a result of the Contractor's operations, the Contractor shall repair, replant, reseed, or otherwise correct the situation to meet pre-construction conditions at no expense to the Owner.
- B. Prevention of Water Pollution: The Contractor shall comply with applicable Federal, State, and local laws, orders, and regulations concerning the control and abatement of water pollution. The Contractor's construction activities shall be performed in a manner that prevents solid matter, contaminants, debris, and other objectionable pollutants and wastes from entering streams, drainage swales, storm sewers, and underground water sources. Such pollutants and wastes include, but are not limited to refuse, garbage, cement, concrete, sewage effluent, industrial waste, mineral salts, oil and other petroleum products. Erosion and Sediment control measures shall be used to reduce the potential for offsite sediment pollution.
- C. Abatement of Air Pollution: The Contractor shall comply with applicable Federal, State and local laws, orders, and regulations concerning the prevention and control of air pollution. During construction activities and operation of equipment, the Contractor shall use such practicable methods and devices as are reasonably available to control, prevent, or otherwise minimize atmospheric emissions or discharges of air contaminants. Equipment and vehicles that produce excessive emissions of exhaust gases due to poor engine adjustments or other inefficient operating conditions shall not be operated until they are repaired or adjustments are made. The Contractor shall store and handle cement and pozzolans in a manner that eliminates atmospheric discharges of dust to the extent possible. Storage and handling of flammable and combustible liquids and provisions for fire prevention shall be in accordance with local requirements and construction safety standards.
- D. Dust Abatement: The Contractor shall control dust with water spray or other methods approved by the Owner. The Contractor shall furnish all the labor, equipment, materials, and means required to prevent dust, which has originated from his operations from causing a nuisance to neighboring properties and streets. The Contractor shall carry out proper and efficient measures wherever and as often as necessary to prevent dusting. The Contractor will be held liable for any damage resulting from dust originating from his operations. The cost of water sprinkling or other methods used to reduce dust shall be included in the prices bid for other items of work.
- E. Noise Pollution Prevention: The Contractor shall carry out proper and efficient measures to prevent excessive noise pollution. "Low noise" and properly muffled equipment is to be used whenever applicable. The operation of construction equipment is to be done only during normal workday hours, unless otherwise approved by the Owner and the local municipality having jurisdiction.

3.05 SITE PREPARATION REQUIREMENTS

- A. Conduct site preparation activities in a manner, which minimizes interference with existing utilities to remain.
- B. Immediately cease site preparation activities if adjacent structures appear to be in danger. Notify authority having jurisdiction. Do not resume site preparation activities until directed by the Owner or his representative.
- C. Conduct site preparation activities with minimum interference to public or private accesses. Maintain vehicular access to adjacent properties.

3.06 STOCKPILES

- A. Stockpile reusable materials onsite. The materials shall be stockpiled a sufficient distance away from excavations and trenches to prevent slides or cave-ins. The Contractor shall select stockpile locations.
- B. Suitable material, if stockpiled, shall be stored so as not to interfere with the established sequence of the construction.
- C. The height of the topsoil stockpile is not to exceed 10 feet, and the side slopes of soil stockpiles shall not be steeper than 2 horizontal to 1 vertical.
- D. Separate differing materials with dividers or stockpile apart to prevent mixing.
- E. Direct surface water away from stockpile site to prevent erosion or deterioration of materials. Stockpiled material shall be protected from precipitation such that it does not become too wet to achieve the project specified compaction requirements.
- F. Install silt fence around the perimeter of all topsoil stockpiles in accordance with the approved Erosion and Sediment Control Plan and Section 31 2500.
- G. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor shall be required to furnish an offsite storage area.
- H. Remove all stockpiled materials that will not be used for construction, and leave area in a clean and neat condition. Grade ground surface to prevent free-standing surface water.

3.07 DISPOSAL

- A. Non-reusable materials shall be disposed of off-site at an approved storage or waste facility.

END OF SECTION 31 1000

SECTION 31 2000 - EARTH MOVING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Preparing subgrades for walks, pavements, turf, and grasses and plants.
 - 2. Excavating and backfilling for buildings and structures.
 - 3. Subbase course for concrete walks and pavements.
 - 4. Aggregate base course for asphalt paving.
 - 5. Excavation of existing soil and bedrock, if applicable.
 - 6. Placement of excavated materials as new fill, as required.
 - 7. Excavating and backfilling for utilities trenches and below grade vaults.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Aggregate Base Course: Aggregate layer placed between the subgrade and binder course for hot-mix asphalt pavement or concrete.
- B. Backfill: Soil material used to fill an excavation or overexcavation.
 - 1. Initial Backfill: Backfill placed beside and over pipe in a trench, including haunches to support sides of pipe.
 - 2. Final Backfill: Backfill placed over initial backfill to fill a trench.
- C. Bedding Course: Aggregate layer placed over the excavated subgrade and below a pipe, vault, inlet, manhole, or other structure in a trench or excavation.
- D. Borrow Soil: Suitable soil imported from off-site for use as fill or backfill.
- E. Excavation: Removal of material encountered above subgrade elevations and to lines and dimensions indicated. Authorized additional excavation and replacement material will be paid for according to Contract provisions. Unauthorized excavation shall be without additional compensation and shall be replaced with new fill material in accordance with these specifications.
- F. Fill: Suitable soil materials used to raise existing grades.
- G. Overexcavation: Removal of material encountered at subgrade elevations that is not suitable to support new pavements or new fills. Authorized overexcavation and replacement material will be paid for according to Contract provisions.
- H. Structures: Buildings, footings, foundations, retaining walls, slabs, tanks, curbs, mechanical and electrical appurtenances, or other man-made stationary features constructed above or below the ground surface; either existing or proposed.

- I. Subgrade: Uppermost surface of an excavation or the top surface of a fill or backfill immediately below pavement aggregate base course, bedding course, subbase, drainage fill, drainage course, or topsoil materials.
- J. Topsoil: Organic laden material generally occurring at or near ground surface. Areas to be graded should be cleared and grubbed to remove trees, stumps, exposed roots, and other deleterious and compressible materials. Topsoil should be stripped and stockpiled for post-grading landscaping applications. Topsoil is not suitable for reuse as fill in structural areas.
- K. Utilities: Onsite underground pipes, conduits, ducts, and cables, as well as existing or proposed underground services in and adjacent to the project area.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.

1.04 ACTION SUBMITTALS

- A. Product Data: For each type of the following manufactured products required:
 - 1. Geotextiles.
 - 2. Warning tapes.

1.05 INFORMATIONAL SUBMITTALS

- A. Material Test Reports: For each on-site and borrow soil material proposed for fill and backfill as follows:
 - 1. Classification according to ASTM D2487.
 - 2. Laboratory moisture/density relationship curve according to ASTM D1557.
 - 3. Soil gradation and contents according to ASTM D422.
 - 4. Relative density tests of coarse aggregate according to ASTM D4253 and ASTM D4254.

1.06 PROJECT CONDITIONS

- A. Traffic: Minimize interference with adjoining roads, streets, walks, and other adjacent occupied or used facilities during earth moving operations.
 - 1. Do not close or obstruct streets, walks, or other adjacent occupied or used facilities without permission from Owner and authorities having jurisdiction.
 - 2. Provide alternate routes around closed or obstructed traffic ways if required by Owner or authorities having jurisdiction.
- B. Utility Locator Service: Notify PA One-Call for area where project is located before beginning earth moving operations.
- C. Do not commence earth moving operations until required erosion and Sediment control measures specified in the construction drawings are in place.

1.07 QUALITY ASSURANCE

- A. Pre-excavation Conference: Conduct conference at project site prior to on-site excavation.

PART 2 - PRODUCTS

2.01 SOIL AND FILL MATERIALS

- A. General: Provide borrow soil materials when sufficient satisfactory soil materials are not available from on-site excavations.
- B. Satisfactory Soils: USCS Soil Classification Groups GW, GP, GM, GC, SW, SP, SM, SC, or CL according to ASTM D 2487, or a combination of these groups; free of rock or gravel larger than 6 inches in any dimension, debris, waste, frozen materials, vegetation, and other deleterious matter. A reduced maximum particle size of 2 inches shall be utilized in areas where hand-operated compaction equipment is required.
 - 1. Liquid Limit: Max 45.
 - 2. Plasticity Index: Max 20.
- C. Unsatisfactory Soils: USCS Soil Classification Groups ML, OL, CH, MH, OH, and PT according to ASTM D 2487, or a combination of these groups. Unsatisfactory soils also include satisfactory soils not maintained within ± 2 percent of optimum moisture content according to ASTM D 698.
- D. Aggregate Base Course Material: Graded mixture of crushed limestone meeting the requirements of PennDOT No. 2A coarse aggregate as described in Section 703 of PennDOT Publication 408.
- E. Fill: See Satisfactory Soils.
- F. Bedding Course: Naturally or artificially graded mixture of natural or crushed gravel, crushed stone, and natural or crushed sand placed below the utilities, vaults, pipes, or other structures as shown on the construction drawings. Material gradation, type, and placement requirements shall comply with the project drawings or specifications indicated herein.
- G. All work shall be considered *unclassified*. Contractor shall perform all rock removal/remediation work, all undercutting and backfill work, all dewatering work, etc., AS REQUIRED, to a firm subgrade at no additional cost to the Owner, to complete the work. Contractor shall obtain all off-site fill as required at no additional cost to the Owner. Contractor shall dispose of all spoils and excess materials off-site at no additional cost to the Owner.
- H. "Unclassified" is defined as "all excavation, undercutting and fill required to provide the specified engineered subgrade at the required elevations regardless of materials encountered."

2.02 GEOTEXTILES

- A. Separation Geotextile: PennDOT Class 4 Type A geotextile according to PennDOT Publication 408.

2.03 ACCESSORIES

- A. Detectable Warning Tape: Acid- and alkali-resistant, polyethylene film warning tape manufactured for marking and identifying underground utilities, a minimum of 6 inches (150 mm) wide and 4 mils (0.1 mm) thick, continuously inscribed with a description of the utility, with metallic core encased in a protective jacket for corrosion protection, detectable by metal detector when tape is buried up to 30 inches (750 mm) deep; colored as follows:

1. Red: Electric.
2. Yellow: Gas, oil, steam, and dangerous materials.
3. Orange: Telephone and other communications.
4. Blue: Water systems.
5. Green: Sewer systems.

PART 3 - EXECUTION

3.01 PREPARATION AND PROTECTION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earth moving operations.
- B. Protect and maintain erosion and Sediment controls during earth moving operations.
- C. Protect subgrades and foundation soils from freezing temperatures and frost. Remove temporary protection before placing subsequent materials.
- D. Protect benchmarks, existing streets, adjacent properties and other works and structures throughout the entire project.
- E. Protect excavation by shoring, bracing, underpinning or other methods required to prevent cave-in or loose soil from falling into excavated areas.
- F. Protect settlement monitoring points after their installation.
- G. Grade excavation for proper surface water runoff. Prevent ponding of surface water in excavations, backfills, and stockpiles.
- H. Protect stockpiles from precipitation that could increase the moisture content above ± 3 percent of optimum moisture content as determined by ASTM D698.
- I. Protect all subsurface drain outlets after installation.

3.02 DEWATERING

- A. Prevent surface water and groundwater from entering excavations, from ponding on prepared subgrades, and from flooding the project site and surrounding areas.
- B. Protect subgrades from softening, undermining, washout, and damage by rain or water accumulation. Reroute surface water runoff away from excavated areas. Do not allow water to accumulate in excavations. Do not use excavated trenches as temporary drainage ditches.
- C. Grade excavation for proper surface water runoff. Prevent surface water, rain water, and subsurface or groundwater from flowing into excavations and from flooding the Project site and surrounding area.
- D. Provide, maintain and operate pumps and related equipment, including standby equipment, of sufficient capacity to keep excavations free of water until construction is complete and backfilling is finished.
- E. Keep trenches free from water until trenches have been backfilled.
- F. Use methods that will not draw down the surrounding water table, so that adverse impacts on adjacent structures, walls, and surface water resources are prevented.

- G. Dispose of water from trenches and excavation in accordance with the Erosion and Sediment Control Plan.

3.03 COORDINATION

- A. Verify that all site clearing and select demolition activities have been completed prior to commencing with rough grading.
- B. All erosion and Sediment control measures shall be installed prior to commencing with rough grading.
- C. Notify Owner or his representative a minimum of five days prior to the initiation of grading activities.
- D. Notify the Geotechnical Engineer performing quality assurance of the grading schedule a minimum of five days prior to initiating any work under this section.
- E. Coordinate with and make available to the Geotechnical Engineer the site for observation and testing as required by the Geotechnical Engineer's field representative.

3.04 CONTRACTOR RESPONSIBILITY

- A. When the excavating operations encounter artifacts of historical or archaeological significance, temporarily discontinue the operations. Notify the Owner or his representative immediately. Excavate the remainder of the site in such a manner as to preserve the artifacts encountered and allow for their removal by others.
- B. If it is necessary to interrupt existing surface drainage, sewers or underdrains, conduits, utilities, or similar underground structures, take necessary precautions to preserve them and provide temporary services. Repair, to the Owner's satisfaction, or pay the cost of damage to such facilities or structures, which may result from any of the Contractor's operations during the period of the contract.
- C. Blasting shall not be permitted unless written authorization from the Local or State jurisdiction in authority and Owner have been obtained.

3.05 EXCAVATION, GENERAL

- A. Unclassified Excavation: Excavate to required subgrade elevations regardless of the character of surface and subsurface conditions encountered. Excavated materials may include rock, soil materials, and obstructions. No changes in the Contract Sum or the Contract Time will be authorized for rock excavation or removal of obstructions.
 - 1. If excavated materials intended for fill and backfill include unsatisfactory soil materials and rock, replace with satisfactory soil materials.
 - 2. Remove rock and soil to lines and grades indicated to permit installation of permanent construction.

3.06 EXCAVATION FOR STRUCTURES

- A. Excavate to indicated elevations and dimensions within a tolerance of plus or minus 1-inch. If applicable, extend excavations a sufficient distance from structures for placing and removing concrete formwork, for installing services and other construction, and for inspections.
- B. Excavations for Footings and Foundations: Do not disturb bottom of excavation. Excavate by hand to final grade just before placing concrete reinforcement. Trim bottoms to required lines and grades to leave solid base to receive other work.

3.07 EXCAVATION FOR WALKS AND PAVEMENTS

- A. Excavate surfaces under walks and pavements to indicated lines, cross sections, elevations, and subgrades.

3.08 EXCAVATION FOR UTILITY TRENCHES

- A. Excavate trenches to indicated gradients, lines, depths, and elevations.
- B. Excavate trenches to uniform widths to provide clearance on each side of pipe or conduit as per plans. Excavate trench walls vertically from trench bottom to the grades shown on the plans.
- C. Trench Bottoms: Excavate trenches as shown on the drawings to allow for bedding course. Hand-excavate deeper for bells of pipe.

3.09 SUBGRADE INSPECTION

- A. Notify Owner when excavations have reached required subgrade.
- B. If Owner determines that unsatisfactory soil is present, continue excavation and replace with compacted backfill or fill material as directed.
- C. Proofroll new fill, pavement, and floor slab subgrades using a fully-loaded triaxle dump truck weighing at least 20 tons to identify soft pockets and areas of excess yielding. Do not proofroll wet or saturated subgrades.
 - 1. Completely proofroll subgrades in one direction, repeating proofrolling in a direction perpendicular to the first direction. Limit truck speed to 3 mph.
 - 2. Excavate soft spots, unsatisfactory soils, and areas of excessive pumping or rutting, as determined by Owner. Excavate to a depth at which the resulting subgrade will display minimal elasticity under heavy construction equipment as determined by the Owner.
 - 3. Backfilled overexcavations shall be proofrolled again to verify that excessive deflection is not occurring.
- D. Authorized additional excavation or overexcavation and replacement material will be paid for according to Contract provisions.
- E. Reconstruct subgrades damaged by freezing temperatures, frost, rain, accumulated water, or construction activities, as directed by Owner, without additional compensation.

3.10 UNAUTHORIZED EXCAVATION

- A. Fill unauthorized excavation areas as directed by Owner/Architect.

3.11 STORAGE OF SOIL MATERIALS

- A. Stockpile borrow soil materials and excavated satisfactory soil materials without intermixing. Place, grade, and shape stockpiles to drain surface water. Cover to prevent windblown dust. Stockpile soil materials away from edge of excavations. Do not store within drip line of remaining trees.

3.12 UTILITY TRENCH BACKFILL

- A. Place backfill on subgrades free of mud, frost, snow, or ice.

- B. Place and compact bedding course on trench bottoms and where indicated in accordance with the project construction drawings. Shape bedding course to provide continuous support for bells, joints, and barrels of pipes and for joints, fittings, and bodies of conduits.
- C. Backfill voids with satisfactory soil while removing shoring and bracing.
- D. Carefully compact backfill under pipe haunches and compact evenly up on both sides and along the full length of piping or conduit to avoid damage or displacement of piping or conduit. Coordinate backfilling with utilities testing, if required.
- E. Place and compact backfill of satisfactory soil to final subgrade elevation in accordance with the construction drawings.
- F. Install detectable warning tape in accordance with the construction drawings.

3.13 BELOW GRADE VAULT BEDDING AND BACKFILL

- A. Excavate vault to firm/non-yielding subgrade. Overexcavate soft/wet subgrade soils if encountered.
- B. Place vault bedding material on firm/non-yielding subgrade. Vault bedding material to consist of PennDOT No. 2A coarse aggregate a minimum of 6 inches thick. The bedding material shall be placed so that it conforms to the external shape and dimensions of the vault and provides an even bearing surface. Do not place bedding material over porous, wet, frozen, or yielding surfaces.
- C. Compact vault bedding material to within ± 2 percent of optimum moisture and to at least 100 percent of the maximum dry density according to ASTM D 698.
- D. Place vault backfill material adjacent to vault on subgrades free of mud, frost, snow, or ice. Vault backfill material to consist of PennDOT No. 2A coarse aggregate a minimum of 6 inches thick.
- E. Place and compact vault backfill to final subgrade elevation in accordance with the construction drawings.
- F. Compact aggregate backfill within ± 2 percent of optimum moisture and to at least 100 percent of the maximum dry density according to ASTM D 698.

3.14 SOIL FILL

- A. Place and compact fill and backfill material in maximum 8-inch thick loose layers if heavy-compaction equipment is used to compact the fill. Place and compact fill and backfill material in maximum 4-inch thick loose layers if steel plate tampers or other hand-operated compaction equipment is used to compact the fill.
- B. Place soil fill on subgrades free of loose soil and rock, ponded water, mud, frost, snow, or ice.

3.15 SOIL MOISTURE CONTROL

- A. Uniformly moisten or allow to air-dry, each subsequent fill layer before compaction to within ± 2 percent of optimum moisture content as determined by ASTM D 698.
 - 1. Do not place fill material on surfaces that are muddy, frozen, or contain frost or ice.
 - 2. Remove and replace, or scarify and air dry, otherwise satisfactory soil material that exceeds optimum moisture content by 2 percent and is too wet to compact to specified dry unit weight.

3.16 COMPACTION OF SOIL FILLS

- A. Place fill materials in layers not more than 8 inches in loose depth for material compacted by heavy compaction equipment, and not more than 4 inches in loose depth for material compacted by steel plate tampers or hand-operated tampers.
- B. Place fill materials evenly on all sides of structures to required elevations, and uniformly along the full length of each structure.
- C. Compact soil materials to no less than the 100 percent of the maximum dry unit weight according to the Standard Proctor compaction test (ASTM D 698) and to within ± 2 percent of optimum moisture content at time of compaction according to ASTM D 698. Reduced compaction criteria of 95 percent of the Standard Proctor maximum dry density may be utilized for landscaped (non-critical) areas.

3.17 GRADING

- A. General: Uniformly grade areas to a smooth surface, free of irregular surface changes. Comply with compaction requirements and grade to cross sections, lines, and elevations indicated. Provide a smooth transition between adjacent existing grades and new grades. Cut out soft spots, fill low spots, and trim high spots to comply with required surface tolerances.
- B. Site Rough Grading: Slope grades to direct water away from buildings and to prevent ponding. Finish subgrades to required elevations as shown on the construction drawings to within $\frac{1}{2}$ -inch of proposed grades.

3.18 AGGREGATE BASE COURSES UNDER PAVEMENTS AND WALKS

- A. Place aggregate base course on subgrades free of loose soil, mud, frost, snow, or ice.
- B. On prepared subgrade, place aggregate base course under pavements and walks as follows:
 - 1. Install separation geotextile on prepared subgrade according to manufacturer's written instructions, overlapping sides and ends.
 - 2. Place aggregate base course material over separation geotextile in a manner to prevent damage to the separation geotextile. Use a minimum thickness of 4 inches prior to operating machinery over the separation geotextile.
 - 3. Shape aggregate base course to required crown elevations and cross-slope grades.
 - 4. Place aggregate base course in maximum 8-inch loose lifts.
 - 5. Compact aggregate base course within ± 2 percent of optimum moisture and to at least 100 percent of the maximum dry density according to ASTM D 698.
- C. Pavement Shoulders: Place shoulders along edges of aggregate base course to prevent lateral movement.

3.19 FIELD QUALITY CONTROL

- A. Special Inspections: Owner will engage a qualified special inspector to perform the following special inspections and construction quality assurance observations and testing:
 - 1. Determine prior to placement of fill that site has been prepared in compliance with requirements.
 - 2. Determine that fill material and maximum lift thickness comply with requirements.
 - 3. Determine, at the required frequency, that in-place density of compacted fill complies with requirements.

- B. Testing Agency: Owner will engage a qualified geotechnical engineering testing agency to perform tests and inspections.
- C. Allow testing agency to inspect and test subgrades and each fill or backfill layer. Proceed with subsequent earth moving only after test results for previously completed work comply with requirements.
- D. Testing agency will test compaction and moisture content of soils in place according to ASTM D 698, ASTM D 1556, ASTM D 1557, ASTM D 2167, ASTM D 6938, and ASTM D 2937, as applicable. Tests will be performed at the following locations and frequencies:
 - 1. Building and pavement Areas: At subgrade and at each compacted fill and backfill layer, at least one test for every 5,000 square feet or less of fill placed at the site.
 - 2. Trench/Vault Bedding and Backfill: At each compacted bedding and backfill layer, at least one test for every 100 feet or less of trench length, but no fewer than one test per lift.
- E. Footing Subgrade: At footing subgrades, at least one test of each soil stratum will be performed to verify design bearing capacities. Subsequent verification and approval of other footing subgrades may be based on a visual comparison of subgrade with tested subgrade when approved by Architect.
- F. When testing agency reports that subgrades, fills, or backfills have not achieved degree of compaction specified, scarify and moisten or air-dry, or remove and replace soil materials to depth required; recompact and retest until specified compaction is obtained.
- G. The Contractor is responsible for completing the work in accordance with these specifications. The Owner will retain the services of the Geotechnical Engineer to provide quality assurance monitoring and testing during earthwork operations. The Contractor shall make available the site at all times for monitoring or testing.
- H. The Contractor shall assist with the preparation of areas to be tested or the collection of materials to be tested.
- I. The Contractor shall be responsible for, at no additional cost to the Owner, corrective measures based on monitoring or testing performed by the Owner or his representative. Corrective measures include, but are not limited to, removing wet, soft or unsuitable material, recompact or reworking fill; or correcting other work on completed areas in accordance with these specifications.
- J. The Owner or his representative will visually observe the site grading to verify that a firm; unyielding foundation with no sudden, sharp, or abrupt changes or break in grades shall exist after compaction. No standing water or excess moisture shall be allowed. All soft or yielding areas will be excavated to a depth at which, when replaced with approved subsoil materials and recompact at a moisture content not exceeding optimum, the subgrade will display minimal elasticity.
- K. In addition to performing confirmatory in-place moisture-density tests, the CQA consultant shall visually monitor the action of compaction and construction equipment on the lift surface (i.e., penetration, pumping, cracking, movement), the compacted layer thicknesses, and the number of passes used for compaction.
- L. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.20 PROTECTION

- A. Protecting Graded Areas: Protect newly graded areas from traffic, freezing, and erosion. Keep free of trash and debris.
- B. Repair and reestablish grades to specified tolerances where completed or partially completed surfaces become eroded, rutted, settled, or where they lose compaction due to subsequent construction operations or weather conditions.

1. Scarify or remove and replace soil material to depth as directed by Owner; reshape and recompact.
- C. Where settling occurs before Project correction period elapses, remove finished surfacing, backfill with additional soil material, compact, and reconstruct surfacing.
 1. Restore appearance, quality, and condition of finished surfacing to match adjacent work, and eliminate evidence of restoration to greatest extent possible.

3.21 DISPOSAL OF SURPLUS AND WASTE MATERIALS

- A. Remove surplus satisfactory soil and waste materials, including unsatisfactory soil, trash, and debris, and legally dispose of them off Owner's property.

END OF SECTION 31 2000

SECTION 31 2300 - EXCAVATION, BACKFILLING, AND COMPACTION

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Excavation and stockpiling of suitable backfill material.
 - 2. Excavation, removal, and disposal from the site of unsuitable backfill materials.
 - 3. Bracing, shoring, and protection of existing structures, utilities, and roadways.
 - 4. Dewatering.
 - 5. Cutting, filling, and rough contouring the site for building areas, pavement areas, landscaped and lawn areas.
 - 6. Providing, placing, and compacting suitable fill and drainage materials.
 - 7. Finish Grading.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by Civil & Environmental Consultants, Inc.
- D. Section 02 4113 – Demolition.
- E. Section 31 1000 – Site Preparation and Clearing.
- F. Section 31 2500 – Erosion and Sediment Control.
- G. Section 32 1000 – Aggregate Materials.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Control Manual, latest edition.
- B. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- C. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by Sand-Cone Method.

- D. ASTM D2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- E. ASTM D2487 – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System).
- F. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.
- G. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- H. ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- I. ASTM D4371 – Standard Test Method for Determining the Washability Characteristics of Coal.
- J. ASTM D6913 – Standard Test Methods for Particle-Size Distribution (Gradation) of Soils Using Sieve Analysis.
- K. 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. The Contractor is responsible for selecting the supplier of any required imported soil materials and submitting the name of the supplier to the Owner or his representative 14 days prior to trucking any imported material to the site. The Contractor shall submit to the Owner standard Proctor (performed in accordance with ASTM D698), Atterberg limits (performed in accordance with ASTM D4318), and grain size distribution (performed in accordance with ASTM D6913) results from samples of the soil materials to be imported. The Owner or his representative may request information about the supplier, and the Owner holds the right to reject a supplier. If the Contractor chooses to change the supplier, he must first receive approval from the Owner or his representative.
- B. Submit evidence that the method of any bracing and shoring of excavations conforms to Occupational Safety and Health Administration (OSHA) Standards.
- C. Submit written authorization and releases from the Owner(s) of the property where any excess or unsuitable material will be deposited absolving the Owner from responsibility in connection with disposal of excess or unsuitable materials.
- D. The Contractor is responsible for submitting the information specified on the retaining wall drawing set.

1.06 REGULATORY REQUIREMENTS

- A. Obtain required approvals/permits from the appropriate authorities for the off-site disposal of any unusable materials.
- B. Conform to State and local codes for disposal of debris.
- C. Do not close or obstruct emergency entrances, roadways, fire lanes, sidewalks, or hydrants without approval from the Owner, municipality, local Department of Public Works, and Pennsylvania Department of Transportation (PennDOT).
- D. Conform to the requirements of the approved Erosion and Sediment Control Plan, municipality, and the PADEP Erosion and Sediment Control Manual with regards to the installation of erosion control measures.
- E. Maintain adjoining streets and roads free of mud and debris that are deposited from vehicles traveling to and from the work site.

- F. Contractors shall call 1-800-242-1776 (PA One-Call) a minimum of three and no more than ten working days prior to starting any excavation.

1.07 COORDINATION

- A. Not used.

1.08 PROJECT RECORD DOCUMENTS

- A. Compile recorded information and include as-built drawings to be submitted to the Owner.
- B. All quality control/quality assurance test results and construction monitoring daily field reports shall be provided to the Owner by the contractor. The Owner or his representative may request additional tests at no cost to the Owner.

1.09 EXISTING CONDITIONS

- A. An attempt has been made to show all utilities known to exist in their approximate location. The Contractor shall be responsible in determining the exact location, nature and status of all utilities whether shown on the plans or not before removing, adjusting, altering, extending or relocation and shall make all necessary caps, plugs and terminations as required by the utility owner and/or governing authorities to return said utility to complete operation at no cost to the Owner. Any utility, which is damaged due to construction, shall be repaired and/or replaced by the Contractor at no cost to the Owner.
- B. Information shown on the existing condition plans is for general information of bidders. Contractors are expected to examine the site, make investigations, and decide for themselves the character of the materials to be encountered, existing conditions, and work to be done.
- C. The Owner will not assume responsibility for variations of subsoil quality or conditions at locations other than places shown at the time the Geotechnical Investigations were made.
- D. The Contractor shall verify the existence or nonexistence of septic tanks, wells, cisterns, basements or cellars on the site. The existence of any of the above items not shown on the plans shall be brought to the attention of the Owner or his representative immediately. The above shall be demolished in accordance with Section 024113 and the area filled and compacted as specified at no additional cost to the Owner, unless directed otherwise by the Owner or his representative.

PART 2 – PRODUCTS

2.01 SOIL MATERIALS

- A. Topsoil: Excavated and re-usable material, graded, free of roots, rocks larger than 1 inch, subsoil, debris, large weeds, and foreign matter. The excavated topsoil material shall be approved by the Owner or his representative prior to its re-use.
- B. General Structural Fill: General structural fill material shall be used in all areas of the site requiring fill. Excavated and re-usable material, graded, free of rocks larger than 6-inches and free of debris, waste, frozen materials, vegetation, and other deleterious matter. The moisture content of the general structural fill shall be ± 3 percent of optimum moisture content as determined by ASTM D698. General structural fill materials must consist of GW, GP, GM, GC, SP, SM, SW, and/or SC (or combinations thereof) in accordance with ASTM D2487. CL soils may also be used as general structural fill materials provided the liquid limit and plasticity index is less than 40 and 20 percent, respectively. On-site excavated

or off-site soil fill shall be sampled, tested and determined as suitable material by the Geotechnical Engineer prior to incorporation in the work.

- C. Crushed Concrete: Crushed concrete shall meet the gradation requirements for general structural fill.
- D. All work shall be considered unclassified. Contractor shall perform all rock removal/remediation work, all undercutting and backfill work, all dewatering work, etc., AS REQUIRED, to a firm subgrade at no additional cost to the Owner, to complete the work. Contractor shall obtain all off-site fill as required at no additional cost to the Owner. Contractor shall dispose of all spoils and excess materials off-site at no additional cost to the Owner.
- E. "Unclassified" is defined as "all excavation, undercutting and fill required to provide the specified engineered subgrade at the required elevations regardless of materials encountered."
- F. Drain Backfill: Imported aggregate that meets AASHTO No. 57 gradation aggregate.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Protect benchmarks, existing streets, adjacent properties, and other works and structures throughout the entire project.
- B. Protect excavation by shoring, bracing, underpinning, or other methods required to prevent cave-in or loose soil from falling into excavated areas.
- C. Protect settlement monitoring points after their installation.
- D. Protect stockpiles from precipitation that could increase the moisture content above ± 3 percent of optimum moisture content.
- E. Protect any subsurface drain outlets after installation.

3.02 PREPARATION

- A. Establish and maintain suitable grade control stakes over areas to be graded. Maintain other reference points during construction to properly perform the Work.
- B. Prior to excavation and grading operations, install the Erosion and Sediment Control measures as shown on the Erosion and Sediment Control Plan.
- C. Identify known underground utilities. Stake and flag locations. Coordinate with utility companies and maintain and protect existing utilities remaining which pass through work area.

3.03 DEWATERING

- A. Grade excavation for proper surface water runoff. Prevent surface water, rain water, and subsurface or ground water from flowing into excavations and from flooding the project site and surrounding area.
- B. Provide, maintain, and operate pumps and related equipment, including standby equipment, of sufficient capacity to keep excavations free of water until construction is complete and backfilling is finished.
- C. Keep trenches free from water until trenches have been backfilled.

- D. Contractor shall install dewatering/sump pump system in accordance with manufacturer and architect plans, recommendations, and specifications.
- E. Dispose of water from trenches and excavation in accordance with the Erosion and Sediment Control Plan.

3.04 COORDINATION

- A. Verify that all site clearing and demolition activities have been completed prior to commencing with rough grading.
- B. All erosion and Sediment control measures shall be installed prior to commencing with rough grading.
- C. Notify Owner or his representative a minimum of 5 days prior to the initiation of grading activities.
- D. Notify the Geotechnical Engineer performing quality assurance of the grading schedule a minimum of five days prior to initiating any work under this section.
- E. Coordinate with and make available to the Geotechnical Engineer the site for observation and testing as required by the Geotechnical Engineer's field representative.

3.05 CONTRACTOR RESPONSIBILITY

- A. When the excavating operations encounter artifacts of historical or archaeological significance, temporarily discontinue the operations. Notify the Owner or his representative immediately. Excavate the remainder of the site in such a manner as to preserve the artifacts encountered and allow for their removal by others.
- B. If it is necessary to interrupt existing surface drainage, sewers or underdrains, conduits, utilities, or similar underground structures, take necessary precautions to preserve them and provide temporary services. Repair, to the Owner's satisfaction, or pay the cost of damage to such facilities or structures, which may result from any of the Contractor's operations during the period of the contract.
- C. Blasting shall not be permitted unless written authorization from the local or state jurisdiction in authority and Owner have been obtained.

3.06 EXCAVATION

- A. No excavation shall be started until adequate horizontal and vertical control has been established in the field by the Contractor and reviewed by the Owner.
- B. When the volume of suitable excavated material exceeds that required for the Project Work, the excess shall be disposed of as directed by the Owner.
- C. Work requiring sheeting, shoring, and bracing is the responsibility of the Contractor and shall, at all times, be in conformance with the latest requirements for construction standard for excavations (29 CFR Part 1926.650-652 Subpart P) as promulgated by OSHA.
- D. The Contractor shall refer to the Geotechnical Report for rock removal recommendations. The sequence of excavation operations shall be such as to ensure the most efficient reuse of excavated materials where suitable. Suitable materials shall be used or stockpiled for later use as backfill or embankment.
- E. Stockpile reusable materials on site. Remove unsuitable materials from the site to an approved storage and/or waste facility. Suitable material, if stockpiled, shall be stored so as not to interfere with the established sequence of the

construction. If there is not sufficient area available for stockpiling within the limits of the project, the Contractor shall be required to furnish an offsite disposal area.

- F. Soil and rock materials along the limits of excavations or adjacent to and outside the limits of Work, which are unstable or unsuitable and constitute a potential slide area, shall be excavated and/or benched to reduce the risk of slides and slips. The Contractor shall immediately notify the Owner or his representative if potential unstable conditions are identified.
- G. When the plans require excavation in areas in close proximity to existing roads, structures and utilities, it shall be the responsibility of the Contractor to construct suitable drainage ditches or use other satisfactory means and methods to protect and maintain the stability of such roads and structures located immediately adjacent to but outside the limits of excavation.
- H. Cut slope banks in accordance with applicable OSHA requirements. Excavation shall not interfere with any adjacent soil supported foundation. Temporary excavations shall be graded in accordance with OSHA excavation/trenching standards.
- I. Muck, peat, matted roots, or other organic material, unsatisfactory as a subgrade, shall be removed to the depth specified or as directed by the Geotechnical Engineer or Owner. Unsuitable materials shall be disposed of off-site. The excavated area shall be refilled with suitable material, obtained from the grading operations or borrow areas and compacted to the project compaction specifications.
- J. Overbreak, including slides, is that portion of any material displaced or loosened beyond the finished limit of work. All overbreaks shall be removed by the Contractor and used as fill or disposed of as directed.
- K. Any overexcavation or excess excavation performed by the Contractor for any purpose or reason, except as may be ordered in writing by the Owner or his representative, and whether or not due to the fault of the Contractor, shall be at the expense of the Contractor. All such excess excavations or over excavations shall be refilled with materials furnished, placed, and compacted by and at the expense of the Contractor. All over excavations shall be reworked to the satisfaction of the Owner or his representative.

3.07 FILL PLACEMENT

- A. Prior to fill placement, areas receiving fill shall be proofrolled with a fully-loaded dump truck with a minimum loaded weight of 20 tons to determine the uniformity of the compaction below the subgrade surface and to locate and permit timely correction of subgrade deficiencies. Any and all deficiencies shall be corrected in a manner satisfactory to the Owner or his representative. After all corrective work has been completed; the surface shall be proofrolled again. The corrective work shall not be considered complete until the subgrade shows satisfactory response to the proofrolling operations.
- B. Fill areas to contours and elevations with suitable materials. In the event that any fill, which has already been placed or the embankment foundation shall become frozen before the next lift is placed, it shall be scarified and recompacted or removed to the approval of the Owner or his representative.
- C. Do not fill over wet, frozen, snow covered or yielding subgrade surfaces. Any soft spots shall be removed or recompacted to the satisfaction of the Owner or his representative, as specified herein, before new fill is placed.
- D. Place suitable soil fill materials as recommended by the Geotechnical Engineer of record.
- E. Place backfill and fill soil materials, including crushed concrete, in layers not more than 12 inches in loose depth for material compacted by heavy compaction equipment. Fill materials shall be compacted to no less than the 100 percent of the maximum dry unit weight according to the Standard Proctor compaction test (ASTM D698) and to within ± 3 percent of optimum moisture content at time of compaction according to ASTM D698. Reduced compaction criteria of 95 percent of the Standard Proctor maximum dry density may be utilized for landscaped (non-critical) areas.

- F. Coarse-grained and AASHTO No. 57 aggregate materials shall be compacted to a minimum 75 percent of the relative density and visual non-movement with vibratory compaction equipment. Coarse-grained materials shall be compacted using a minimum of three passes with heavy compaction equipment.
- G. At the end of each work day the fill shall be sloped back toward the existing hillsides, and/or subsurface drains, to reduce potential erosion of finished slope faces. The last lift of reinforced fill materials shall be sloped away from wall faces to direct runoff away from retaining walls. The fill should also be compacted with a smooth-drum roller at the end of the workday to "seal" the fill and reduce the impact of precipitation.
- H. Placement of rock material as fill, if necessary, shall be done at the direction of and sole direction of the Geotechnical Engineer of record.
- I. Fill materials may be moisture sensitive, and the Contractor shall anticipate the need to implement drying measures to facilitate fill placement. Drying of wet soil materials may be expedited by the use of plows, disks, harrows, industrial dryers and/or heaters, mixing with dry fill materials, or other methods approved by the Owner or his representative.

3.08 FIELD QUALITY CONTROL

- A. The Contractor is responsible for completing the work in accordance with these specifications. The Owner will retain the services of a geotechnical engineer to provide quality assurance monitoring and testing during earthwork operations. The Contractor shall make available the site at all times for monitoring or testing.
- B. The Contractor shall assist with the preparation of areas to be tested or the collection of materials to be tested.
- C. The Contractor shall be responsible for, at no additional cost to the Owner, corrective measures based on monitoring or testing performed by the Owner or his representative. Corrective measures include, but are not limited to, removing wet, soft or unsuitable material, recompact or reworking fill; or correcting other work on completed areas in accordance with these specifications.
- D. The Owner or his representative will visually observe the site grading to verify that a firm, unyielding foundation with no sudden, sharp, or abrupt changes or break in grades shall exist after compaction. No standing water or excess moisture shall be allowed. All soft or yielding areas will be excavated to a depth at which, when replaced with approved subsoil materials and recompact at a moisture content not exceeding optimum, the subgrade will display minimal elasticity.
- E. The Owner or his representative shall perform field moisture-density tests on each lift of structural fill in accordance with ASTM D6938. Nuclear density testing shall be performed at a frequency of one test per 5,000 square feet of fill placed, but no less than one test per lift of fill. Nuclear density testing shall be supplemented by visual inspection of fill materials. Fill materials observed to pump, rut, or deflect beneath the weight of construction equipment shall be deemed unsuitable and shall be recompact until the fill surface is firm and non-yielding.
- F. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

3.09 DUST CONTROL

- A. Employ methods and/or materials to prevent the spread of dust as required and approved by the Owner and as required by the local conservation district.

3.10 CLEAN-UP

- A. At the end of excavation, backfilling, and grading operations and before acceptance of the work, remove debris, materials, rubbish, etc., from the site and dispose of in an approved waste facility. The premises shall be left clean, presentable, and satisfactory.

END OF SECTION 31 2300

SECTION 31 2333 - TRENCHING

PART 1 – GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Excavating trenches for new utility lines from at least 5 feet outside the building to a point of connection with utility main lines.
 - 2. Backfill and compaction of fill placed in utility trenches between the top of the utility bedding and the subgrade elevations.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Utility: Any buried water, sanitary and/or storm sewer, gas, electric, telephone, or cable line, appurtenance, or fitting.
- B. Bedding: Fill material placed under, beside, and directly over the utility prior to subsequent backfill operations.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 31 1000 – Site Preparation and Clearing.
- E. Section 31 2300 – Excavation, Backfill, and Compaction.
- F. Section 32 1000 – Aggregate Materials.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Control Manual, latest edition.
- B. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- C. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
- D. ASTM D2216 – Standard Test Method for Laboratory Determination of Water and Rock by Mass.

- E. ASTM D2922 – Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- F. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
- G. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight and Unit Weight of Soils Using a Vibratory Table.
- H. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- I. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Standards for Roadway Construction, Series RC 0 – 100.
- J. PennDOT Publication 203 – Work Zone Traffic Control.

1.05 SUBMITTALS

- A. Not used.

1.06 REGULATORY REQUIREMENTS

- A. Obtain required approvals/permits from the appropriate authorities for materials to be disposed off-site.
- B. The work of sheeting, shoring, and bracing is the responsibility of the Contractor and shall at all times be in conformance with the latest requirements for construction standard for excavations (29 CFR Part 1926.650-.652 Subpart P) promulgated by Occupational Safety and Health Administration (OSHA).
- C. The Contractor shall notify individual utilities of intent to commence construction around existing utility lines. Contractors shall call 1-800-242-1776 (PA One-Call) a minimum of three and no more than ten working days prior to the start of work.

1.07 COORDINATION

- A. Verify work associated with lower elevation utilities has been completed before placing higher elevation utilities. Installation of new utilities shall commence at the lowest connection point.
- B. Verify that all site clearing activities have been completed and all erosion and Sediment control measures have been installed prior to commencing with trenching.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 – PRODUCTS

2.01 MATERIALS

- A. Subsoil and topsoil as specified in Section 31 2300.
- B. Aggregate Material as specified in Section 32 1000.

PART 3 – EXECUTION

3.01 EXAMINATION

- A. Verify that survey benchmarks and intended elevations for the Work are as shown on the drawings. Coordinate with the Surveyor of Record.

3.02 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Stake and flag locations of known utilities.
- C. Locate, identify, and protect above and below grade utilities, which are to remain, from damage.
- D. Notify utility companies of intent to remove and relocate utilities.
- E. Protect trees, plant life, lawns, and other site features, which will remain as part of the final landscaping.
- F. Protect bench marks, existing structures, sidewalks, pavement, curbs, and other site features from excavation and construction equipment, and vehicular traffic.

3.03 TRENCH EXCAVATION

- A. Excavate subsoil and/or rock required for the various utility installations to the established lines and grades as shown on the drawings. Provide a firm and uniform bearing for the entire length of pipe and appurtenances.

If the material found at the bottom of the excavation might cause unequal settlement or provide unequal bearing for the pipe, structure, etc., or is otherwise unsuitable for a foundation or for pipe bedding, it shall be removed by the Contractor to a depth and width specified by the Owner or his representative and replaced with competent subgrade foundation material.

The subgrade foundation materials shall be compacted to a density consistent with the undisturbed soils and to the satisfaction of the Owner or his representative. This specification also applies to excavations for manholes and other below-grade structures.

- B. Cut trenches sufficiently wide to enable installation and allow for inspection.
- C. Do not interfere with 45 degree bearing splay of existing and/or new foundations.
- D. All excavations shall be kept free of water, snow, and ice during construction.

- E. Hand trim excavations. Hand trim for bell and spigot pipe joints. Remove loose matter. The bottom portion of all trenches shall, in general, conform to the external shape and dimensions of the structure and provide an even bearing pressure for the structure.
- F. Remove lumped subsoil and boulders.
- G. Any excavation below the required level without authorization shall be backfilled with approved subsoil materials by the Contractor, at no expense to the Owner. Placement and compaction of such backfill shall be to the satisfaction of the Owner or his representative.
- H. Correct undercut areas by backfilling with soil materials as specified by the Geotechnical Engineer of record.
- I. The trench excavations shall not advance more than 200 feet ahead of the pipe laying and masonry work, except where it is absolutely necessary because of site conditions. The Contractor shall extend the trench or dig test pits to locate utilities when approaching existing utilities to be crossed or connected to. Any necessary changes in line or grade of the Work, or any excavation and removal of pipe, caused by failure to take such precautions, will be at no expense to the Owner.
- J. When excavations are to be made in paved surfaces, the paved surfaces shall be line cut 1- foot beyond each side of the trench and ahead of the excavation by means of pneumatic tool, saw cutting, or other approved tools to provide a clean, uniform edge, with minimum disturbance of remaining pavements. The pavements so removed shall not be used for trench backfill, but shall be disposed of off-site in an approved manner. Mats shall be placed for excavation equipment where damage could be caused to existing pavements.
- K. Whenever it is necessary to work near, or in any way interfere with a public sewer, drain pipe, catch basin, culvert, or other structure, the Contractor shall maintain same in working order and shall repair and make good any damage done to them during the progress of the work.
- L. The Contractor shall furnish, install, and maintain such sheeting, shoring, bracing, and coffer damming, etc., as may be needed to support the sides and roofs of excavations and to prevent any earth or rock movements which might in any way diminish or affect the necessary width of the excavation, endanger the safety of persons, injure or delay the work, or jeopardize the safety or adjacent pavements, property, buildings, or other structures. The work of sheeting, shoring, and bracing shall, at all times, be in conformance with the latest requirements for construction standard for excavations (29 CFR Part 1926.650-.652 Subpart P) promulgated by OSHA.
- M. Shoring, sheeting, and bracing shall be removed progressively up from the bottom of the trench as the compacted backfill is placed. During backfill operations, sheeting which is to be removed shall at no time extend into the backfill, which is being compacted. The sheeting shall be withdrawn so as to always be above the backfill.
- N. The Contractor shall remove, by pumping or other means, any surface or groundwater which may accumulate in trench excavations, and shall at all times keep trench excavations free from water while work is being performed in them. The water shall be disposed of in a manner that will not cause injury or damage to the public health, public property, nearby streams or rivers, the work contemplated or in progress, surfaces of the streets, nor cause any interference with the use of same. The disposal of this water shall be performed in a manner satisfactory to the Owner or his representative, and authorities having jurisdiction. Drainage of water by way of the section of pipe under construction will not be permitted.

3.04 STOCKPILING

- A. Stockpile reusable materials in accordance with Section 31 1000.

3.05 TRENCH BACKFILLING

- A. Backfill trenches between the top of the bedding material and the subgrade elevation with suitable materials.

- B. Systematically backfill to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or yielding subgrade surfaces.
- C. Place soil materials and/or aggregate, as specified on the drawings and according to the recommendations of the Geotechnical Engineer of record.
- D. Employ placement and compaction methods that do not disturb or damage foundation perimeter drainage and other utility trenches.
- E. Remove surplus excavation materials from site.

3.06 RESTORATION

- A. As the trenching work, or portions of the work, is completed, and due allowance is made for the trench settlement, the Contractor shall complete the final grading and dressing up. This final cleanup shall include the raking of the surface to remove all debris and stones. The Contractor will be required to replace, at his own expense, any pavement, curb, sidewalk, or other structure outside the trench area which has been damaged, has settled or moved out of alignment, either during the progress of the work or due to subsequent settlement by reason of trenching, or improper backfilling. The area disturbed by construction shall be left in as good condition as it was before the commencement of the work. Any repairs required because of unsatisfactory trench backfilling shall be at the expense of the Contractor.

3.07 STOCKPILE CLEAN-UP

- A. Remove all stockpiled materials that will not be used for construction, and leave area in a clean and neat condition. Grade ground surface to prevent free-standing surface water.

3.08 DISPOSAL

- A. Excess excavation material not being reused shall be disposed of off-site in an approved waste facility.

3.09 TOLERANCES

- A. Top Surface of Subgrade: Plus or minus 1/10-foot.

3.10 FIELD QUALITY CONTROL

- A. The Owner or his representative will visually observe to verify that lift thickness of backfill placement is not greater than the Geotechnical Engineer's recommended thickness.
- B. Compaction testing will be performed in accordance with ASTM D698, ASTM D4253, and/or ASTM D4254.
- C. The Owner or his representative will visually observe the utility trenches to verify that a firm, unyielding foundation with no sudden, sharp, or abrupt changes or break in grades shall exist after compaction. No standing water or excess moisture shall be allowed. All soft or yielding areas will be excavated to a depth at which, when replaced with approved subsoil materials and recompacted at a moisture content not exceeding optimum, the subgrade will display minimal elasticity.
- D. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.
- E. Frequency of Tests: To be approved by the Owner or his representative.

3.11 PROTECTION OF FINISHED WORK

- A. The Contractor shall be responsible for protecting and maintaining the trench bottom in a suitable condition. Should the Contractor fail to maintain the trench foundation in a condition suitable for utility installation, he shall, at his own expense, excavate and dispose of unsuitable material and replace and compact new subgrade foundation material to the required grade. If the trench bottoms become wet, all soft materials shall be removed and replaced with a suitable material and compacted to a density equal to that of the undisturbed soil. Trench bottoms shall be protected from frost or freezing.
- B. The Contractor shall be entirely and solely responsible for the adequacy and sufficiency of all supports and of all sheeting, bracing, shoring, coffer damming, etc. The Contractor shall assume entire and sole liability for damages on account of injury to persons, adjacent pavements, and public and private property including, but not limited to, the work under construction, buildings and other structures, which injury shall result directly or indirectly from the Contractor's failure to install or to leave in place adequate and sufficient supports, sheeting, bracing, shoring, coffer damming, etc.

END OF SECTION 31 2333

SECTION 31 2500 - EROSION AND SEDIMENT CONTROL

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Installation of erosion and sediment control best management practices (BMPs).
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTION

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 31 3400 – Geotextiles.
- E. Section 32 1000 – Aggregate Materials.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Control Manual, latest edition.

1.05 SUBMITTALS

- A. Manufacturer's Product Data: Provide product data for all erosion and Sediment control products used, as indicated on the Approved Erosion and Sediment Control Plan.
- B. Manufacturer's Installation Instructions: Indicate special procedures required to install approved products.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.06 REGULATORY REQUIREMENTS

- A. Adhere to the requirements set forth in the approved Erosion and Sediment Control Plan.
- B. Adhere to the requirements of the approved PADEP National Pollutant Discharge Elimination System (NPDES) Permit for the project.

1.07 COORDINATION

- A. Protect adjacent properties and water resources from erosion and sediment damage throughout life of contract.
- B. Conduct earthmoving activities to minimize earth disturbance.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Temporary Seeding: Quick growing grasses such as wheat, rye, or oats and temporary mulches such as loose straw, netting, wood cellulose, or agricultural silage unless otherwise specified in the Erosion and Sediment Control Plan or Construction Drawings.
- B. Geotextiles for Rock Construction Entrance: Refer to Section 31 3400.
- C. Rock for Rock Construction Entrance: Rock used for the rock construction entrance shall be AASHTO No. 1 crushed stone in accordance with Section 32 1000.
- D. Inlet Protection: Inlet protection shall be Verti-Pro, Dandy Bag, or an Owner approved equal.
- E. Compost Filter Sock: In accordance with the requirements of the Pennsylvania Department of Environmental Protection requirements.

2.02 STORAGE AND HANDLING

- A. Deliver, store and handle fabrics, geotextiles, and herbicides in accordance with the manufacturer's recommendations. During periods of shipment and storage, the geotextiles shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 degrees Fahrenheit, mud, dirt, dust, and debris. The fabric shall be wrapped in a heavy duty covering or shielded from direct sunlight.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Review Construction Drawings and Erosion and Sediment Control Plan.
- B. Deficiencies or changes on Construction Drawings or Erosion and Sediment Control Plan as it is applied to current conditions shall be brought to the attention of Owner for remedial action.
- C. Contractor to verify that all permits and approvals have been received prior to construction. Contractor shall keep a copy of the Erosion and Sediment Control Plan and drawings onsite at all times.

3.02 EROSION CONTROL AND SLOPE PROTECTION IMPLEMENTATION

- A. Place erosion control systems in accordance with Construction Drawings and Erosion & Sediment Control Plan or as may be dictated by site conditions in order to maintain the intent of the specifications and permits at no additional cost to Owner.
- B. Owner has authority to limit surface area of erodible earth material exposed by clearing and grubbing, excavation, borrow and embankment operations and to direct Contractor to provide immediate permanent or temporary pollution control measures. Contractor will be required to incorporate permanent erosion control features into project at earliest practical time to minimize need for temporary controls. Permanently seed and mulch cut slopes as excavation proceeds to extent considered desirable and practical.
- C. Maintain temporary erosion control systems as directed by Owner or governing authorities to control siltation during life of contract. Contractor shall respond to maintenance or additional work ordered by Owner or governing authorities within 48 hours or sooner if required.
- D. Slopes that erode easily or that will not be graded for a period of 4 days or more shall be temporarily seeded as work progresses in accordance with the landscape plans and specifications unless otherwise specified on the Construction Drawings or Erosion and Sediment Control Plan.

END OF SECTION 31 2500

SECTION 31 3400 - GEOTEXTILES

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Geotextiles for under asphalt pavement sections.
 - 2. Geotextiles for under riprap channels, ditches, and construction entrances.
 - 3. Geotextiles for underdrains.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 31 2300 – Excavation, Backfill, and Compaction.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sediment Control Manual, latest edition.
- B. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications Publication 408, latest edition.

1.05 SUBMITTALS

- A. Submit manufacturer's certification attesting that materials meet or exceed the Specification requirements.

1.06 REGULATORY REQUIREMENTS

- A. Not used.

1.07 COORDINATION

- A. Verify that all site grading and subgrade preparation is complete and that gradients and elevations are correct prior to placement of geotextile.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. All Geotextile shall satisfy the requirements of Section 735, PennDOT Specifications Publication 408.
 - 1. Class 1 – Subsurface Drainage.
 - 2. Class 2 – Erosion Control.
 - 3. Class 3 – Sediment Control.
 - 4. Class 4 – Separation.
- B. During periods of shipment and storage, the fabric shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 degrees Fahrenheit, mud, dirt, dust, and debris. The fabric shall be wrapped in a heavy-duty covering or shielded from direct sunlight to the extent possible.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Remove and replace fabric areas damaged during construction. Lap or sew replaced fabric, as specified for the class of fabric used. No traffic or construction equipment will be permitted on the fabric.

3.02 PREPARATION AND PLACEMENT

- A. Remove vegetation, large stones, and other debris from the area to be protected and grade the surface to a relatively smooth condition. Undercut areas of soft material and replace with acceptable compacted material in accordance with Section 31 2300.
- B. Place the fabric on the prepared area in a loose and unstretched condition to minimize shifting, puncturing, or tearing the fabric. Join adjacent edges and ends with a folded seam and sew using a single lock-type stitch seam or a double chain-type stitch seam equivalent in strength to the fabric tensile strength. Sewing may be done on-site or by the manufacturer. Overlap only if permitted. Provide a minimum overlap of 1-foot. Offset adjacent roll ends a minimum of 5 feet when lapped.
- C. If permitted, anchor the fabric in place by securing pins or other acceptable methods, along sewn seams or overlaps at a spacing of 2 feet for slopes steeper than 3:1, 3 feet for 4:1 slopes, and 5 feet for slopes flatter than 4:1. Also place securing pins on a maximum 6-foot grid on the unsewn or unlapped portions of the fabric.
- D. Where slopes are flatter than 6:1, if permitted, securing pins may be eliminated, provided that aggregate, rock or other acceptable means are used to secure the fabric.

- E. Cover the fabric with the covering material as soon as possible, so the fabric is not exposed. Prevent slippage of the cover material on the fabric.
- F. Do not drop rocks larger than 2 feet in diameter directly on the fabric from a height greater than 1-foot. Do not allow the rock placement procedure to puncture or damage the fabric.

3.03 PROTECTION OF FINISHED WORK

- A. The Contractor shall be responsible for protecting geotextile fabric. Damage to any part of the geotextile at any time during the course of construction shall be repaired by the Contractor prior to the placement of any overlying materials, at no expense to the Owner, and to the complete satisfaction of the Owner or his representative.

END OF SECTION 31 3400

SECTION 32 1000 - AGGREGATE MATERIALS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Aggregate materials.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by Civil & Environmental Consultants, Inc.
- D. Section 31 1000 – Site Preparation and Clearing.

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications Publication 408, latest edition.
- B. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils.
- C. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- D. ASTM D2216 – Standard Test Method for Laboratory Determination of Water and Rock by Mass.
- E. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight and Unit Weight of Soils Using a Vibratory Table.
- F. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.

1.05 SUBMITTALS

- A. The Contractor is responsible for selecting the supplier of the imported aggregate materials and providing the name of the supplier to the Owner or his representative prior to the commencement of construction. The Owner or his representative may request information about the supplier, and the Owner holds the right to direct the Contractor to use a supplier of the Owner's choice. If the Contractor chooses to change the supplier, he must first receive approval from the Owner or his representative.
- B. The Contractor shall provide certifications from the suppliers of the aggregate materials to confirm that each material conforms to the applicable PennDOT Specification.
- C. The Owner or his representative shall receive copies of all test results and may request additional tests of the aggregate at no cost to the Owner.

1.06 REGULATORY REQUIREMENTS

- A. Not used.

1.07 COORDINATION

- A. Not used.

1.8 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 AGGREGATE MATERIALS

- A. Coarse Aggregate Fill: PennDOT No. 2A crushed stone or crushed gravel conforming to the requirements of Section 703 of PennDOT Specifications Publication 408. The aggregate shall be non-expansive and be free of any and all organic or other deleterious material. The aggregate shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing</u>
2"	100
3/4"	52-100
3/8"	36-70
#4	24-50
#8	16-38
#16	10-30
#200	0-10

- B. Coarse Aggregate Fill: AASHTO No. 57 crushed stone conforming to the requirements of the latest edition of PennDOT Form 408, Section 703. The aggregate shall be non-expansive and be free of any and all organic or other deleterious material. The aggregate shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing</u>
1-1/2"	100
1"	95-100
1/2"	25-60
#4	0-10
#8	0-5

- C. Fine Aggregate Fill: PennDOT Type A cushion sand conforming to the requirements of Section 703 of PennDOT Specifications Publication 408. The aggregate shall be free of any and all organic or other deleterious material.
- D. Aggregate Fill: AASHTO No. 1 crushed stone conforming to the requirements of Section 703 of PennDOT Specifications Publication 408. The stone shall be non-expansive and be hard, durable, clean, washed, and free from soft, then, elongated, or laminated pieces, disintegrated particles, and any organic or other deleterious material. The aggregate shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>Percent Passing</u>
4"	100
3-1/2"	90-100
2-1/2"	25-60
1-1/2"	0-15
3/4"	0-5

2.02 SOURCE QUALITY CONTROL

- A. Perform laboratory tests of aggregate samples to determine the moisture-density relationship of each sample in accordance with ASTM D4253 and D4254.
- B. Perform laboratory sieve analysis of aggregate samples to determine the percentages of aggregates passing the sieves as identified above in accordance with ASTM D422.
- C. Visually observe aggregate materials to verify they meet the project description.
- D. If tests indicate materials do not meet specified requirements, change materials and retest at no cost to the Owner, and/or change placement and compaction methods.

PART 3 - EXECUTION

3.01 STOCKPILING

- A. Stockpile materials in accordance with Section 31 1000.

3.02 DISPOSAL

- A. All aggregate material not being used shall be disposed of off-site before the date of completion.

END OF SECTION 32 1000

SECTION 32 1123 - AGGREGATE BASE COURSE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Placing and compacting aggregate base course where shown on the drawings.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 31 2300 – Excavation, Backfilling, and Compaction.
- E. Section 32 1000 – Aggregate Materials.

1.04 REFERENCES

- A. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- B. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
- C. ASTM D2216 – Standard Test Method for Laboratory Determination of Water and Rock by Mass.
- D. ASTM D2922 – Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- E. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).
- F. ASTM D4318 – Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.
- G. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

- H. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- I. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications (Publication 408, latest edition).
- J. PennDOT Standards for Roadway Construction, Series RC 0 – 100.

1.05 SUBMITTALS

- A. In accordance with Section 32 1000

1.06 REGULATORY REQUIREMENTS

- A. Not used.

1.07 COORDINATION

- A. Placement of the aggregate base course shall not proceed until all utility and site work has been completed.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 AGGREGATE MATERIALS

- A. Coarse Aggregate Fill: AASHTO No. 57 crushed stone conforming to the requirements of Section 703 of PennDOT Specifications Publication 408 and Section 32 1000.
- B. Coarse Aggregate Fill: PennDOT Type 2A crushed stone conforming to the requirements of Section 703 of PennDOT Specifications Publication 408 and Section 32 1000.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that the pavement subgrade has been inspected and accepted by the Owner for proper gradients and elevations and that the subgrade is dry.

3.02 AGGREGATE PLACEMENT

- A. Subgrade Preparation: The Contractor shall prepare the subgrade in accordance with the following specifications:

1. The pavement subgrade shall be fine graded so that, after compaction, the subgrade surface will be at the proper elevation (+0.1 feet) to accommodate the pavement section. Fine grading of the subgrade shall be performed in sections, working the equipment perpendicular to the contours. Fine grading shall not be performed when the subgrade is frozen or excessively wet.
 2. The subgrade shall be proofrolled with a minimum 10-ton roller. The subgrade shall be firm and able to support, without displacement, the construction equipment and the compaction effort specified herein. Soft or yielding subgrades shall be over excavated, backfilled, and recompact in accordance with Section 312300 of these specifications before construction proceeds.
 3. Areas to be paved shall be turned over to the paving Contractor at an elevation equal to the finished grade minus the specified pavement section thickness plus or minus 0.1 feet. The subgrade shall be graded and shaped as required to construct the aggregate base course in conformance with the grades, lines, and thicknesses shown on the drawings.
 4. The Contractor shall be responsible for protecting the subgrade from damage. Any damage occurring to the pavement subgrade, before and during paving operations, shall be corrected at the Contractor's expense.
- B. Aggregate Placement: Place designated crushed aggregate in continuous, loose lifts in a manner to minimize segregation. The loose lift thickness shall be a maximum of 6 inches. The total average thickness of the aggregate base course shall be greater than or equal to what is shown on the drawings.
- C. Compact aggregate to at least 75 percent of its relative density, or until sufficient non-movement of the material is observed by the Owner or his representative under the weight of the compaction equipment. Add water, if necessary, to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content. Use mechanical tamping equipment in areas inaccessible to compaction equipment. When a base course has been placed, but subsequent paving operations have been delayed so that the base has been disturbed by construction activities or frost action, the Contractor shall recompact or repair the base course. Level and contour surfaces to elevations and gradients indicated on the drawings.
- D. The Contractor shall be required to maintain the aggregate base course in good condition until the application of the bituminous concrete binder course. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the Contractor at his own expense, and repeated as often as may be necessary to keep the area continuously intact.

3.03 TOLERANCES

- A. Aggregate Base Course:

Flatness: Maximum variation of 1/4-inch as measured with a 10-foot long straight edge.

Thickness: Within 1/4-inch after compaction.

Variation from True Elevation: Plus or minus 1/100-foot.

3.04 FIELD QUALITY CONTROL

- A. The Owner or his representative shall visually observe to verify that lift thicknesses meet project specifications.
- B. Compaction testing will be performed in accordance with ASTM D4253 and ASTM D4254.
- C. The Owner or his representative will visually observe the site grading to verify that a firm, unyielding foundation with no sudden, sharp, or abrupt changes or break in grades shall exist after compaction. No standing water or excess moisture shall be allowed. All soft or yielding areas will be excavated to a depth at which, when replaced with approved subsoil materials and recompact at a moisture content not exceeding optimum, the subgrade will display minimal elasticity.
- D. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest.

- E. Frequency of Tests: To be approved by the Owner or his representative.

3.05 PROTECTION OF FINISHED WORK

- A. The movement of construction equipment on this course may be permitted at locations designated by and under such restrictions, as directed by the Owner or his representative. At locations where permission is granted for such movement, the temporary surface of the course upon which the construction traffic is running shall be placed and maintained at least 2 inches above the final surface of the course. Just prior to paving, and after all construction traffic not required for the removal has ceased, the 2-inch protective layer shall be removed, and the exposed surface of the course shall be prepared and compacted to the specified tolerance. No payment will be made for furnishing, placing, maintaining, removing and disposing of the 2-inch thick protective layer. The cost shall be included in the price bid for the aggregate base course.

Should the base course become mixed with the subgrade or any other material, through any cause whatsoever, the Contractor shall, at his expense, remove such mixture and replace it with the appropriate base material. The Contractor shall be responsible for protecting all compacted lifts. Damage to any compacted lift occurring at any time during the course of construction shall be fully repaired by the Contractor prior to the placement of any overlying materials, at no expense to the Owner, and to the complete satisfaction of the Owner or his representative.

- B. In the event of heavy rains, the Contractor shall suspend aggregate placement operations immediately and shall take all necessary steps to keep the site well drained. Fill operations shall not resume until the moisture content of the fill to be placed is such as to permit compliance with these specifications.
- C. Reshape and recompact fills subjected to vehicular traffic during construction.

END OF SECTION 32 1123

SECTION 32 1216 – ASPHALT PAVING

PART 1 - GENERAL

1.01 GENERAL

- A. Section Includes:
 - 1. Asphaltic binder course and bituminous wearing course materials.
 - 2. Placing and compacting asphaltic binder course and asphaltic wearing course.
 - 3. Striping and pavement markings.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.
- D. Section 32 1000 – Aggregate Materials.
- E. Section 32 1123 – Aggregate Base Course.
- F. Section 32 1313 – Concrete Paving.

1.04 REFERENCES

- A. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- B. ASTM D422 – Standard Test Method for Particle-Size Analysis of Soils.
- C. ASTM D2216 – Standard Test Methods for Laboratory Determination of Water (Moisture) Content of Soil and Rock by Mass.
- D. ASTM D6938 – Standard Test Method for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth).
- E. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight of Soils Using a Vibratory Table.

- F. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- G. ASTM D2041 – Standard Test Method for Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures.
- H. ASTM D1188 – Standard Test Method for Bulk Specific Gravity and Density of Compacted Bituminous Mixtures.
- I. ASTM D2726 – Standard Test Method for Bulk Specific Gravity and Density of Non-Absorptive Compacted Bituminous Mixtures.
- J. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications Publication 408, latest edition.
- K. PennDOT Standards for Roadway Construction, Series RC 0 – 100.
- L. PennDOT Publication 19 – Field Test Manual of Pennsylvania Test Methods (PTM).
- M. PennDOT Publication 27 – Specifications for Bituminous Mixtures (Bulletin 27).
- N. PennDOT Publication 37 – Specifications for Bituminous Materials (Bulletin 25).
- O. PennDOT Publication 203 – Work Zone Traffic Control.
- P. PennDOT Publication 34 – Aggregate Producers (Bulletin 14).

1.05 SUBMITTALS

- A. The Owner or his representative shall receive copies of all test results and may request additional tests of the aggregate at no cost to the Owner.
- B. The Contractor shall provide certifications from the suppliers of the aggregate and bituminous concrete materials to confirm that each material conforms to the applicable PennDOT Specification.
- C. Submit asphaltic concrete mix designs for approval prior to commencing with paving activities.
- D. Contractor to submit duplicate load slips stamped with the time the truck was loaded at the plant site.

1.06 REGULATORY REQUIREMENTS

- A. Conform to applicable local code for paving work on private property.
- B. Obtain required approvals and permits from the appropriate authority for the disposal of waste materials.
- C. Contractor shall not obstruct or close any road or driveway without approval of the local governing authority and/or highway department.
- D. Contractor shall not obstruct access to any fire hydrants without approval of the local fire department.

1.07 COORDINATION

- A. Placement of asphalt binder course shall not proceed until the aggregate base course has been completed.
- B. Coordinate the work with the installation of the concrete curbs and sidewalks.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Bituminous Binder Course: The bituminous binder course shall satisfy the requirements of Section 409 of PennDOT Specifications Publication 408.
- B. Bituminous Wearing Course: The bituminous wearing course shall satisfy the requirements of Section 409 of PennDOT Specifications Publication 408.
- C. Bituminous Tack Coat: The bituminous tack coat shall satisfy the requirements of Section 460 of PennDOT Specifications Publication 408.
- D. Striping: Painted pavement markings shall be formulated and manufactured from first-grade materials and shall be free from defects that may adversely affect the serviceability of the finished product. When the paint is stored in its container, the pigmented binder shall not settle out to the extent that re-mixing is difficult by standard methods or the application is detrimentally affected. Paint shall conform to the requirements of PennDOT Specifications Publication 408. Paint colors for accessible parking stalls shall satisfy the requirements of the Americans with Disabilities Act, the local jurisdictional authority, and the Owner. All paint (for striping) furnished must be shipped in strong, substantial, and properly sealed containers. All striping shall be 4-inch (minimum) wide and color as specified on the construction drawings.
- E. Joint Sealer: Sealer materials shall be as specified in Section 705.4 (Joint Sealing Material) of PennDOT Specifications Publication 408.
- F. Geotextile: A nonwoven geotextile, if specified on the construction drawings, for the asphalt pavement section shall be composed of polypropylene yarns. The geotextile shall conform to Section 735 of PennDOT Specification Publication 408 for Class 4, Type A Geotextiles.

2.02 STORAGE AND HANDLING

- A. Deliver, store, and handle geotextiles in accordance with the manufacturer's recommendations. During periods of shipment and storage, the geotextile shall be protected from direct sunlight, ultraviolet rays, temperatures greater than 140 degrees Fahrenheit, mud, dirt, dust, and debris. The fabric shall be wrapped in a heavy covering or shielded from direct sunlight.
- B. All paint shall be furnished in strong, substantial, and properly sealed containers.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify subgrade is dry and has been compacted and proof rolled, and that gradients and elevations are correct immediately prior to placement of the geotextile, if required, and aggregate base course. Contractor shall maintain the pavement subgrade in good condition until placement of aggregate base course.
- B. Verify that all curb work is complete, and all backfill placed, graded, and compacted immediately after the concrete curing period to avoid ponding water before any aggregate base course construction begins.
- C. Verify the aggregate base course is dry and has been compacted, and that gradients and elevations are correct prior to placement of the binder course.
- D. Verify that all frames, covers, grates, and all other miscellaneous castings located in the new pavement areas have been accurately positioned and set to the proper slope and elevation. All covers and grates shall be set flush with the required finish pavement surface. No depressions or mounds will be permitted to accommodate inaccuracies in the setting of these appurtenances.
- E. The Contractor shall be required to maintain the subgrade and aggregate base course in good condition until the application of the bituminous concrete binder course. Maintenance shall include immediate repairs of any defects that may occur. Any damage occurring to the pavement subgrade, before and during paving operations, shall be corrected at the Contractor's expense.

3.02 PLACEMENT OF GEOTEXTILE

- A. Place geotextile on the prepared subgrade prior to placement of the aggregate base course. Provide a minimum overlap of 12 inches between geotextile panels.

3.03 PLACING AGGREGATE BASE COURSE

- A. Place base coarse aggregate in continuous, loose lifts on the prepared geotextile and in a manner to minimize segregation. Uncontrolled spreading from piles dumped on the subgrade resulting in segregation will not be permitted. If geotextile is damaged during placement of aggregate base course, the geotextile shall be replaced or completely covered by an additional layer of fabric. The loose lift thickness shall be a maximum of 10 inches. The loose layer thickness shall be kept within the compacting ability of the equipment used.
- B. Level and contour surfaces to elevations and gradients indicated on the drawings.
- C. Add water, if necessary, to assist compaction. If excess water is apparent, remove aggregate and aerate to reduce moisture content.
- D. Use mechanical tamping equipment in areas inaccessible to compaction equipment.
- E. Compact aggregate base course to at least 100 percent of its maximum dry density and within 3 percent of optimum moisture contents determined by ASTM D698, or until sufficient non-movement of the material is observed by the Owner or his representative under the weight of the compaction equipment. When an aggregate base course has been placed, but subsequent paving operations have been delayed so that the base has been disturbed by construction activities or frost action, the Contractor shall recompact or repair the base course prior to continuation of paving activities.

- F. The Paving Contractor shall be required to maintain the aggregate base course in good condition until the application of the bituminous concrete binder course. Maintenance shall include immediate repairs of any defects that may occur. This work shall be done by the Paving Contractor at his own expense, and repeated as often as may be necessary to keep the area continuously intact.

3.04 PLACING ASPHALT PAVEMENT

- A. Machine place hot-mix asphalt on prepared surface, spread uniformly, and strike off. Place asphalt mix by hand to areas inaccessible to equipment in a manner that prevents segregation of mix. Place each course to required grade, cross section, and thickness when compacted.
1. Place hot-mix asphalt surface course in lifts not exceeding recommended thicknesses per PennDOT Publication 408.
 2. Spread mix at minimum temperature of 250 degrees F.
 3. Begin applying mix along centerline of crown for crowned sections and on high side of one-way slopes unless otherwise indicated.
 4. Regulate paver machine speed to obtain smooth, continuous surface free of pulls and tears in asphalt-paving mat.
- B. Place paving in consecutive strips not less than 10 feet wide unless infill edge strips of a lesser width are required.
1. After first strip has been placed and rolled, place succeeding strips and extend rolling to overlap previous strips. Complete a section of asphalt binder before placing asphalt wearing course.
- C. Promptly correct surface irregularities in paving course behind paver. Use suitable hand tools to remove excess material forming high spots. Fill depressions with hot-mix asphalt to prevent segregation of mix; use suitable hand tools to smooth surface.
- D. If the wearing course is not placed immediately on top of the binder course, Contractor shall protect the binder course from precipitation. If water is allowed to come in contact with the binder course, it can soften and compromise the underlying aggregate base course and subgrade. If the aggregate base course or subgrade is damaged due to inadequate protection, the Contractor shall repair the aggregate base course, binder course, and subgrade at no additional cost to the Owner.
- E. Do not run construction equipment on the binder course (except during placement of wearing course) or on the final wearing course. The pavement section was not designed to accommodate construction traffic. If the Contractor would like to run dump trucks or equipment on paved areas during construction, the contractor must notify CEC and the Owner. The Owner may opt, at its discretion, to allow construction traffic. However, the pavement sections will likely have to be redesigned. Allow a minimum of two weeks for consideration of a request to allow construction traffic on pavement surfaces.

3.05 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 degrees F.
- B. Breakdown Rolling: Complete breakdown or initial rolling immediately after rolling joints and outside edge. Examine surface immediately after breakdown rolling for indicated crown, grade, and smoothness. Correct laydown and rolling operations to comply with requirements.
- C. Intermediate Rolling: Begin intermediate rolling immediately after breakdown rolling while hot-mix asphalt is still hot enough to achieve specified density. Continue rolling until hot-mix asphalt course has been uniformly compacted to the following density:

1. Average Density: Greater than or equal to 92% and less than 97% of the daily maximum density.
- 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.

3.06 CONSTRUCTION JOINTS

- A. At the end of each working day, a straight transverse and/or longitudinal construction joint shall be formed by cutting back into the completed work to form a true vertical face, which shall be properly maintained until the abutting section is completed. The finished pavement at joints shall comply with the surface smoothness requirements and exhibit the same uniformity of texture and compaction as other sections of the course. Rollers shall not pass over the unprotected edges of a freshly laid mixture.

In the formation of all joints, the exposed edge of the existing layer that will become part of the joint shall be the full thickness of the layer and straight. If the existing edge is unacceptable, the edge shall be corrected by using a power driven saw or other approved tools to cut a neat line. A light coat of bituminous material shall be applied to the existing pavement edges in order to provide a bond with the newly laid pavement.

1. Transverse Joints: The placing of the course shall be as continuous as possible. The transverse joint shall be formed by cutting back on the previous run to expose the full depth of the course.
2. Longitudinal Joints: Longitudinal joints in the surface wearing course shall correspond with the edges of proposed traffic lanes, unless otherwise directed by the Owner or his representative. The mixture shall be laid such that no more than 100 feet of pavement edge will be exposed at the end of the working day. An exposed edge of this type in excess of 100 feet may be permitted, provided that the edge is adequately protected against damage by vehicles and equipment.

3.07 JOINT SEALING

- A. Prepare and seal joints between bituminous and concrete surfaces, bituminous and bituminous surfaces, and bituminous and utility castings with a minimum 4-inch wide bituminous joint sealer applied in accordance with Section 705.4 of PennDOT Specifications Publication 408.

3.08 MEETING EXISTING PAVEMENTS

- A. Where new pavements are to meet existing pavements, the Contractor shall line cut the existing pavements with approved pneumatic, saw cutting, or mechanical cutting tools so that there will be a vertical butting surface between the old and new pavements. There shall be a one (1) foot offset in each pavement course to permit each successive course to overlap the lower existing course. Line cutting of existing pavements shall be along neat, straight, and even lines, and shall be performed in such a manner so as not to damage the adjacent pavement, which is to remain.

3.09 VERTICAL SURFACES IN CONTACT WITH BITUMINOUS MIXTURES

- A. All vertical surfaces of curbs, structures, gutters, and existing pavement in contact with new bituminous mixtures shall be painted with a uniform coating of an approved bituminous emulsion or priming material. Extreme care shall be exercised in the application of this material to prevent splattering or staining of surfaces that are to remain exposed. Work that is stained as a result of the Contractor's operations shall be repaired and/or replaced at the Contractor's expense.

3.10 STRIPING

- A. The Contractor shall clean the pavement of any and all dust, dirt, old pavement markings, concrete curing compounds, and other foreign material, which may be detrimental to the adhesion of the striping.
- B. The striping shall be applied only on thoroughly dry pavement surfaces, when the atmospheric temperature is at or above 60 degrees Fahrenheit for plastic striping and markings and 50 degrees Fahrenheit for paint striping and markings, and when the weather is otherwise favorable. Waterborne paint must be stored and used at temperatures above 50 degrees Fahrenheit.
- C. Painted pavement markings shall be applied with atomizing spray type striping machines. The equipment shall be compatible with and suitable for the application of the type of paint being used and shall have clean-cut edges, true and smooth alignment, and uniform film thickness of 15 +1 mils. Use of waterborne paint for line striping and pavement markings shall be applied in two coats to fully achieve the film thickness required.
- D. The Contractor shall apply, for accessible symbols, white, yellow, and/or blue paint (as required by the local jurisdiction in authority and the Americans with Disabilities Act), utilizing rollers and/or brushes for marking turn arrows, letters, stop bars, accessible stalls, etc. Normal spreading rates for pavement marking paints shall be from 100 to 115 square feet per gallon so as to obtain a wet film thickness of 15 +1 mils. Use of waterborne paint for line striping and pavement markings shall be applied in two coats to fully achieve the film thickness required.
- E. Existing pavement markings that are to be removed shall be removed in an approved manner that will cause the least damage to the pavement surface. Removal by painting over with black paint is not acceptable.
- F. The Contractor shall remove tracking marks, spilled paint, or striping applied incorrectly or in unauthorized areas.
- G. One coat of pavement striping shall be applied unless otherwise specified on the plans and specification.

3.11 DISPOSAL

- A. Removed excess material not being reused shall be disposed of off-site in an approved waste facility

3.12 TOLERANCES

- A. Aggregate Base Course:

Flatness: Maximum variation of 1/4 inch as measured with a 10-foot long straight edge

Scheduled Compacted Thickness: Within 1/4-inch

Variation from True Elevation: Plus or minus 1/10-foot

B. Asphalt Pavement:

Flatness: Maximum variation of 1/6 inch as measured with a 10-foot long straight edge

Scheduled Compacted Thickness: Within 1/8 inch

Variation from True Elevation: Plus or minus 1/100 foot

3.13 FIELD QUALITY CONTROL

- A. Testing Agency: Owner will engage a qualified testing agency to perform tests and inspections.
- B. All equipment shall be in first-class operating condition for the duration of the paving activities.
- C. The Owner or his representative shall visually observe to verify that compacted lift thicknesses for the aggregate base course do not exceed 8 inches.
- D. Owner's Testing Agency shall perform compaction testing of the aggregate base course and asphalt pavement in accordance with ASTM D2216, ASTM D2922, and/or ASTM D3017. The pavement subgrade shall be proof rolled prior to placement of the geotextile and aggregate base using a fully loaded (25 ton) pneumatic-tired dump truck. Areas displaying elasticity should be overexcavated to suitable material and replaced with properly compacted fill materials.
- E. The Owner or his representative shall visually observe the aggregate base course to verify that a firm unyielding foundation with no sudden, sharp, or abrupt changes or break in grades shall exist after compaction.
- F. In-Place Density: Testing Agency will take samples of uncompacted paving mixtures for determination of theoretical maximum density.
 - 1. Reference maximum theoretical density will be determined by averaging results from four samples of hot-mix asphalt-paving mixture delivered daily to site, prepared according to ASTM D2041, and compacted according to job-mix specifications.
 - 2. In-place density of compacted pavement will be determined by testing core samples according to ASTM D1188 or ASTM D2726.
 - a. Contractor shall provide to testing agency one core sample for every 1000 square yard or less of installed pavement, with no fewer than three cores taken.
 - b. Field density of in-place compacted pavement may also be determined by nuclear method according to ASTM D2950 and correlated with ASTM D1188 or ASTM D2726.
- G. Frequency of Tests: Perform in-place density and moisture content tests (where applicable) for every 1,000 square yards of paving, or at least once per day of paving operations, at a minimum or as directed by the Owner or his representative.
- H. If tests indicate Work does not meet specified requirements, remove Work, replace, compact, and retest, at no cost to the Owner.

3.14 QUALITY ASSURANCE

- A. Perform Work in accordance with Section 409 (Superpave Mixture Design, Standard and RPS Construction of Plant-Mixed HMA Courses) of PennDOT Specifications Publication 408.
- B. Mixing Plant: As approved by the Owner.
- C. Obtain materials from same source throughout.

- D. Provide representative samples of proposed aggregate base course to Owner's Testing Agency a minimum of one week prior to placing aggregate base course. Owner's Testing Agency shall perform laboratory tests of aggregate to determine the maximum density and optimum moisture content in accordance with ASTM D698.
- E. Owner's Testing Agency shall perform laboratory sieve analysis of aggregate in accordance with ASTM D422 to determine if the percentages of aggregate meet the gradation requirements for PennDOT 2A aggregate.
- F. Visually observe aggregate to verify that it meets the project description.
- G. If tests indicate aggregate does not meet specified requirements, change material and retest, at no cost to the Owner.

3.15 TEMPERATURE REQUIREMENTS

- A. Do not place asphalt when base surface temperature is less than 40 degrees Fahrenheit, or surface is wet or frozen.

3.16 PROTECTION OF FINISHED WORK

- A. Immediately after placement of asphalt wearing course, protect pavement from mechanical injury until adequate stability and adhesion have been attained and the material has cooled to 140 degrees Fahrenheit or less.
- B. Provide barricades and/or flagmen to protect workers and the public where necessary.

3.17 DEFECTIVE WORK

- A. Defective areas shall be removed, subgrade recompact and area repaved, unless otherwise directed by the Owner or his representative at no additional cost to the owner.

END OF SECTION 32 1216

SECTION 32 1313 - CONCRETE PAVING

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes exterior cement concrete paving for the following:
 - 1. Curbs
 - 2. Sidewalks
 - 3. Driveways
 - 4. Concrete Encasement
- B. Related Sections include the following:
 - 1. Section 31 2000 – Earthmoving for subgrade preparation, grading and subbase course.
- C. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- D. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Cementitious Materials: Portland cement alone or in combination with one or more of blended hydraulic cement, fly ash and other pozzolans, and ground granulated blast-furnace slag.

1.03 RELATED DRAWINGS, DOCUMENTS AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by CEC.

1.04 SUBMITTALS

- A. Product Data: For each type of manufactured material and product indicated.
- B. Design Mixtures: For each concrete pavement mixture. Include alternate mixture designs when characteristics of materials, Project conditions, weather, test results, or other circumstances warrant adjustments.
- C. 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:
 - 1. Aggregates: Include service record data indicating absence of deleterious expansion of concrete due to alkali-aggregate reactivity.
- D. Material Certificates: Signed by manufacturers certifying that each of the following materials complies with requirements:

1. Cementitious materials.
2. Steel reinforcement and reinforcement accessories.
3. Fiber reinforcement.
4. Admixtures.
5. Curing compounds.
6. Applied finish materials.
7. Bonding agent or epoxy adhesive.
8. Joint fillers.

E. Field quality-control test reports.

1.05 QUALITY ASSURANCE

- A. Manufacturer Qualifications: Manufacturer of ready-mixed concrete products who complies with ASTM C 94/C 94M requirements for production facilities and equipment.
1. Manufacturer certified according to NRMCA's "Certification of Ready Mixed Concrete Production Facilities".
 2. Onsite batching of concrete will not be permitted.
- B. ACI Publications: Comply with ACI 301, "Specification for Structural Concrete," unless modified by requirements in the Contract Documents.
- C. Concrete Testing Service: Engage a qualified independent testing agency to perform material evaluation tests and to design concrete mixtures.

1.06 PROJECT CONDITIONS

- A. Traffic Control: Maintain access for vehicular and pedestrian traffic as required for other construction activities.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

- A. In other Part 2 articles where titles below introduce lists, the following requirements apply to product selection:
1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, products specified.
 2. Products: Subject to compliance with requirements, provide one of the products specified.
 3. Available Manufacturers: Subject to compliance with requirements, manufacturers offering products that may be incorporated into the Work include, but are not limited to, manufacturers specified.
 4. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.

2.02 FORMS

- A. Form Materials: Plywood, metal, metal-framed plywood, or other approved panel-type materials to provide full-depth, continuous, straight, smooth exposed surfaces.
 - 1. Use flexible or curved forms for curves with a radius 100 feet or less.
 - 2. Forms shall be of metal or new wood at least 10 feet long.
 - 3. Wood forms shall be rigid enough not to bow and deflect when concrete is placed. Worn, broken, or distorted forms shall not be used.
- B. Form-Release Agent: Commercially formulated form-release agent that will not bond with, stain, or adversely affect concrete surfaces and will not impair subsequent treatments of concrete surfaces.
- C. Each form shall be braced and staked in at least three places for each 10-foot length, closer if necessary to keep from deforming when concrete is placed.
- D. Forms must extend the full depth of the concrete curb, sidewalk, or driveway.
- E. The entire front and rear face of the curb must be formed. No wild pours or partial forming will be allowed.

2.03 STEEL REINFORCEMENT

- A. The Contractor shall submit data sheets for all steel reinforcement.

2.04 SYNTHETIC FIBER REINFORCEMENT

- A. Synthetic Fiber: Monofilament or fibrillated polypropylene fibers engineered and designed for use in concrete pavement, complying with ASTM C1116, Type III, 0.5 to 1.5 inches long.
 - 1. Products:
 - a. Monofilament Fibers:
 - 1) Axim Concrete Technologies; Fibrasol IIP.
 - 2) Euclid Chemical Company (The); Fiberstrand 100.
 - 3) FORTA Corporation; Forta Mono.
 - 4) Grace, W. R. & Co.--Conn.; Grace MicroFiber.
 - 5) Metalcrete Industries; Polystrand 1000.
 - b. Fibrillated Fibers:
 - 1) Axim Concrete Technologies; Fibrasol F.
 - 2) FORTA Corporation; Forta.
 - 3) Euclid Chemical Company (The); Fiberstrand F.
 - 4) Grace, W. R. & Co.--Conn.; Grace Fibers.

2.05 CONCRETE MATERIALS AND MIXTURES

- A. Cementitious Material: Provide cementitious material equal to or exceeding the specified quality, of the same type, brand, and source throughout the Project.
 - 1. Portland-Limestone Cement: ASTM C595, Type IL, non-air entraining. Cement shall be from a single source and shall comply with all applicable ASTM requirements.

- B. Normal Weight Aggregates: ASTM C33 coarse aggregate or better, graded. Provide aggregates from a single source with documented service record data of at least 10 years satisfactory service in similar applications and service conditions using similar aggregates and cementitious materials.
 - 1. Maximum Coarse-Aggregate (1530 lbs/cu.yd) must be limestone for reinforced concrete pavement, concrete curb, concrete sidewalk, reinforced concrete drives, and any exposed concrete in structures. To obtain approval, the aggregate mix design must be submitted two weeks before contemplated use.
 - 2. Fine Aggregate: Type A aggregate; 1220 lbs/cu.yd.
- C. Water: ASTM C 94/C 94M or 33 gallons/cu.yd.
- D. Twenty-eight (28)-day strength: 4000 psi.
- E. Slump shall be 4 inches plus or minus 1-inch.
- F. Air Entraining Admixtures shall be in accordance with AASHTO Designation M-154 (ASTM C-260-01).
- G. Entrained air content shall be 5 percent with a tolerance of plus or minus 1 percent.
- H. Synthetic Fiber: Uniformly disperse in concrete mix at manufacturer's recommended rate, but not less than 2.0 lb/cu. yd. Note: Synthetic Fiber is in addition to any traditional steel reinforcement required in the concrete.
- I. Prepare design mixtures, proportioned according to ACI 301, for each type and strength of normal-weight concrete determined by either laboratory trial mixes or field experience.
 - 1. Use a qualified independent testing agency for preparing and reporting proposed concrete mixture designs for the trial batch method.

2.06 CURING MATERIALS

- A. Absorptive Cover: AASHTO M182, 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 C171, polyethylene film or white burlap-polyethylene sheet.
- C. Water: Potable.
- D. Curing and Sealing Compound: ASTM C309, Type 1, Classes A and B; ASTM C1315, Type 1, Class A; and AASHTO M148, Type 1 Classes A and B. Must meet US EPA maximum allowable VOC requirements.

2.07 RELATED MATERIALS

- A. Expansion- and Isolation-Joint-Filler Strips: ASTM D1751, asphalt-saturated cellulosic fiber (AASHTO M213).
- B. Concrete Joint Sealant: Sikaflex-1a (or approved equal). The sealant shall be a one part polyurethane, elastomeric sealant/adhesive meeting Federal Specification TT-S-00230C, Type II, Class A and ASTM C920, Type S, Grade NS, Class 35 use T, NT, O, M, G and I. Color shall be limestone or as chosen by the Owner.
- C. Bonding Agent: ASTM C1059, Type II, non-redispersible, acrylic emulsion or styrene butadiene.
- D. Epoxy Bonding Adhesive: ASTM C881, two-component epoxy resin, capable of humid curing and bonding to damp surfaces, of class suitable for application temperature and of grade to requirements, and as follows:

1. Types I and II, non-load bearing or IV and V, load bearing, for bonding hardened or freshly mixed concrete to hardened concrete.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine exposed subgrade and subbase for compliance with requirements for dimensional, grading, and elevation tolerances.
- B. Proof-roll prepared subgrade surface with heavy pneumatic-tired equipment to identify soft pockets and areas of excess yielding as follows or as dictated by field conditions:
 1. Completely proof-roll subgrade in one direction and repeat in perpendicular direction. Limit vehicle speed to 3 mph.
 2. Proof-roll with a loaded tandem-axle dump truck weighing not less than 15 tons.
 3. Subgrade with soft spots and areas of pumping or rutting exceeding depth of 1/2-inch shall be repaired prior to placement of concrete.
 4. Concrete curb and sidewalk subbases shall be compacted using mechanical equipment to 100 percent maximum dry density within ± 3 percent optimum moisture content as per ASTM D698.
- C. Proceed with concrete pavement operations only after non-conforming conditions have been corrected.

3.02 PREPARATION

- A. Remove loose material from compacted subbase surface immediately before placing concrete.
- B. Concrete slabs shall be a minimum of 8 inches thick for roadways and 4 inches thick for sidewalks. The aggregate bed shall be a minimum of 6 inches thick and shall consist of AASHTO No. 57 crushed aggregate (or equivalent).

3.03 SUBGRADE REPAIR

- A. After the existing pavement and subbase have been removed to subgrade, the Owner will determine if soft spots exist and, if so, mark the limits of soft spots to be corrected.
- B. If soft spots are marked, the Contractor shall excavate such areas and replace excavated unsuitable materials with PennDOT Class IV, Type A geotextile fabric placed under a minimum of 12 inches of AASHTO No. 1 aggregate with a 2-inch PennDOT 2A aggregate "choke". The fabric shall wrap over the top of the placed aggregate prior to the placement of the required aggregate subbase. All unsuitable materials shall be removed from the site at no additional cost to the Owner.

3.04 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.

3.05 STEEL REINFORCEMENT

- A. General: Comply with CRSI's "Manual of Standard Practice" for fabricating, placing, and supporting reinforcement.
- B. Clean reinforcement of loose rust and mill scale, earth, ice, or other bond-reducing materials.
- C. Arrange, space, and securely tie bars and bar supports to hold reinforcement in position during concrete placement. Maintain minimum cover to reinforcement.
- D. Install welded wire reinforcement in lengths as long as practicable. Lap adjoining pieces at least one full mesh, and lace splices with wire. Offset laps of adjoining widths to prevent continuous laps in either direction.
- E. Concrete sidewalks and driveways shall be reinforced with 6-inch by 6-inch, W2.9 x W2.9 wire mesh with a minimum cover of 2 inches and 3 inches, respectively.
- F. Install fabricated bar mats in lengths as long as practicable. Handle units to keep them flat and free of distortions. Straighten bends, kinks, and other irregularities, or replace units as required before placement. Set mats for a minimum 2-inch overlap of adjacent mats.
- G. Concrete slabs shall be constructed per PennDOT Publication 408 (most current edition), PennDOT RC standards and applicable plan Details.

3.06 JOINTS

- A. General: Form 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. All joints in new concrete shall be sealed including the joints in straight and rolled curbs, sidewalks, driveway and other concrete structures. The joints between old and new concrete must also be sealed.
- C. Contraction joints in the reinforced concrete pavement and/or base shall be constructed by sawing with a special concrete saw using one or more circular blades, cooled and lubricated with water.
- D. Expansion joints in reinforced concrete pavement and/or base shall be constructed with slip dowels, and minimum 1-inch thick expansion joint filler as detailed. A steel plate, slip dowels and minimum 1-inch joint filler can be used as an alternate. Spacing shall be at all points of curve, points of tangent, and at street intersections.
- E. Contraction joints in concrete curbs shall match joint spacing (or limits of remediation) to existing sidewalk or shall be spaced a minimum of 4 to a maximum of 6 feet. They shall not exceed 1/2-inch in thickness. Expansion joints 1-inch thick, shall be formed at not more than 40-foot intervals.
- F. Contraction joints in concrete sidewalks shall match joint spacing (or limits of remediation) to existing sidewalk or shall be spaced a minimum of 4 to a maximum of 6 feet and formed with a device to have the completed joint at least 1/4-inch deep. Expansion joints shall be spaced no more than 40 feet apart and formed with 1-inch pre-molded filler to the full depth of the slab. The 1-inch pre-molded filler shall also be placed adjacent to curbs, other sidewalks, buildings or pavement. If the sidewalk abuts a curb the joints on the sidewalk shall match the joints in the curb.
- G. Construction Joints: Set construction joints at side and end terminations of pavement and at locations where pavement operations are stopped for more than one-half hour unless pavement terminates at isolation joints.

- H. Isolation Joints: Form isolation joints of preformed joint-filler strips abutting concrete curbs, catch basins, manholes, inlets, structures, walks, other fixed objects, and where indicated.
1. Locate expansion joints at intervals of 40 feet unless otherwise indicated or directed.
 2. Extend joint fillers full width and depth of joint.
 3. Terminate joint filler not less than 1/2-inch or more than 1-inch below finished surface if joint sealant is indicated.
 4. Place top of joint filler flush with finished concrete surface if joint sealant is not indicated.
 5. Furnish joint fillers in one-piece lengths. Where more than one length is required, lace or clip joint-filler sections together.
 6. Protect top edge of joint filler during concrete placement with metal, plastic, or other temporary preformed cap. Remove protective cap after concrete has been placed on both sides of joint.
- I. On any tooled joints or edges of concrete do not use the jointing or edging tool until the surface water has evaporated from the concrete (sheen disappears). Bull float and broom the surface, then finish the joint and edges and use broom to remove the tool marks on the surface.

3.07 SEALING OF CONCRETE JOINTS

- A. All expansion joints and joints against structures shall be sealed.
- B. The sealant shall be "Sikaflex-1A Polyurethane, Elastomeric Sealant/Adhesive" (or Owner approved equal). Sealant color shall be selected from the range of available colors by the Owner prior to application.
- C. All joints must be sound, clean, dry, and free from oil and grease. Curing compound residues and any foreign material must be thoroughly removed. A roughened surface will also enhance the bond. Install bond breaker tape or back rod to prevent bond at the base of the joint.
- D. Apply Sikaflex-1A at a temperature between 40 degrees Fahrenheit and 100 degrees Fahrenheit with a gun using the 20 ounce "uni-pac" sausage.

3.08 CONCRETE PLACEMENT

- A. Inspection: Before placing concrete, inspect and complete formwork installation, steel reinforcement, 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. No concrete shall be placed prior to April 15 or after December 1 except with written permission of the Owner and only if the Contractor is prepared to comply with the cold weather requirements specified in PennDOT Specification 408 (most current edition).
- D. When the air temperature is expected to drop below 40 degrees Fahrenheit at any time during the day or night for the first 24 hours following the placement of concrete, an additional three bales of straw hay, weighing approximately 100 pounds each, shall be spread for each 35 square yards of concrete placed and then covered with a tarpaulin. The concrete shall be maintained at a temperature of not less than 50 degrees Fahrenheit and not more than 80 degrees Fahrenheit. Gradually lower the temperature to the surrounding area for at least three additional days.
- E. Moisten subbase to provide a uniform dampened condition at time concrete is placed. Do not place concrete around manholes or other structures until they are at required finish elevation and alignment.
- F. Comply with ACI 301 requirements for measuring, mixing, transporting, and placing concrete.

- G. Do not add water to concrete during delivery or at project site.
- H. Do not add water to fresh concrete after testing.
- I. No private, public, or contractor vehicles and/or equipment shall be placed or moved on concrete pavement until 14 days have elapsed from time of pour, and then only when earth shoulders are placed against the pavement edges. Opening to traffic shall not constitute a final acceptance of pavement from centerline. The Contractor shall provide the Owner with breaks at 7, 14, and 28 days from the date of the pour to determine the strength.
- J. 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.
- K. The concrete shall be placed in forms in horizontal layers not to exceed 5 inches and vibrated sufficiently to eliminate all voids.
- L. Place concrete in two operations; strike off initial pour for entire width of placement and to the required depth below finish surface. Lay welded wire fabric or fabricated bar mats immediately in final position. Place top layer of concrete, strike off, and screed.
 - 1. Remove and replace concrete that has been placed for more than 15 minutes without being covered by top layer or use bonding agent if approved by Owner.
- M. The crown in any pavement or base shall be measured from the high side edge where one edge is higher than the other except where otherwise noted.
- N. Screed pavement surfaces with a straightedge and strike off.
- O. Commence initial floating using bull floats or darbies to impart an open textured and uniform surface plane before excess moisture or bleed water appears on the surface. Do not further disturb concrete surfaces before beginning finishing operations or spreading surface treatments.
- P. Curbs and Gutters: When automatic machine placement is used for curb and gutter placement, submit revised mix design and laboratory test results that meet or exceed requirements. Produce curbs and gutters to required cross section, lines, grades, finish, and jointing as specified for formed concrete. If results are not approved, remove and replace with formed concrete.
- Q. 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 degrees Fahrenheit, uniformly heat water and aggregates before mixing to obtain a concrete mixture temperature of not less than 50 degrees Fahrenheit and not more than 80 degrees Fahrenheit 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.
- R. Hot-Weather Placement: Comply with ACI 301 and as follows when hot-weather conditions exist:
 - 1. Cool ingredients before mixing to maintain concrete temperature below 90 degrees F at time of placement. 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 steel reinforcement with water-soaked burlap so steel temperature will not exceed ambient air temperature immediately before embedding in concrete.
 - 3. Fog-spray forms, steel reinforcement, and subgrade just before placing concrete. Keep subgrade moisture uniform without standing water, soft spots, or dry areas.

3.09 CONCRETE SIDEWALKS

- A. Forms shall be of metal or new wood at least 10 feet long. Each form shall be braced and staked in at least three places for each 10-foot length and closer if necessary to keep from deforming when concrete is placed. They shall be thoroughly cleaned and coated with non-staining oil. Wood forms shall be rigid enough not to bow and deflect when concrete is placed. Worn, broken, or distorted forms shall not be used.
- B. Contraction joints in concrete sidewalks shall match joint spacing (or limits of remediation) to existing sidewalk or shall be spaced a minimum of 4 to a maximum of 6 feet and formed with a device to have the completed joint at least 1/4-inch deep. Expansion joints shall be spaced no more than 40 feet apart and formed with 1-inch pre-molded filler to the full depth of the slab. The 1-inch pre-molded filler shall also be placed adjacent to curbs, other sidewalks, buildings or pavement. If the sidewalk abuts a curb the joints on the sidewalk shall match the joints in the curb.
- C. Concrete sidewalks shall be reinforced with 6-inch by 6-inch, W2.9 x W2.9 wire mesh with a minimum cover of 2 inches and 3 inches, respectively.
- D. The surface of the slab shall be brought to a uniform plane surface by means of a wood screed riding on forms. The surface shall then be finished with a wood or magnesium float and fine broom finished. The tool marks for joints and edges shall match the marks in the existing walk. Neither dry cement nor water shall be added to the surface during the finishing process.
- E. On any tooled joints or edges of concrete do not use the jointing or edging tool until the surface water has evaporated from the concrete. Bull float and broom the surface, then finish the joint and edges and use the broom to remove the tool marks on the surface.
- F. After 28 days (or as recommended by the manufacturer or directed by the Owner), apply an approved sealer.
- G. The concrete shall be thoroughly vibrated to eliminate voids within the placed concrete.
- H. Sealing of Joints
 - 1. All expansion joints and joints against structures shall be sealed.
 - 2. The sealant shall be "Sikaflex 1A Polyurethane, Elastomeric Sealant/Adhesive" (or Owner approved equal). Sealant color shall be selected from the range of available colors by the Owner prior to application.
 - 3. All joints must be sound, clean, dry and free from oil and grease. Curing compound residues and any foreign material must be thoroughly removed. A roughened surface will also enhance the bond. Install bond breaker tape or back rod to prevent bond at the base of the joint.
 - 4. Apply Sikaflex 1A at a temperature between 40 degrees F and 100 degrees F with a gun using the 20 ounce "uni-pac" sausage.
- I. Insulated protection of the concrete shall be required dependent on weather conditions at the time of pouring and during the curing period. A polyethylene plastic sheeting shall be considered as the adequate minimum protection required for concrete during adverse weather conditions. The Owner reserves the right to require additional protective measures such as blanketing. No additional compensation will be considered in the event protective measures above the minimum are required by the Owner.
- J. Replace rain conductors in kind if found under a sidewalk. Place a piece of No. 9 gauge wire mesh reinforcing 1-foot over the pipe for reinforcement. In addition, a construction joint shall be placed over the rain conductor location. No additional compensation will be considered for the removal and/or replacement of roof or driveway drains under a sidewalk.
- K. Restore and/or raise to grade all gas valves, water valves, sewer vents, or other utility valve boxes encountered during driveway restoration. No additional compensation will be considered for work associated with this requirement.

3.10 CONCRETE CURB

- A. Forms shall be of metal or new wood at least 10 feet long. Each form shall be braced and staked in at least three places for each 10-foot length and closer if necessary to keep from deforming when concrete is placed. They shall be thoroughly cleaned and coated with non-staining oil. Wood forms shall be rigid enough not to bow and deflect when concrete is placed. Worn, broken or distorted forms shall not be used.
- B. Effort shall be made to minimize damage to curbs.
- C. The Contractor shall be responsible for providing AASHTO No. 57 crushed limestone aggregate for a suitable base for the curb in accordance with the Detail.
- D. A 2-ply tar paper must be placed between the AASHTO base and the concrete curb.
- E. Control joints shall be placed at 10 feet on center.
- F. Expansion joints shall be spaced no more than 50 feet apart and formed with 1/4 inch pre-molded filler to the full depth of the slab. The 1/4-inch pre-molded filler shall also be placed adjacent to curbs, other sidewalks, buildings, or pavement. If the curb abuts a sidewalk the joints on the curb shall match the joints in the sidewalk.
- G. A 4- inch minimum diameter PE slotted underdrain may be placed behind the curb in accordance with the Detail and connected to the storm sewer system as directed by the Owner.
- H. The concrete shall be thoroughly vibrated to eliminate voids within the placed concrete.
- I. The finish on the concrete shall match the finish of the existing curb.
- J. Sealing of Joints
 - 1. All expansion joints and joints against structures shall be sealed.
 - 2. The sealant shall be "Sikaflex 1A Polyurethane, Elastomeric Sealant/Adhesive" (or Owner approved equal). Sealant color shall be selected from the range of available colors by the Owner prior to application.
 - 3. All joints must be sound, clean, dry, and free from oil and grease. Curing compound residues and any foreign material must be thoroughly removed. A roughened surface will also enhance the bond. Install bond breaker tape or back rod to prevent bond at the base of the joint.
 - 4. Apply Sikaflex 1A at a temperature between 40 degrees Fahrenheit and 100 degrees Fahrenheit with a gun using the 20 ounce "uni-pac" sausage.
- K. After 28 days (or as recommended by the manufacturer or directed by the Owner), apply an approved sealer.
- L. If any rain conductors exist through the curb, they shall be replaced in kind. No additional compensation will be provided for the restoration of roof/driveway drains through the curb.
- M. Insulated protection of the concrete shall be required dependent on weather conditions at the time of pouring and during the curing period. A polyethylene plastic sheeting shall be considered as the adequate minimum protection required for concrete during adverse weather conditions. The Owner reserves the right to require additional protective measures such as blanketing. No additional compensation will be considered in the event protective measures above the minimum are required by the Owner.

3.11 CONCRETE ENCASEMENT FOR UTILITIES

- A. Under this item the Contractor shall be required, if necessary, and as approved by the Owner in writing to install concrete encasement around utility lines that are exposed within 12 inches of a proposed sewer.

- B. The installation of concrete encasement shall be completed with an 8-inch minimum bed of air entrained 4000 psi high early strength concrete placed below an existing utility line. The concrete must then extend up the sides of the utility line and placed to a minimum depth of at least 8 inches above the utility line.
- C. The concrete shall be allowed to cure for a minimum of 24 hours prior to backfilling. The Owner reserves the right to extend the curing period until the concrete has cured sufficiently so that the encasement does not become damaged during backfilling. The curing period may vary depending on weather conditions.
- D. The Contractor shall use caution during backfilling to prevent damage to the concrete encasement.
- E. The Contractor shall be required to take all necessary precautions for curing concrete in hot and/or cold weather at no additional cost to the Owner.

3.12 FINISHING

- A. General: Do not add water to concrete surfaces during finishing operations.
- B. Float Finish: Begin the second floating operation when bleed-water sheen has disappeared and concrete surface has stiffened sufficiently to permit operations.
- C. The surface of concrete sidewalks shall be brought to a uniform plane surface by means of a wood screed riding on forms. The surface shall then be finished with a wood or magnesium float and stiff textured broom finished perpendicular to line of traffic. The tool marks for joints and edges shall match the marks in the existing walk. Neither dry cement nor water shall be added to the surface during the finishing process.
- D. The portion of the curb to be exposed to the elements shall be finished smooth with a wood or magnesium float. All minor defects shall be filled with cement mortar. No watered brush finish or plastering of the curb will be permitted. All joints and exposed edges shall be tooled to a radius of 1/4-inch but no tool marks will be permitted to show on the finished curb. Final finish shall be made with a coarse broom.
- E. The surface of the concrete driveway slab shall be brought to a uniform plane surface by means of a wood screed riding on forms. The surface shall then be finished with a wood or magnesium float and fine broom finished. The tool marks for joints and edges shall match the marks in the existing driveway. Neither dry cement nor water shall be added to the surface during the finishing process.
- F. On any tooled joints or edges of concrete do not use the jointing or edging tool until the surface water has evaporated from the concrete. Bull float and broom the surface, then finish the joint and edges and use the broom to remove the tool marks on the surface.

3.13 CONCRETE PROTECTION AND CURING

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures.
- B. Comply with ACI 306.1 for cold-weather protection.
- C. Evaporation Retarder: Apply evaporation retarder to concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.2 pounds per square foot by depth before and during finishing operations. Apply according to manufacturer's written instructions after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- D. Begin curing after finishing concrete but not before free water has disappeared from concrete surface.

3.14 PAVEMENT TOLERANCES

A. Comply with tolerances of ACI 117 and as follows:

1. Elevation: 1/4-inch.
2. Thickness: Plus 3/8-inch, minus 1/4-inch.
3. Surface: Gap below 10-foot long, unleveled straightedge not to exceed 1/4 inch.
4. Lateral Alignment and Spacing of Tie Bars and Dowels: 1-inch.
5. Vertical Alignment of Tie Bars and Dowels: 1/4-inch.
6. Alignment of Tie-Bar End Relative to Line Perpendicular to Pavement Edge: 1/2-inch.
7. Alignment of Dowel-Bar End Relative to Line Perpendicular to Pavement Edge: Length of dowel 1/4-inch per 12 inches.
8. Contraction Joint Depth: Plus 1/4-inch, no minus.
9. Joint Width: Plus 3/16-inch, no minus.

3.15 BACKFILLING

A. The Contractor shall not backfill against walks, driveways, curbs, etc., until concrete forms have been removed, concrete cured and written authorization has been given by the Owner. All debris shall be removed from top to bottom of all excavations prior to all backfilling operations. In lawn or ground covers areas, backfilling shall be done with clean earth placed in 6-inch compacted layers.

3.16 TESTING

A. The Contractor shall engage a qualified professional to perform concrete testing. All results shall be forwarded to the Owner for review.

B. Concrete Tests: Testing of composite samples of fresh concrete obtained according to ASTM C 172 shall be performed according to the following requirements:

1. Testing Frequency: Obtain one composite sample for each day's pour of each concrete mixture exceeding 5 cubic yards but less than 25 cubic yards plus one set for each additional 50 cubic yards or fraction thereof.
2. Testing Frequency: Obtain at least one composite sample for each 100 cubic yards 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.
3. 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.
4. Air Content: ASTM C 231, pressure method, for normal-weight concrete (ASTM C 173/C 173M, 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 concrete mixture.
5. Concrete Temperature: ASTM C 1064/C 1064M; one test hourly when air temperature is 40 degrees F and below and when 80 degrees F and above, and one test for each composite sample.
6. Unit Weight: ASTM C 567, 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 mixture.
7. Compression Test Specimens: ASTM C31/C31M.
 - a. Cast and laboratory cure two sets of two standard cylinder specimens for each composite sample.
 - b. Cast and field cure two sets of two standard cylinder specimens for each composite sample.
8. Compressive-Strength Tests: ASTM C 39/C 39M; test one set of two laboratory-cured specimens at 7 days and one set of two specimens at 28 days.

- a. Test one set of two field-cured specimens at seven days and one set of two specimens at 28 days.
 - b. A compressive-strength test shall be the average compressive strength from a set of two specimens obtained from same composite sample and tested at age indicated.
- 9. When strength of field-cured cylinders is less than 85 percent of companion laboratory-cured cylinders, Contractor shall evaluate operations and provide corrective procedures for protecting and curing in-place concrete.
 - 10. Strength of each concrete mixture will be satisfactory if every average of any three consecutive compressive-strength tests equals or exceeds specified compressive strength and no compressive-strength test value falls below specified compressive strength by more than 500 psi.
 - 11. Test results shall be reported in writing to Owner, concrete manufacturer, and Contractor within 48 hours of testing. Reports of compressive-strength tests shall contain project identification name and number, date of concrete placement, name of concrete testing and inspecting agency, location of concrete batch in Work, design compressive strength at 28 days, concrete mixture proportions and materials, compressive breaking strength, and type of break for both 7- and 28-day tests.
 - 12. Non-destructive Testing: Impact hammer, sonoscope, or other nondestructive device may be permitted by Owner but will not be used as sole basis for approval or rejection of concrete.
 - 13. Additional Tests: Testing and inspecting agency shall make additional tests of concrete when test results indicate that slump, air entrainment, compressive strengths, or other requirements have not been met, as directed by Owner. Testing and inspecting agency may conduct tests to determine adequacy of concrete by cored cylinders complying with ASTM C42/ 42M or by other methods as directed by Owner.
 - 14. Additional testing and inspecting, at Contractor's expense, will be performed to determine compliance of replaced or additional work with specified requirements.
 - 15. Correct deficiencies in the Work indicated by insufficient results shown by testing and/or inspection at no additional cost to the Owner.

3.17 REPAIRS AND PROTECTION

- A. Remove and replace concrete pavement that is broken, damaged, or defective or that does not comply with requirements in this Section.
- B. Drill test cores, where directed by Owner, 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 2 days before date scheduled for Substantial Completion inspection or as directed by the Owner.

END OF SECTION 32 1313

SECTION 32 3100 – FENCES AND GATES

PART 1 - GENERAL

1.01 SUMMARY

- A. This Section includes provisions for the following:
 - 1. Provision of chain link fence posts, fabric, rails, attachments, gate(s), and component parts.
 - 2. Provision of concrete footings for fence posts.
- B. Provide items, articles, materials, operations or methods shown, listed, mentioned, or scheduled, and herein specified, including labor, supervision, materials, equipment, and incidentals necessary and required for the completion of Work.

1.02 QUALITY ASSURANCE

- A. Guarantee Work until acceptance by Owner.
- B. Restore damage to Work caused by Contractors' employees, subcontractors, or material providers shall be restored to its original condition. Pay cost of such work or material required in repairing or replacement of damaged work.
- C. Remove from the premises materials condemned as failing to conform, whether incorporated into the Work or not. Promptly replace and re-execute the Work in accordance with this contract and without expense to the Owner. Bear the expense of making good all Work of Subcontractors which has been destroyed or damaged by such removal and replacement.
- D. Should a discrepancy exist between the Drawings and Specifications, the following shall govern:
 - Quantity: - greater number governs
 - Size: - largest size governs
 - Material - as directed
- E. Abbreviations:
 - 1. ACI: American Concrete Institute
 - 2. ASTM: American Society for Testing and Materials
- F. Conform to Recommended Practice for Concrete Formwork ACI 347
- G. Conduct pre-installation conference at Project Site. Include fencing manufacturer, fencing installer, and concrete foundation installer.

1.03 SUBMITTALS

- A. Product literature stating material specifications, as well as a shop drawing for each height of fence and type of gate indicated, stating supports, post sizes, rails, fittings, hardware, fabric, reinforcements, attachments, vision slats, finishes. Submit written certification that the materials and installation meet requirements of this specification and the manufacturer's installation instructions, whichever is more stringent.
- B. Indicate dimensions of individual components and profiles.

- C. No portion of the Work requiring submission of shop drawing, product data, of sample shall be commenced until submission has been approved in writing by the Owner's Representative. All such portions of the Work shall be in accordance with the Contract Documents.
- D. Concrete data and material to include concrete design mixes indicating the proportions to be used on the project.
- E. Qualification Data: For qualified professional engineer
- F. Samples for Verification: Prepared on Samples of size indicated below:
 - 1. Color-Coated Metal Components: In 6-inch lengths for components and on full-sized units for accessories.
 - 2. Vision slats: 6-inch length
- G. Delegated-Design Submittal: For chain-link fence and gate framework indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
- H. Operation and Maintenance Data: Include in operation, and maintenance manuals at closeout:
 - 1. Vinyl/Polymer finishes.
 - 2. Gate hardware.

1.04 PERFORMANCE REQUIREMENTS

- A. Delegated Design: At trash and dumpster enclosures, design chain-link fences, gates and hardware, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.
- B. Structural Performance: Chain-link fence and gate framework shall withstand the effects of gravity loads and the following loads and stresses within limits and under conditions indicated according to ASCE/SEI 7 and PA UCC.
 - 1. Gate Framing and Hardware, Minimum Post Size and Maximum Post Spacing: Determine according to CLFMI WLG 2445, based on mesh size and pattern specified and on the following:
 - a. Design Wind Loads and Loading Conditions
 - b. Fence Height: Match dimensions indicated on Drawings
 - c. Material Group: As recommended by fencing manufacturer and contractor's design engineer to comply with performance requirements.

1.05 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer or installer agrees to repair or replace components of chain-link fences and gates that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failure of load-bearing components
 - b. Faulty operation of gates.
 - c. Deterioration of metals, metal finishes, hardware and other materials beyond normal weathering.
 - 2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. General: Fence members, fabric posts, rails, etc. shall be vinyl coated or Polyolefin coated, color black. Comply with CLFMI Product Manual
- B. Fence fabric: Galvanized or aluminum-coated steel chain link fabric, coated before weaving (ASTM A-491). Fabric shall be 2" x 2" x #9 gauge, unless indicated or directed otherwise.

Aluminum coated fabric shall be knuckle selvaged. Barbed edges are not acceptable for this project, and a special order may be required to provide knuckled selvaged finishes on tops and bottoms of fence.

C. Pipe for Posts and Rails

- Lines, terminal and pull posts; top, middle, and bottom rails or braces; gate frame materials shall be Type I Schedule 40 pipe with 1.8 ounce per square foot zinc coating conforming to the "Standard Specifications for Black and Hot-Dipped Zinc Coated" (Galvanized Welded and Seamless Steel Pipe) to meet the requirements of ASTM Designation A-120; or Type II pipe manufactured from steel conforming to ASTM A-569, Cold-Formed, Electric Welded and Triple Coated with 1.0 ounce +/- 0.1 ounce zinc per square foot, 30 +/- 15 micrograms Chromate, 0.5 +/- 0.2 mils clear cross-linked Polyurethane Acrylic exterior coating. The internal surface shall be given corrosion protection by zinc-rich based organic coating with an 87% minimum zinc powder loading, capable of providing galvanic protection.
- Posts shall be straight, true to section, and shall conform to lengths shown on the details.
- Except as otherwise indicated, posts shall have the physical Dimensions and Strength Performances as per the following chart and Type of Pipe:

<u>Pipe Size I.D.</u>	<u>Pipe Size O.D.</u>	<u>Schedule 40 Type I Wt. Lbs/Ft. Min.</u>	<u>SS-40 Type II Wt. Lbs/Ft. Min.</u>
1"	1 3/8"	1.68	1.345
1 1/4"	1 5/8"	2.27	1.836
1 1/2"	2"	2.72	2.281
2"	2 1/2"	3.65	3.117
2 1/2"	3"	5.79	4.640
3"	3 1/2"	7.58	5.706

D. Nuts and Bolts

- After threading, galvanize wire, clamps, truss rods, and truss attachments to match framing.

E. Fittings

- Of size and strength for their intended use, made of galvanized steel or malleable iron (aluminum fittings will not be acceptable).
- Comply with ASTM F 626

F. Stretcher Bars

- Galvanize stretcher bars. Bars shall be one piece for height of fence needed.

G. Wire Fabric

1. Selvedged wire fabric with knuckled finish on both top and bottom. Tie-wire shall be a minimum of #6 gauge aluminum wire. Note: twisted barbed finish will not be acceptable, and will be cause for rejection.

H. Gates

1. Complete, with hinges, catch, stops, and center rest, and other components. Swing gates swing back against the fence 180 degrees; sliding gates shall provide a minimum 10' opening. Location of gate shall be as determined by Owner's Representative.
2. In addition to applicable performance requirements, comply with ASTM F 900 for industrial swing gate frames, bracing, hardware and posts, single and double swing gate types, for structural and coating requirements. Provide welded frame corner construction.

I. Concrete for Footings

1. Standard concrete (conforming to Section 32 0523 Cement and Concrete for Exterior Improvements) with a 28-day minimum compressive strength of 3500 psi.
2. Diameter and depth of concrete post footing: four times the post diameter by three feet deep with the post imbedded two feet-six inches into concrete, unless otherwise noted.

J. Water: Potable

K. Admixtures: Air entraining admixture, in accordance with ASTM C260-86.

L. Anti-spalling Compound: Combination of boiled linseed oil and mineral spirits complying with AASHTO M-233.

M. Tension Wire: Polymer-Coated Steel Wire, 0.177-inch-diameter, complying with ASTM F 1664, Class 2b over metallic-coated steel wire. Match fabric color.

N. Vision Slats: Fiber-glass-reinforced plastic, UV-light stabilized, not less than 0.06 inch thick, sized to fit mesh specified for direction indicated; with vandal-resistant fasteners and lock strips. Color: to be selected from manufacturer's standard colors.

O. Anchoring Cement: Factory-packaged, two-component hydrophobic hybrid polyurethane system for anchoring, patching, and grouting, to provide a tough weather resistant seal in Portland cement. Product may be used with specified aggregate to create mix-in-place polymer concrete, resistant to erosion, that withstands thermal and shock movement.

1. Product: Flexible Cement II by Roadware Incorporated, 800-522-7623; www.concretemender.com

PART 3 - EXECUTION

3.01 GENERAL

- A. Verify fence layout with Owner's Representative prior to installation. Erect fence in a workmanlike manner, per ASTM F 567.

3.02 METHODS

A. PREPARATION

1. Leveling: The ground shall be leveled to a flat plane, or an easy even slope along the length of the area where the fence is to be installed.

B. FENCE INSTALLATION

1. Install pipe posts and rails per details.
2. Locate terminal post at each fence panel termination. Space line posts uniformly, and at maximum 10'-0 intervals, unless otherwise noted.
3. Set line and terminal posts in concrete footings as detailed. Place concrete around post in a continuous pour. Trowel finish around post. Slope to direct water away from post.
4. Check each post for vertical and top alignment, and maintain in position during placement and finishing operations.
5. Top rails: Provide top rails for all heights of fence. Connect joints with sleeves for rigid connections with expansion/contraction joint. Maximum length per section 21 feet.
6. Bottom rails: Provide on all heights of fence. Install bottom rails between posts with fittings and accessories, two inches (2") clear above finished grade, unless otherwise directed.
7. Comply with ASTM F 567.
8. Vision Slats: Install slats vertically, securely locked in place, for privacy factor of 70 to 75.
9. 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.
10. Adjust gates 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.
11. Engage a factory-authorized service representative to train Owner's personnel to adjust, operate, and maintain chain-link fences and gates.

C. FENCE FABRIC

1. Install fabric on inside (facing level) of proposed area and attach so that fabric remains in tension after pulling is released. The chain link fabric shall be drawn taut, without kinks or bends. Fabric shall be firmly secured to supporting pipes with clamps, and tie wires, attaching at 15" on center to rails and braces. Where splicing is necessary, interweave an additional steel wire between the two ends of the fabric sheets, under the manufacturer's direction. Pull point spacing is not to exceed 250' fabric tied to posts with stretcher bars and fittings. Pull point spacing is not to exceed 250' fabric tied to posts with stretcher bars and fittings.
2. Attach fabric to stretcher bars secured to posts. Pull fabric taut; thread tension bar through fabric and attach to terminal posts with bands or clips spaced maximum 15" on center.
3. Bend tie wire ends to minimize hazard to persons and clothing.

D. INSTALLATION OF CONCRETE FOOTINGS

1. Formwork: Conform to shape form, size, grade and line as required.
 - a. Soak forms with clean water prior to placing concrete footings. Exposed surfaces shall be treated with form oil; wipe off excess oil with rags, leave surface just oily to the touch.
 - b. Forms shall be constructed to full dimension indicated on drawings and set with top of form at finished elevation of concrete work.
2. Preparation for Placing

- a. Remove water from excavation before depositing concrete. Remove hardened concrete, debris and foreign materials from interior.
- 3. Placing Concrete
 - a. Conform to ACI 301.
 - 1) Placing will not be permitted when the sun, heat, wind, rain or limitations of facilities furnished by the Contractor prevent proper curing of the concrete.
 - 2) Time interval between mixing and placing: Concrete shall be placed in the forms within one (1) hour from the time ingredients are charged into the mixing drum.
 - 3) All concrete shall be thoroughly consolidated during placement.
- 4. Weather Conditions
 - a. The methods and recommendations described in ACI Standard 306 shall be followed for winter concreting and ACI Standard 305 for hot weather concreting.
 - b. Concrete, when deposited, shall have a temperature not below 50 degrees F and not above 85 degrees F. Maximum temperature of concrete produced with heated aggregates and/or water, shall not exceed 90 degrees F at any time during its production or transportation.
 - c. Salt, chemicals or other materials shall not be used in mixing concrete for the purpose of preventing freezing.
 - d. Admixtures intended to accelerate the hardening of the concrete to produce higher than normal strength at early periods will not be permitted unless specified or prior approval is obtained from the Owner's Representative.
 - e. Records shall be kept and must show the date of placements, the mix used and the air temperature at time of concreting for the various portions of the work. These records shall be available to the Owner's Representative when requested.
- 5. Concrete Control Tests
 - a. Strength of concrete placed will be based on laboratory compression tests of standard cylindrical specimens, by an independent testing laboratory approved by the Owner. All testing costs shall be paid for by the Contractor.
 - b. Test specimens shall be prepared, handled and cured in accordance with ASTM C31-90 and C 172-90. Each specimen shall be identified with respect to date and location of concrete placed, proportion of mix and type of cement, and delivered to the Testing Laboratory.
 - c. A minimum of three test cylinders for 7- and 28-day compression tests shall be taken from concrete poured within each 8-hour period or fraction thereof.
 - d. Evaluation of test results shall be in accordance with ACI 318 and ACI 214. If the results indicate that the strength of the concrete does not meet specification requirements, said concrete may be required to be removed and replaced.

E. CLEAN-UP

- 1. Clean and level the ground disturbed by installation of the fence. Dispose of excess spoil material off site.
- 2. Seed and mulch disturbed areas as applicable with seed mixture to match existing turf.

F. WARRANTY

- 1. Provide Owner with fence manufacturer's written against all product failure, including that due to rust or corrosion. Warranty shall be numbered and registered with the manufacturer at the time of project installation.

END OF SECTION 32 3100

SECTION 32 3223 - CONCRETE UNIT / SEGMENTAL WALL

PART 1 - GENERAL

1.01 SUMMARY

- A. Work includes professional design, furnishing and installing segmental retaining wall with soil reinforcement (MSE or Mechanically Stabilized Earth wall) to the lines and grades designated on the construction drawings, or as directed by the Owner's Representative.
- B. Construction includes installation of soil reinforcement, wall facing units, backfill placement, and appurtenant materials in accordance with this specification, and the structural design prepared by the wall manufacturer.
- C. Work also includes submittal of engineered wall designs to Owner's Representative for approval prior to construction.
- D. Related Sections:
 - 1. Division 31 Section "Excavation, Backfill, and Compaction" for excavation.
 - 2. Division 31 Sections "Geotextiles", "Aggregates", and "Aggregate Base Course" for drainage fill and leveling course.

1.02 PERFORMANCE REQUIREMENTS

- A. Delegated Design: Design segmental retaining walls, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria required for this project.
- B. Structural Performance: Engineering design shall be based on the following loads and be according to NCMA's "Design Manual for Segmental Retaining Walls", and applicable building codes.
 - 1. Gravity loads due to soil pressures resulting from grades indicated.
 - 2. Surcharge load resulting from load reactions of chain-link fence and paved areas at top of wall.

1.03 WALL DESIGN CRITERIA

- A. Basis of Design: Versalock standard block, size, color range, options, etc., or approved equivalent.
- B. Design walls in accordance with NCMA Design manual for Segmental Retaining Walls (latest edition) or the FHWA Mechanically Stabilized Earth Walls and Reinforced Soil Slopes Design and Construction Guidelines (latest edition), except otherwise noted in these specifications.
 - 1. Wall designs shall include internal stability and calculations for global stability and wall settlement.
- C. Design Height: The design height "H" shall be measured from the top of the leveling pad to the top of the wall. Note: height of wall shown on Contract Documents (Grading Plan) is from finished grade at bottom of wall, to top of wall).
- D. Wall Batter: Design with a minimum wall batter of 5 degrees.
- E. Geogrid: The geogrid length shall be a minimum of $0.7 \times H$.

F. Soils:

1. Soil parameters, as determined by the Owner's Geotechnical Engineer shall be used for the preparation of the final design. Refer to the Geotechnical Exploration and Engineering Report prepared for this project.
2. Poor soils below the retaining wall: Poor soils exist within the site that may not be suitable under the proposed wall. Boring logs are available in the Geotechnical Exploration and Engineering Report. The Structural Engineer should evaluate whether over-excavation and backfill is required to prepare adequate subgrade below proposed walls.
3. Should the actual soil conditions observed during construction differ from those assumed for the design, design shall be reviewed by the Wall Design Engineer at the Owner's Geotechnical Engineer's direction.
4. The design provided by the Contractor and prepared by the Wall Design Engineer shall consider the internal and local stability of the reinforced soil mass and shall be in accordance with acceptable engineering practice and these specifications.

G. Reference Standards:

1. The latest edition or revision of the Manufacturers specifications for materials and installation shall apply. Where Manufacturer's requirements and referenced or design requirements conflict, the more stringent shall apply.
2. Engineering Design
 - a. NCMA Design Manual for Segmental Retaining Walls
 - b. NCMA TEK 2-4 – Specifications for Segmental Retaining Wall Units
 - c. NCMA SRWU-1 – Determination of Connection Strength between Geosynthetics and Segmental Concrete Units
 - d. NCMA SRWU-2 – Determination of Shear strength between Segmental Concrete Units
3. MSE Wall, or SRW, Units
 - a. ASTM C140 – Sampling and Testing Concrete Masonry Units
 - b. ASTM C150 – Standard Specification for Portland Cement
 - c. ASTM C1262 – Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
 - d. ASTM C1372 – Standard Specification for Segmental Retaining Wall Units
4. Geosynthetic Reinforcement
 - a. ASTM D4595 – Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
 - b. ASTM D5262 – Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics
 - c. GRI GG-1 – Single Rib Geogrid Tensile Strength
 - d. GRI GG-4 – Long-Term Design Strengths of Flexible Geogrids
 - e. GRI GG-5 – Geogrid Pullout
 - f. GRI GT-6 – Geotextile Pullout
5. Soils
 - a. ASTM D1557 – Moisture Density Relationship for Soils, Modified Method
 - b. ASTM D4253 – Maximum Index Density of Soils Using a Vibratory Table
 - c. ASTM D4254 – Minimum Index Density of Soils and Calculation of Relative Density
 - d. ASTM D422 – Gradation of Soils
 - e. ASTM D424 – Atterberg Limits of Soils
 - f. ASTM DG51 – Soil pH
6. Drainage Pipe
 - a. ASTM D3034 – Specification for Polyvinyl Chloride (PVC) Plastic Pipe
 - b. ASTM D1248 – Specification for Corrugated Plastic Pipe

1.04 PRECONSTRUCTION TESTING

- A. Preconstruction Testing Service: If not sufficiently addressed by Owner's geotechnical investigation report made available as information for bidders, engage a qualified testing agency to perform the following preconstruction testing, unless otherwise directed:

1. Test soil reinforcement and backfill materials for pullout resistance according to ASTM D 6706.
 2. Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D 5321.
- B. Drainage Fill: Submit for approval the name of the supplier and recent gradation, weight, and density test results for the proposed drainage fill a minimum of two weeks prior to delivery. Test results available from the supplier shall be acceptable.

1.05 DEFINITIONS

- A. Cap Unit: A modular concrete cap unit machine-made and produced by approved suppliers as listed in this specification section.
- B. Concrete Facing Unit: A modular concrete unit which is machine-made from Portland cement, water, and mineral aggregates, designed to be exposed on the wall face, and produced by approved suppliers as listed in this specification section.
- C. Design Engineer: The Contractor's professional engineer who performs the delegated design services of the retaining wall and provides the calculations for the design.
- D. Drainage Fill: Free draining "open" aggregate fill which is within, between and extends minimum of 24 inches behind the concrete facing units.
- E. Drainage Geocomposite: A drainage mat placed on the face of the temporary excavation to control groundwater; consisting of a high compressive strength core with a nonwoven filter fabric bonded to both sides.
- F. Foundation Soil: Compacted fill material or in-situ soil beneath entire wall, including under the reinforced zone.
- G. Geotechnical Engineer: Refers to the consulting geotechnical engineer of record retained by the Architect or Owner to investigate subsurface conditions at the site and review the wall design and submittals.
- H. Leveling Pad: Level compacted gravel or unreinforced concrete footing upon which first course of wall concrete facing units are placed.
- I. Reinforced Soil: Compacted soil which is within the reinforced zone.
- J. Retained Soil: Compacted soil or in-situ soil behind reinforced zone of retaining wall.
- K. Soil Reinforcement: Structural geogrid formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth and function primarily as structural reinforcement.
- L. Testing Agency: The firm retained by the Owner to provide oversight and testing during wall construction.

1.06 SUBMITTALS

- A. Installer's Experience: Submit documentation of Installer's past experience constructing MSE retaining walls to the Architect. Include a list of ten comparable projects located in western Pennsylvania that are similar in terms of size and scope, and where the walls were installed. A list of any walls that the Contractor constructed that have failed or required significant repairs shall also be provided, along with an explanation of the reason for the wall failure. Contractors unable to meet this requirement shall not be considered.

1. The Installer's foreman shall have a minimum of three years' experience constructing MSE walls or an NCMA Level II Certification. Submit the name of the foreman and a copy of his certificate prior to delivery of any materials to the site.
 2. Installers unable to meet this requirement shall not be considered. After award of the Contract, the Contractor shall not change the Installer or Installer's project foreman without written approval from the Architect. Installer's foreman shall be present on site full-time when the MSE walls are being constructed.
- B. Product Data: For each type of product indicated.
- C. Samples for Initial Selection: For concrete units.
- D. Samples for Verification: For each color and texture of concrete unit required. Submit full-size units.
- E. Delegated-Design Submittal: For segmental retaining walls indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional design engineer responsible for their preparation.
1. Compliance Review: Qualified professional engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.
- F. Qualification Data: For qualified professional engineer and testing agency, if used.
- G. Product Certificates: For segmental retaining wall units and soil reinforcement, from manufacturer.
1. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
 2. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.
- H. Product Test Reports: Based on evaluation of comprehensive tests performed by a qualified testing agency, for segmental retaining wall units and soil reinforcement.
1. Include test data for freeze-thaw durability of segmental retaining wall units.
 2. Include test data for shear strength between segmental retaining wall units according to ASTM D 6916.
 3. Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D 6638.
- I. Preconstruction test reports.
- J. Source quality-control reports.
- K. Field quality-control reports.

1.07 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.
- B. Mockups: Build mockups to verify selections made under sample submittals and to demonstrate aesthetic effects.
1. Build mockup of segmental retaining wall approximately 72 inches long by not less than 36 inches high above finished grade at front of wall.
 - a. Include typical soil reinforcement.
 - b. Include typical base and cap or finished top construction.
 - c. Include backfill to typical finished grades at both sides of wall.
 - d. Include typical end construction at one end of mockup.

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.
1. Review methods and procedures related to segmental retaining walls including, but not limited to, the following:
 - a. Structural load limitations.
 - b. Construction schedule. Verify availability of materials, Installer's personnel, equipment, and facilities needed to make progress and avoid delays.
 - c. Field quality-control procedures.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes.
- B. MSE Wall Concrete Facing Units:
1. Check the facing units upon delivery to assure the specified type, grade, color, and texture of units have been received.
 2. Prevent excessive mud, wet concrete, epoxies, and similar materials which may affix themselves from coming in contact with the materials.
 3. Protect the materials from damage. Damaged material shall not be incorporated into the MSE wall system.
- C. Soil Reinforcement:
1. Check the soil reinforcement upon delivery to assure the proper grade and type of reinforcement has been received. Provide a product certification with each shipment.
 2. Store soil reinforcement material in accordance with the manufacturer's recommendations.
- D. Drainage Materials:
1. Store PVC or HDPE pipe in accordance with the manufacturer's recommendations to prevent deleterious materials from becoming affixed or deterioration from sun exposure.
 2. Store drainage aggregate to prevent contamination with other materials.
 3. Store drainage geocomposite in accordance with the manufacturer's recommendations to prevent deleterious materials from becoming affixed or deterioration from sun exposure.
- E. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before using and examine them for defects as material is placed.

PART 2 - PRODUCTS

2.01 SEGMENTAL RETAINING WALL UNITS

- A. Concrete Units: ASTM C 1372, Normal Weight, except that maximum water absorption shall not exceed 7 percent by weight and units shall not differ in height more than plus or minus 1/16 inch from specified dimension.
1. Manufacturers: Subject to compliance with requirements, provide products by licensees of one of the following:
 - a. Allan Block Corporation.
 - b. Anchor Wall Systems, Inc.

- c. GeoWestern, Inc.
 - d. Keystone Retaining Wall Systems, Inc.
 - e. Risi Stone Systems; a division of Rothbury International.
 - f. Rockwood Retaining Walls, Inc.
 - g. Tensar Earth Technologies, Inc.
 - h. Versa-Lok Retaining Wall Systems; a division of Kiltie Corporation.
- 2. The freeze-thaw durability shall be demonstrated by testing per ASTM C1262. Testing shall be conducted for a minimum 100 cycles, and the weight loss shall not exceed one percent.
 - 3. Provide units that interlock with courses above and below by means of integral lugs or lips, pins, or clips.
- B. Color: As selected by Architect from manufacturer's full range.
 - C. Shape and Texture: Provide standard units (6-inch height, 16-inch width, 12-inch depth) to produce segmental retaining walls of dimensions and profiles indicated without interfering with other elements of the Work and with machine-split textured, flat exposed face.
 - D. Cap Units: Provide cap units of shape as selected from manufacturer's standards, with smooth, as-cast top surfaces without holes or lugs.
 - E. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face.

2.02 INSTALLATION MATERIALS

- A. Pins or clips (where used): Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from non-degrading polymer reinforced with glass fibers.
- B. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.
- C. Leveling Base: Comply with the more stringent of delegated design professional's design requirements and requirements in Division 31 Section "Excavation, Backfill and Compaction" for base material.
 - 1. Leveling Course: Lean concrete with a compressive strength of not more than 500 psi.
- D. Drainage Fill: Comply with requirements in Division 31 Section "Excavation, Backfill and Compaction"
- E. Reinforced-Soil Fill: Comply with requirements in Division 31 Section "Excavation, Backfill and Compaction," and as follows, for satisfactory soils. Revise as recommended by Contractor's delegated design professional, subject to Architect's approval.
 - 1. ASTM D 2487; GW, GP, SW, SP, and SM soil classification groups or a combination of these groups; free of debris, waste, frozen materials, vegetation, and other deleterious matter; meeting the following gradation according to ASTM C 136: 20 to 100 percent passing No. 4 sieve, 0 to 60 percent passing No. 40 sieve, 0 to 35 percent passing No. 200 sieve, and with fine fraction having a plasticity index of less than 20.
- F. Nonreinforced-Soil Fill: Comply with requirements in Division 31 Section "Excavation, Backfill and Compaction " for satisfactory soils.
- G. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.
 - 1. Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D 4751.
 - 2. Minimum Grab Tensile Strength: 110 lb; ASTM D 4632.

3. Minimum Weight: 4 oz./sq. yd..
- H. Subdrainage Pipe and Filter Fabric: Comply with requirements in Division 33 Section "Subdrainage."
- I. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as follows:
 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Colbond Inc.
 - b. Huesker, Inc.
 - c. Luckenhaus Technical Textiles, Inc.
 - d. Mirafi Construction Products; Ten Cate Nicolon.
 - e. Propex Fabrics Inc.; Civil Engineering Fabrics.
 - f. Strata Systems, Inc.
 - g. Synteen Technical Fabrics, Inc.
 - h. Tenax Corporation; Subsidiary of Tenax Group.
 - i. Tensar Earth Technologies, Inc.
 - j. Versa-Lok Retaining Wall Systems; a division of Kiltie Corporation.
 - k. Webtec, Inc.
 2. Product Type: Knitted, woven or molded geogrid as recommended by manufacturer's delegated design professional to satisfy performance requirements.

2.03 SOURCE QUALITY CONTROL

- A. Direct manufacturer to test and inspect each roll of soil reinforcement at the factory for minimum average roll values for geosynthetic index property tests, including the following:
 1. Weight.
 2. Roll size.
 3. Grab or single-rib strength.
 4. Aperture opening.
 5. Rib or yarn size.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of segmental retaining walls.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 RETAINING WALL INSTALLATION

- A. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.
 1. Lay units in running bond unless otherwise indicated.
 2. Form corners and ends by using special units.
- B. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D 698.

1. Leveling Course: At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches of base. Compact and screed concrete to a smooth, level surface.
- C. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.
 1. Tamp units into leveling base as necessary to bring tops of units into a level plane.
- D. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.
 1. For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.
 2. For units with lips at front of units, slide units as far forward as possible for firm contact with lips of units below.
 3. For units with lips at bottom rear of units, slide units as far forward as possible for firm contact of lips with units below.
 4. For units with pins, install pins and align units.
 5. For units with clips, install clips and align units.
- E. Cap Units: Place cap units and secure with cap adhesive.

3.03 FILL PLACEMENT

- A. General: Comply with requirements in Division 31 Section "Excavation, Backfill and Compaction," Division 31 Section "Aggregates," NCMA's "Segmental Retaining Wall Installation Guide," and segmental retaining wall unit manufacturer's written instructions.
- B. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.
- C. Place, spread, and compact drainage fill and soil fill in uniform lifts for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall and place and spread fills toward embankment.
 1. Use only hand-operated compaction equipment within 48 inches of wall, or one-half of height above bottom of wall, whichever is greater.
 2. Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D 698.
 - a. In areas where only hand-operated compaction equipment is allowed, compact fills to not less than 90 percent maximum dry unit weight according to ASTM D 698.
 - b. In areas where fill height exceeds 15 feet, compact reinforced-soil fill that will be more than 15 feet below finished grade to not less than 98 percent maximum dry unit weight according to ASTM D 698.
 - c. In areas where fill height exceeds 30 feet, compact reinforced-soil fill that will be more than 30 feet below finished grade to not less than 100 percent maximum dry unit weight according to ASTM D 698.
 3. Compact nonreinforced-soil fill to comply with Division 31 Section "Earth Moving."
- D. Place drainage geotextile against back of wall and place layer of drainage fill at least 12 inches wide behind drainage geotextile to within 12 inches of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.
- E. Place subdrainage pipe in drainage fill as indicated, sloped not less than 0.5 percent to drain.
- F. Place impervious fill over top edge of drainage fill layer.

- G. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at base of wall away from wall. Provide uniform slopes that will prevent ponding.

3.04 SOIL REINFORCEMENT

- A. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.
 - 1. Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.
 - 2. Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.
 - 3. Do not dump fill material directly from trucks onto geosynthetics.
 - 4. Place at least 6 inches of fill over reinforcement before compacting with tracked vehicles or 4 inches before compacting with rubber-tired vehicles.
 - 5. Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

3.05 CONSTRUCTION TOLERANCES

- A. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.
- B. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.
- C. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.

3.06 FIELD QUALITY CONTROL

- A. Owner may engage a qualified testing agency to perform tests and inspections.
- B. Comply with requirements in Division 31 Section "Excavation, Backfill and Compaction" for field quality control.
 - 1. Base Leveling Pad: One test for every 100 lineal feet
 - 2. In each compacted backfill layer, perform at least 1 field in-place compaction test for each 24 inches of fill depth and each 50 feet or less of segmental retaining wall length, except as otherwise recommended by Owner's testing agency.

3.07 ADJUSTING

- A. Remove and replace segmental retaining wall construction of the following descriptions:
 - 1. Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Architect approves methods and results.
 - 2. Segmental retaining walls that do not match approved Samples and mockups.
 - 3. Segmental retaining walls that do not comply with other requirements indicated.
- B. Replace units so segmental retaining wall matches approved Samples and mockups, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 32 3223

SECTION 33 1000 - WATER DISTRIBUTION

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Pipes, fittings, and bedding for new domestic water service, fire protection service, and site fire hydrants.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Bedding: Material placed under and beside pipe.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Approved Erosion and Sedimentation Control Plan prepared by CEC.
- D. Section 31 2333 – Trenching.
- E. Section 32 1000 – Aggregate Materials.

1.04 REFERENCES

- A. ASTM B88 – Standard Specification for Seamless Copper Water Tube.
- B. AWWA C104 – Cement Mortar Lining and Asphalt Seal Coat for Ductile Iron Pipe.
- C. AWWA C105 – Polyethylene Encasement for Ductile Iron Pipe.
- D. AWWA C110 – Ductile Iron Fittings.
- E. AWWA C111 – Push-on Joints for Ductile Iron Pipe.
- F. AWWA C115 – Flanged Ductile Iron Pipe.
- G. AWWA C151 – Ductile Iron Pipe.
- H. AWWA C500 – Gate Valves.

- I. AWWA C502 – Dry-Barrel Fire hydrants.
- J. AWWA C509 – Resilient Seated Gate Valves.
- K. AWWA C600 – Specification for Pressure and Leakage Testing of Water Mains.
- L. AWWA C601 – Disinfecting Water Mains.
- M. ANSI A21.51 – National Standard for Ductile Iron Pipe.
- N. AWWA M23 – PVC Pipe Design and Installation.
- O. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications Publication 408, latest edition.
- P. PennDOT Standards for Roadway Construction, Series RC 0 -100.
- Q. PennDOT Publication 203 – Work Zone Traffic Control.
- R. Water Authority code and specifications.

1.05 SUBMITTALS

- A. Submit shop drawings for waterline pipe, fittings, and appurtenances for review and approval prior to construction.
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- C. Manufacturer's Installation Instructions: Indicate special procedures required to install approved products.
- D. The Contractor is responsible for selecting the supplier(s) of the piping, fittings, appurtenances, and imported bedding materials and providing the name(s) of the supplier(s) to the Owner or his representative prior to the commencement of construction. The Owner or his representative may request information about the supplier(s), and the Owner holds the right to direct the Contractor to use a supplier of the Owner's choice. If the Contractor chooses to change the supplier, he must first receive approval from the Owner or his representative.
- E. Contractor is responsible for providing copies of all applicable materials certifications and test results for bedding materials to the Owner or his representative prior to installation to demonstrate conformance with referenced standards.

1.06 REGULATORY REQUIREMENTS

- A. All work done on water lines shall be done by a licensed contractor who is approved by the Water Authority.
- B. Do not close or obstruct roadways, fire lanes, sidewalks, or fire hydrants without approval from the local authorities.
- C. Conform to Water Authority codes and specifications for materials and installation of water line and appurtenances.
- D. No tapping of the main water line shall be allowed without approval of Water Authority.

1.07 COORDINATION

- A. Coordinate the work with other aspects of the work, including other utility installations and relocations. Coordinate work with the utility companies where existing utilities may be affected by the installation of the water lines.

- B. Verify work associated with lower elevation utilities has been completed before placing higher elevation utilities.
- C. Verify that all erosion and sedimentation control measures have been installed.
- D. Route vehicular and pedestrian traffic away from work at all times during construction activities.
- E. Coordinate inspection and testing of the new water system with Water Authority.
- F. Existing utilities are indicated on the drawings at approximate locations and reflect general ground surface observation. Contractor shall notify utility companies and coordinate exact location of all utilities prior to beginning site preparation.

1.08 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of existing and proposed utilities by horizontal dimensions, elevations or inverts, and slope gradients.

PART 2 - PRODUCTS

2.01 PIPE MATERIALS

- A. All materials required for the installation of the water line from the existing water service line to the building connections, including, but not limited to, pipe, fittings, valves, tapping sleeves, and all other materials required for the completion of the work as shown on the approved drawings and as approved by Water Authority and the owner.
- B. Ductile Iron Pipe: Piping for water lines 3 inches and larger shall be ductile iron conforming to AWWA C151, Class 52, unless otherwise specified by Water Authority. Ductile iron pipe shall be manufactured in accordance with Specification ANSI/AWWA C150/A21.50 and ANSI/AWWA C151/A21.51. All ductile iron pipe shall be double cement mortar lined and provided with an asphaltic seal coat. The cement lining and seal coat shall conform to AWWA Standard C104. All pipe shall be free of defects. All fittings to be mechanical joint type and shall conform to AWWA C110 with a bituminous coating.
- C. Polyvinyl Chloride (PVC) Pipe: All 4-inch diameter through 12-inch diameter PVC pipe shall be rated for AWWA C-900, DR14, Class 200. PVC Pipe 4 inches or less in diameter shall be Schedule 80 with a pressure rating of 200 psi solvent welded, including blow-off assemblies.

2.02 WATERLINE PIPE MATERIALS, FITTINGS, AND APPURTENANCES

- A. Fittings for Ductile Iron Pipe: Fittings shall be ductile iron and shall be manufactured in accordance with AWWA C110 Specifications. Pressure rating shall not be less than 350 psi for ductile iron unless otherwise specified by Owner or Water Authority. All fittings shall be coated and provided with double cement lining in accordance with AWWA Standard C-104.
- B. Ductile Iron Pipe Joints: Pipe joints shall be mechanical joints, ductile iron, Class 350 or greater. Bell and spigot type joints conforming to AWWA Standard C111 or flanged joints conforming to AWWA Standard C115 may only be used if approved by the Owner and Water Authority. Joint restraints shall be Megalug or equivalent.
- C. Gate Valves: All gate valves shall fully comply with AWWA C500 or AWWA C509 Specifications. Working pressure ratings shall not be less than 250 psi unless otherwise specified by Water Authority. All valves shall be of type and make approved by Water Authority, Municipality, and Fire Department.

- D. Valve Boxes: All valve boxes shall be cast iron and shall be round with a bottom diameter required for the size and type of valve. Valve boxes shall be bituminous coated, both inside and outside.
- E. Tapping Sleeve: Tapping sleeves shall be cast iron mechanical joint or stainless steel full gasket and have a minimum working pressure of 350 psi. The mechanical joint sleeve shall be compatible with type and class of pipe being tapped.
- F. Trace Wire: Trace wire shall consist of magnetic detectable conductor wire.
- G. Early Warning Detection Tape: Early warning detection tape shall consist of brightly colored plastic covering with "Water Service" imprinted on it in bold letters or type as approved by Water Authority.
- H. Concrete: All concrete used for thrust blocks and to encase the waterlines shall be Class C cement concrete. All thrust blocks shall satisfy the requirements of Water Authority.
- I. Polyethylene Film: All polyethylene film used to encase water lines and fittings shall comply with AWWA C105.
- J. Fire Department Connections: Per local Municipal and Fire Department requirements.

2.03 BEDDING MATERIALS

- A. Bedding Material: AASHTO No. 57 crushed aggregate conforming to the material requirements of Section 321000 and/or Water Authority.

2.04 THRUST BLOCKING

- A. Thrust blocking shall be provided at all horizontal and vertical bends, tees, etc. or as required by Water Authority. Thrust blocks shall be installed to the dimensions shown on the construction drawings or the requirements of the Water Authority.

2.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle products in accordance with the manufacturer's instructions.
- B. Cementitious materials and aggregates shall be stored in such a manner as to prevent deterioration or intrusion of foreign matter.
- C. Any cement that is kept in storage shall be placed in a suitable, weather tight building in such a manner as to permit easy access for proper inspection and identification of each shipment. Portland cement, which has been reclaimed in any manner, shall not be used.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify building service connections, proposed water line locations, and existing water mains, sizes, materials, and inverts.

3.02 PREPARATION

- A. Ream pipe ends and remove burrs before assembly.

- B. Remove scale and dirt, on inside and outside, before assembly.
- C. Prepare pipe connections in accordance with the manufacturer's recommendations.
- D. Remove large stones or other hard matter which could damage piping or impede consistent backfilling or compaction.

3.03 BEDDING

- A. Place Bedding Material at trench bottom in continuous loose layers not exceeding 6 inches thick. Compact bedding material to a minimum of 75 percent of its relative density. A minimum of 6 inches of compacted bedding material shall be provided beneath the water lines.

3.04 INSTALLATION - PIPE

- A. Maintain a minimum separation of 10 feet horizontally, or 18 inches vertically, between water lines and sanitary sewers.
- B. Place pipe on minimum 6-inch deep bed of bedding material. The pipe shall be uniformly supported throughout its entire length by the bedding material.
- C. Install pipe to elevations determined from the design plans and approved by the Owner or his representative.
- D. Route pipe in a straight line.
- E. Install pipe to allow for expansion and contraction without stressing pipe or joints.
- F. Install access fittings to permit disinfection of water system.
- G. Form and place concrete for thrust blocks.
- H. Establish elevations of buried piping to ensure not less than 4 feet of cover, as measured from the top of the pipe to the final ground surface, is provided.
- I. Backfill around sides and to a point 12 inches above the top of the pipe with Bedding Material. Carefully tamp in-place and compact the bedding material to a minimum of 75 percent of its relative density. Place Bedding Material in maximum 6-inch thick loose lifts, as shown on the drawings.
- J. Backfill trench in accordance with Section 31 2333. Do not displace or damage pipe when compacting.

3.05 INSTALLATION - VALVES

- A. Set valves on solid bearing. Valves shall be mechanical joint with cast iron box or as approved by Water Authority.
- B. Center and plumb valve box over valve. Set box cover flush with finished grade. Prevent shock or stress from being transmitted through valve box to valve.

3.06 INSTALLATION - ACCESSORIES

- A. Form bottom of excavation clean and smooth to the correct elevation.
- B. Place bedding material as previously specified.

- C. Install all water line accessories in accordance with the manufacturer's recommendations and the requirements of Water Authority.

3.07 INSTALLATION - THRUST RESTRAINT

- A. The Contractor shall provide a restraint at all points where a hydraulic thrust may develop.
- B. The Contractor shall install retainer glands on fire hydrants and all associated fittings, valves, and related piping in accordance with Water Authority and Fire Department requirements.
- C. The Contractor shall provide concrete thrust blocking for all bends, tees, valves, and other points where thrust may develop.

3.08 HYDROSTATIC TESTING

- A. Pressure and Flush Test: Testing shall be done in accordance with NFPA 24 standards, or as required by Water Authority.

3.09 FIELD QUALITY CONTROL

- A. Horizontal Separation: Whenever possible, a water main shall be laid at least 10-foot horizontally from any existing or proposed drain or sewer line. Should local conditions prevent a lateral separation of 10 feet, a water main may be laid closer than 10 feet to a storm or sanitary sewer, provided that the main is laid in a separate trench, or on an undisturbed earth shelf located on one side of the sewer at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer. All separations closer than 10 feet shall be confirmed with Water Authority.
- B. Vertical Separation: Whenever water lines must cross sewers, the water line shall be laid at such an elevation that the bottom of the water line is 18 inches above the top of the sewer. This vertical separation shall be maintained for that portion of the water main located within 10 feet horizontally of any sewer it crosses. Whenever the vertical separation between the water line and sewer is less than 18 inches or the water line must cross below a sewer, the crossing shall be encased in concrete a minimum of 2 feet in any direction of the crossing. All separations closer than 18 inches shall be confirmed with Water Authority.
- C. The Owner or his representative shall inspect the installations of pipes, fittings, valves, thrust blocks, etc. prior to and immediately after placing bedding material cover.
- D. The Owner or his representative will visually observe the bedding placement to verify that lift thicknesses and final bedding dimensions comply with the requirements.
- E. Trench subgrade and backfill compaction testing will be performed in accordance with ASTM D2216, ASTM D2922, and/or ASTM D3017, unless other test requirements required by Water Authority.
- F. If tests indicate Work does not meet specified requirements, remove Work, replace, and retest at no cost to Owner.
- G. Flush and disinfect system in accordance with NFPA 24 and the specification of the American Water Works Association Designation C601 - Standard for Disinfection of Water Mains or in accordance with Water Authority requirements. The contractor shall be responsible for contacting and coordinating, flushing and disinfecting of the waterline with Water Authority.

3.10 PROTECTION OF FINISHED WORK

- A. During the suspension of the work at night or other times, suitable stoppers shall be placed in the end pipes to prevent materials from entering the pipe.
- B. No sand, mud, mortar, concrete, or other materials shall be allowed on the inside of the water pipe. Upon completion, the water pipe shall substantially show a full circle of light between appurtenances, and shall be left straight, clean, smooth, and acceptable in every respect. Concrete shall be allowed to set before backfilling or walking overtop the pipe is allowed, and the greatest care shall be taken not to disturb the pipe bedding and joints.
- C. Protect pipe and cover material from damage or displacement until backfilling operation is in progress.

END OF SECTION 33 1000

SECTION 33 3000 - SITE SANITARY SEWERAGE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Gravity sewer pipes and appurtenances for sanitary sewer collection and conveyance.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Bedding: Aggregate placed under, beside, or directly over pipe.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Approved Erosion and Sedimentation Control Plan prepared by CEC.
- D. Section 31 2300 – Excavation, Backfilling and Compaction.
- E. Section 31 2333 – Trenching.
- F. Section 32 1000 – Aggregate Materials.
- G. Section 33 4913 – Manholes and Covers.

1.04 REFERENCES

- A. ASTM 3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
- B. ASTM D2564 – Standard Specifications for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems Fittings.
- C. ASTM D2729 – Standards Specification for PVC Sewer Pipe and Fittings.
- D. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joint Plastic Pipe.
- E. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications Publication 408, latest edition.

- F. Commonwealth of PennDOT Standards for Roadway Construction, Series RC 0 -100.
- G. Commonwealth of PennDOT Publication 203 – Work Zone Traffic Control.
- H. Local Health Department Plumbing Code.
- I. Sanitary Authority code and specifications.

1.05 SUBMITTALS

- A. Submit shop drawings for piping and appurtenances for review and approval prior to construction.
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- C. Manufacturer's Installation Instructions: Indicate special procedures required to install approved products.
- D. The Contractor is responsible for selecting the supplier(s) of the piping, appurtenances, and imported bedding materials and providing the name(s) of the supplier(s) to the Owner or his representative prior to the commencement of construction. The Owner or his representative may request information about the supplier(s), and the Owner holds the right to direct the Contractor to use a supplier of the Owner's choice. If the Contractor chooses to change the supplier, he must first receive approval from the Owner or his representative.
- E. Contractor is responsible for providing copies of all applicable materials certifications and test results for bedding materials to the Owner or his representative prior to installation to demonstrate conformance with referenced standards.

1.06 REGULATORY REQUIREMENTS

- A. All work done on sanitary sewers shall be done by a licensed contractor who is approved by the Municipal Authority.
- B. Do not close or obstruct roadways, fire lanes, sidewalks, or fire hydrants without approval from the local authorities.
- C. Conform to Sewer Authority codes and specifications for materials and installation of sewer system. Deflection testing of sanitary sewers, if required by Municipal Authority, shall be in accordance with the Authority's requirements.
- D. Roof drains, foundation drains, or other clean water connections to the sanitary sewer system are prohibited unless otherwise permitted by the Local Health Department Plumbing code and regulations.

1.07 COORDINATION

- A. Coordinate the work with other aspects of the work, including other utility installations and relocations. Coordinate work with the utility companies where existing utilities may be affected by the installation of sanitary sewer pipe and manholes.
- B. Verify work associated with lower elevation utilities has been completed before placing higher elevation utilities.
- C. Verify that all erosion and sedimentation control measures have been installed.
- D. Route vehicular and pedestrian traffic away from work at all times during construction activities.
- E. Coordinate inspection and testing of the new sanitary sewer system with Municipal Authority.

- F. Existing utilities are indicated on the drawings at approximate locations and reflect general ground surface observation. Contractor shall notify utility companies and coordinate exact location of all utilities prior to beginning site preparation.

1.08 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of existing and proposed utilities by horizontal dimensions, elevations or inverts, and slope gradients.

PART 2 - PRODUCTS

2.01 SEWER PIPE MATERIALS

- A. All materials required for the installation of sanitary sewers and service connections including but not limited to, pipe, fittings, and all other materials required for the completion of the work, shall conform to the Municipal Authority's standards.
- B. PVC Pipe: PVC pipe, joints, and fittings shall be of the best quality and shall conform to the extra-strength requirements of ASTM Designation D-3034, and/or other requirements of the Plastic Pipe Institute. Provisions must be made for contraction and expansion at each joint. Pipe joints shall be O-ring type "OR" mechanical seal joints. Rubber rings used as joint gaskets may be used with a separate coupling or an integral wall bell and spigot joint. Gasket quality shall meet the requirements of ASTM F477.

2.02 PIPE ACCESSORIES

- A. PVC Pipe Fittings and Accessories: All PVC pipe fittings and accessories shall be as manufactured and furnished by the pipe supplier and have bell and/or spigot configurations identical to that of the pipe. Rye connections shall be Ring-Tite PVC sewer fittings to assure tight durable connections. No PVC saddle wye cut-in connections will be permitted.
- B. Traps: All fittings and accessories for traps required by Local Health Department Plumbing Code shall be as manufactured and furnished by pipe supplier. It shall be the contractor's responsibility to coordinate with the Local Health Department on the need and location of all traps whether shown on the construction drawings or not. Vented traps shall satisfy the requirements of the Local Health Department Plumbing Code.
- C. Early Warning Detection Tape: Early warning detection tape shall be installed above all sanitary sewer pipe. Tape shall be GREEN and shall state, "Caution Sanitary Sewer Line Buried Below".

2.03 BEDDING MATERIALS

- A. Bedding Material: AASHTO No. 57 crushed aggregate conforming to the material requirements of Section 32 1000.

2.04 SOURCE QUALITY CONTROL

- A. Perform laboratory tests of bedding material samples to determine the relative density and grain-size distribution of each sample in accordance with ASTM D4253 and ASTM D4254, and ASTM D422, respectively.
- B. Visually observe bedding materials to verify they meet the project description.
- C. If tests indicate materials do not meet specified requirements, change materials and retest at no cost to the Owner, and/or change placement and compaction methods.

- D. Verify that manufacturer certifications are provided with all products.

2.05 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle products in accordance with the manufacturer's instructions.

PART 3 - EXECUTION

3.01 GENERAL

- A. Prior to all work of this Section, Contractor shall become familiar with the site, site conditions, and all portions of the work falling within this Section.
- B. Do not allow or cause any of the work performed or installed to be covered up or enclosed by work of this Section prior to all inspections, tests, and acceptance.
- C. Should any of the work be so enclosed or covered up before it has been approved accepted, Contractor shall uncover all such work at no additional cost to the Owner, if so directed by the Owner or his representative.
- D. Keep active utilities intact and in continuous operation, street drains and sewers open for free drainage at all times.

3.02 EXAMINATION

- A. Verify that survey benchmarks and intended elevations are as indicated on the drawings.
- B. Verify that the building service connection and existing sanitary sewer manhole locations and inverts are as shown on the drawings.
- C. Verify that the utility trenches are in conformance with the drawings.
- D. Verify that the erosion and sedimentation control measures have been properly installed in their proper locations prior to commencing with the work.
- E. Protect existing and newly installed utilities from damage.
- F. Protect adjoining properties and roadways.
- G. Prevent movement or settlement of adjacent structures. Provide bracing and shoring as required.

3.03 PREPARATION

- A. Identify required lines, levels, contours, and datum.
- B. Locate, identify, and protect any and all utilities and appurtenances that are to remain from damage.
- C. Remove large stones or other hard matter, which could damage piping or impede consistent backfilling or compaction.
- D. Notify utility companies to remove and relocate utilities.
- E. Stake and flag locations of known utilities.

- F. Protect benchmarks, existing structures, sidewalks, pavement curbs, and other site features from construction equipment and vehicular traffic.
- G. Ream pipe ends and remove burrs before assembly.
- H. Remove scale and dirt on inside and outside before assembly.
- I. Prepare pipe connections in accordance with the manufacturer's recommendations.
- J. Excavate pipe trenches to the required dimensions in accordance with Section 31 2333. Hand trim excavations for accurate placement of manholes and pipes to required elevations. The subgrade shall be firm and unyielding. Any soft or yielding areas shall be excavated to a firm and competent material, backfilled, and re-compacted in accordance with Section 31 2300 before construction proceeds. The Contractor will be responsible for protecting the subgrade from damage. Any damage occurring to the subgrade shall be corrected at no additional cost to the Owner.

3.04 BEDDING

- A. Sanitary Sewer Pipe: Place Bedding Material at trench bottom in continuous loose layers not exceeding 6 inches thick over the firm, unyielding foundation. The loose layer thickness shall be kept within the compacting ability of the equipment used. The bedding material shall be placed so that it conforms to the external shape and dimensions of the pipe and provides an even bearing surface. Do not place bedding material over porous, wet, frozen, or yielding surfaces. Compact bedding material to a minimum of 75 percent of its relative density using mechanical tampers. A minimum of 6 inches of compacted bedding material shall be provided beneath the sanitary sewer pipes.

3.05 INSTALLATION

- A. No pipe shall be placed unless a suitable outlet is provided. Pipe laying shall begin at the downstream end.
- B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions. In general, the following procedures should be observed for installation of PVC gravity pipe:
 - 1. Inspect the bell interior to make sure that there is no foreign matter in the ring groove. Remove any accumulations of dirt, mud, etc., by washing with soap and water, if necessary. Spigot should be thoroughly clean.
 - 2. Set ring in groove, insuring that the marked edge is toward the outside.
 - 3. Liberally apply lubricant to the spigot end of the pipe. Do not use lubricant other than that furnished with the pipe.
 - 4. After aligning the spigot with the bell, push spigot of pipe through gasket to a point where the stop mark stripe on the spigot is just flush with the face of the bell.
- C. Accurately place pipe to line and grade.
- D. Establish elevations of buried piping to ensure that not less than 4 feet of cover, as measured from the top of the pipe to the final ground surface, is provided. Temporary soil may need to be provided during construction to maintain cover prior to paving.
- E. When cutting a pipe to suit actual distances, cuts shall be made with sharp and proper tools at right angles to the axis of the pipe. Pipe ends shall be smoothed and all burrs removed. Pipe ends shall be cut flush with inside face of structure and finished so as to not impede the flow or affect the hydraulic capacity of the pipe.
- F. Encase pipe in concrete where the sanitary sewer pipe and storm sewer/waterline cross within 10 feet of each other and there is less than 18 inches of vertical clearance between pipes. The concrete encasement shall be a minimum of

4 inches around the pipe. All concrete used to encase the sewer pipe shall be Class C cement concrete which meets the minimum requirements of PennDOT Specifications Publication 408.

- G. Install early warning detection tape continuously overtop the sanitary sewer pipe.
- H. Backfill around sides and to the mid-way point of the pipe with bedding material. Carefully tamp in place and compact the bedding material to at least 75 percent of its relative density.
- I. Place Bedding Material in maximum 6-inch thick, loose layers over top of pipe to a depth of one foot above the top of the pipe, as shown on the Construction Detail Sheets. Compact each lift to at least 75 percent of its relative density.
- J. Backfill trench in accordance with Section 31 2333. Do not displace or damage pipe when compacting backfill. Any damage to the piping caused by placement and compaction of backfill shall be immediately repaired by the Contractor at no expense to the Owner and to the satisfaction of the Owner or his representative.
- K. All pipe entering structures shall be cut flush with the inside face of the structure, and the cut ends of the pipe and surface of the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges, or imperfections that will impede the flow or affect the hydraulic characteristics of the installation.
- L. Install cleanouts, connections, elbows, and vented traps in accordance with manufacturer's specifications. Cleanouts shall be provided at the locations shown on the Site Civil Construction Plans.

3.06 BUILDING CONNECTIONS

- A. The Contractor shall coordinate his work with the Building Contractor. Sanitary sewer connections shall be installed to a point 5 feet outside of the wall of the building. Refer to the architectural drawings for the exact location where the sanitary sewer lateral will connect to the building sewer. If the sanitary sewer connection is installed prior to completion of the building sewer by the Building Contractor, a suitable stopper shall be placed in the last pipe to prevent material from entering the pipe. The stopper locations shall be adequately staked and flagged for future location of the stopper.

3.07 TOLERANCES

- A. All pipe shall be accurately laid to the lines and grades shown on the drawings. Allowable tolerances shall be 1/4-inch on grade and 1-inch on line in any section of pipe between structures, except that the allowable tolerance shall be 1/8-inch on grades of 2.0 percent or less. Deviations from these tolerances shall be a basis for rejection of the line of pipe by the Owner or his representative. Any line, which has been rejected, shall be rebuilt to the correct line and grade by the Contractor at his own expense.

3.08 FIELD QUALITY CONTROL AND TESTING

- A. The sanitary sewer piping, manholes, wye connections, fittings, cleanouts, and traps shall be inspected and tested before backfilling commences, in accordance with Municipal Authority requirements.
- B. The Contractor is responsible for coordinating the inspection and testing in a manner satisfactory to Municipal Authority. If any component of the sanitary sewer system fails to meet the testing requirements, the Contractor shall, at his own expense, repair or replace all defective material and/or workmanship and retest the sanitary sewer system. If the test is conducted after backfilling, rectifications shall include re-excavation and backfill after repairs and/or replacement. All costs of testing, including materials, labor, and supervision, shall be borne by the Contractor.
- C. The Owner or his representative shall visually observe the placement of bedding materials to verify that lift thicknesses and final bedding dimensions comply with the specified requirements.

- D. Compaction testing shall be performed by the Owner or his representative in accordance with ASTM D2216, ASTM D2922, and/or ASTM D3017.
- E. If tests indicate work does not meet specified requirements, remove work, replace and retest at no cost to Owner.
- F. Frequency of Tests: Perform compaction testing at a rate of one test per lift per 100 lineal feet of bedding placed, or portion thereof, or as required by Municipal Authority and the Owner.
- G. The Contractor shall give proper notification to Municipal Authority and the Owner to allow sufficient time for testing. Any work performed by the Contractor prior to the required testing will be performed at the Contractor's own risk. Any rectifications will be performed and paid for by the Contractor.

3.09 PROTECTION OF FINISHED WORK

- A. During the suspension of the work at night or other times, suitable stoppers shall be placed in the end pipes to prevent materials from entering the pipe.
- B. No sand, mud, mortar, concrete, or other materials shall be allowed on the inside of the sewer pipe. Upon completion, the sewer pipe shall substantially show a full circle of light between ends, and shall be left straight, clean, smooth, and acceptable in every respect. Concrete shall be allowed to set before backfilling or walking overtop the pipe is allowed, and the greatest care shall be taken not to disturb the pipe bedding and joints.

END OF SECTION 33 3000

SECTION 33 4100 - SITE STORM SEWERAGE SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Pipe and fittings, structures, wye connections, and bedding for storm sewer lines.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Bedding: Aggregate placed under, beside, or directly over pipe.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Erosion and Sediment Control Plan prepared by Civil & Environmental Consultants, Inc.
- D. Section 31 2333 – Trenching.
- E. Section 32 1000 – Aggregate Materials.
- F. Section 32 1300 – Site Work Concrete Construction.

1.04 REFERENCES

- A. AASHTO M252 – Standard Specifications for Corrugated Polyethylene Drainage Pipe.
- B. ASTM 3212 – Standard Specification for Joints for Drain and Sewer Plastic Pipes Using Flexible Elastomeric Seals.
- C. ASTM D2564 – Standard Specifications for Solvent Cements for Poly Vinyl Chloride (PVC) Plastic Piping Systems Fittings.
- D. ASTM D2729 – Standards Specification for PVC Sewer Pipe and Fittings.
- E. ASTM F477 – Standard Specification for Elastomeric Seals (Gaskets) for Joint Plastic Pipe.
- F. ASTM C76/AASHTO M170 – Standard Specification for Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe.
- G. ASTM C443 – Standard Specification for Joints for Concrete Pipe and Manholes, Using Rubber Gaskets.

- H. Standard Specification for Stormwater Oil and Sediment Separator for water quality treatment device. Refer to Rinker Materials website technical information.
- I. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Standards for Roadway Construction, Series RC 0 – 100.
- J. PennDOT Specifications Publication 408, latest edition.
- K. PennDOT Publication 203 – Work Zone Traffic Control.
- L. Local Health Department Plumbing Code.

1.05 SUBMITTALS

- A. Submit shop drawings for piping, outlet structures, water quality items, valves, and all other stormwater appurtenances for review and approval prior to construction.
- B. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.
- C. Manufacturer's Installation Instructions: Indicate special procedures required to install approved products.
- D. The Contractor is responsible for selecting the supplier(s) of the piping, appurtenances, and imported bedding materials and providing the name(s) of the supplier(s) to the Owner or his representative prior to the commencement of construction. The Owner or his representative may request information about the supplier(s), and the Owner holds the right to direct the Contractor to use a supplier of the Owner's choice. If the Contractor chooses to change the supplier, he must first receive approval from the Owner or his representative.
- E. Contractor is responsible for providing copies of all applicable materials certifications and test results for bedding materials to the Owner or his representative prior to installation to demonstrate conformance with referenced standards.

1.06 REGULATORY REQUIREMENTS

- A. Not used.

1.07 COORDINATION

- A. Coordinate the Work with other utility installations and relocations.
- B. Coordinate the Work with the termination of storm sewer roof drainage connections outside the building, connection to the existing storm sewer system, and trenching.

1.08 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of existing and proposed utilities by horizontal dimensions, elevations or inverts, and slope gradients.
- B. PLEASE NOTE: The contractor shall be responsible for documenting and maintaining as-built information which shall be recorded as construction progresses or at the completion of appropriate intervals and shall be responsible for providing as-built drawings to the owner for the purpose of certification to jurisdictional agencies, such as (for example) the township, conservation district, and/or the PADEP. All as-built data shall be collected by, and sealed by, a

Commonwealth of Pennsylvania Professional Land Surveyor whose services are engaged by the contractor at the contractor's cost. The fee for the as-built shall be included in the contractor's submitted project bid amount.

All as-built data (including PDFs and CAD files) shall be provided to the project engineer of record for review and analysis against the approved design plans at time of project completion. If as-built non-conformities are found by the project engineer of record, revisions to the collected as-built data may be required. Once all as-built non-conformities are resolved by the project engineer of record, a final as-built shall be provided to the owner and project engineer of record.

PART 2 - PRODUCTS

2.01 SEWER PIPE MATERIALS

- A. PVC Pipe: PVC pipe, joints, and fittings shall be of the best quality and shall conform to the extra-strength requirements of ASTM Designation D-3034, and/or other requirements of the Plastic Pipe Institute. Provisions must be made for contraction and expansion at each joint. Pipe joints shall be O-ring type "OR" mechanical seal joints. Rubber rings used as joint gaskets may be used with a separate coupling or an integral wall bell and spigot joint. Gasket quality shall meet the requirements of ASTM F477.
- B. Smooth-line Corrugated Polyethylene Pipe (SLCPP) or High Density Polyethylene Pipe (HDPE): SLCPP and HDPE Pipe and fittings for use as storm pipe shall meet the requirements of AASHTO M294 and M252 and ASTM D3212. Pipe shall be installed in accordance with pipe manufacturer's installation "Guidelines for Culvert Storm Drainage Applications." Acceptable manufacturers are Lane Drainage Products, Advanced Drainage Systems, Inc. ADS (N-12), Hancor, Inc. "HI-Q," or approved equal.
- C. Reinforced Concrete Pipe (RCP): ASTM C 76, Class III unless noted otherwise on Drawings.
 - 1. Joint Material: Provide joints to the extent allowable in Part 3 Joints.
 - a. Rubber O-ring Gasket: AASHTO M 198, Type B or ASTM C 443.
 - b. Bitumen or Butyl-Rubber Sealant: ASTM C990.
 - 2. Flared End Sections: ASTM C 76 or, for sections with toe wall, AASHTO M 170.

2.02 PIPE ACCESSORIES

- A. All pipe fittings and accessories shall be as manufactured and furnished by the pipe supplier and have bell and/or spigot configurations identical to that of the pipe. Rye connections shall be Ring-Tite PVC sewer fittings to assure tight durable connections. No PVC saddle wye cut-in connections will be permitted.

2.03 STORM SEWER APPURTENANCES

- A. Storm Sewer Cleanouts: Cleanouts shall be constructed as shown on the details. Cleanout piping shall be of the same material as the downstream storm pipe or PVC with the contractor providing a manufactured coupling or connection for pipes of different materials. Frames and lids shall be provided as specified. Concrete support blocks shall be provided for reinforcement in excess of that available from the soil and backfill.
- B. Storm Sewer Inlets: Storm sewer inlets shall generally consist of concrete top units, inlet boxes, grade adjustment rings, frames, and grates. The storm sewer inlets shall be constructed in accordance with the requirements of Section 605 of PennDOT Specifications Publication 408 and the detail drawings as referenced from the PennDOT Standards for Roadway Construction.

The castings shall be thoroughly cleaned and free from cold shuts, blow holes, and other imperfections. The casting shall be sound, true to form and thickness, cleaned by means of sand blast, and shall be neatly finished. The metal-bearing areas of frames and grates in contact shall be machine-ground to fit in pairs, shall be marked as pairs, and each pair shall be match-marked with notches to insure satisfactory seating. Casting details shall be submitted to the Owner or his representative for approval prior to installation.

A sealant shall be provided between the top concrete section of the storm sewer inlet and the frame. The Contractor shall use a sealant recommended by the casting manufacturer.

- C. Underdrains: The storm sewer inlet underdrains shall consist of perforated PVC pipe that conforms to the requirements of ASTM D2729. Solvent cement used for perforated PVC pipe and fittings shall comply with the requirements of ASTM D2564. The geotextile used to construct the underdrains shall be Class 1 geotextile that satisfies the requirements of PennDOT Specifications Publication 408, Section 735.

2.04 BEDDING MATERIALS

- A. Bedding Material: AASHTO No. 57 crushed aggregate conforming to the material requirements of Section 32 1000.

2.05 SOURCE QUALITY CONTROL

- A. Perform laboratory tests of bedding material samples to determine the relative density and grain-size distribution of each sample in accordance with ASTM D4253 and ASTM D4254, and ASTM D422, respectively.
- B. Visually observe bedding materials to verify they meet the project description.
- C. If tests indicate materials do not meet specified requirements, change materials and retest at no cost to the Owner, and/or change placement and compaction methods.
- D. Verify that manufacturer certifications are provided with all products.

2.06 DELIVERY, STORAGE AND HANDLING

- A. Deliver, store, protect, and handle products in accordance with the manufacturer's instructions.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify that survey benchmarks and intended elevations are as indicated on the drawings.
- B. Verify that the roof drainage connections and existing storm sewer pipe sizes, locations and inverts are as shown on the drawings.
- C. Verify that the utility trenches are in conformance with the drawings.
- D. Verify the excavations for inlets and manholes are correct.

3.02 PREPARATION

- A. Excavate pipe trenches in accordance with Section 31 2333. Hand trim excavations for accurate placement of pipe to required elevations.
- B. Remove large stones or other hard matter, which could damage piping or impede consistent backfilling or compaction.

3.03 BEDDING

- A. Place bedding material at the bottom of the excavations made for the storm sewer inlets and piping. Place the material in continuous loose layers not exceeding 6 inches thick. Compact bedding material to a minimum of 75 percent of its relative density. Refer to construction details for minimum bedding thicknesses under structures and pipes.

3.04 INSTALLATION - PIPE

- A. No pipe shall be placed unless a suitable outlet is provided. Pipe laying shall begin at the downstream end.
- B. Install pipe, fittings, and accessories in accordance with manufacturer's instructions. In general, the following procedures should be observed for installation of storm gravity pipe:
 - 1. Inspect the bell interior to make sure that there is no foreign matter in the ring groove. Remove any accumulations of dirt, mud, etc. by washing with soap and water, if necessary. Spigot should be thoroughly clean.
 - 2. Set ring in groove, insuring that the marked edge is toward the outside.
 - 3. Liberally apply lubricant to the spigot end of the pipe. Do not use lubricant other than that furnished with the pipe.
 - 4. After aligning the spigot with the bell, push spigot of pipe through gasket to a point where the stop mark stripe on the spigot is just flush with the face of the bell.
- C. The pipe shall be uniformly supported throughout its entire length by the bedding material.
- D. Accurately place pipe to line and grade.
- E. Establish elevations of buried piping to ensure that not less than 2 feet of cover, as measured from the top of the pipe to the final ground surface, is provided.
- F. All pipe entering structures (e.g., outfall structure, catch basins, etc.) shall be cut flush with the inside face of the structure, and the cut ends of the pipe and surface of the structure shall be properly rounded and finished so that there will be no protrusion, ragged edges, or imperfections that will impede the flow of water or affect the hydraulic characteristics of the installation.
- G. Backfill around sides and to a minimum depth of 1-foot above the top of the pipe with the bedding material. Compact the bedding material to at least 75 percent of its relative density.
- H. Backfill trench in accordance with Section 31 2333. Do not displace or damage pipe when compacting. Contractor shall mound, where necessary, fill material over installed pipe to maintain minimum depths of cover during construction and prior to pavement installation.

3.05 INSTALLATION - PIPE ACCESSORIES

- A. Form bottom of excavation clean and smooth to the correct elevation.

- B. Place bedding material as previously specified.
- C. Install cleanouts, connections and elbows in accordance with manufacturer's specifications.

3.06 INSTALLATION - STORM SEWER APPURTENANCES

- A. Form bottom of excavation clean and smooth to the correct elevation.
- B. Place bedding material as previously specified.
- C. No concrete or masonry shall be placed when the temperature is below 40 degrees Fahrenheit, or when indications are for lower temperatures within 24 hours, unless protection of concrete and masonry is provided by the Contractor. The Contractor shall take measures to prevent concrete and masonry from being exposed to freezing temperatures for a period of not less than five days after installation. Approval of the method of protection by the Owner or his representative shall not relieve the Contractor of his responsibility to protect the masonry from freezing, and any damage to the structure because of freezing. Any damage to the structure because of freezing shall be corrected by the Contractor at his own expense.

3.07 SERVICE CONNECTIONS

- A. See architectural drawings for locations of downspout and other building connections.

3.08 TOLERANCES

- A. All pipes shall be accurately laid to the lines and grades shown on the drawings. Allowable tolerances shall be 1/4-inch on grade and 1-inch on line in any section of pipe between structures, except that the allowable tolerance shall be 1/8-inch on grades of 2.0 percent or less. Deviations from these tolerances shall be a basis for rejection of the line of pipe. Any line, which has been rejected, shall be rebuilt to the correct line and grade by the Contractor at his own expense.

3.09 FIELD QUALITY CONTROL

- A. The Owner or his representative shall inspect the installations of pipes, wye connections, cleanouts, inlets, etc., prior to and immediately after placing bedding material cover.
- B. The Owner or his representative shall visually observe the placement of bedding materials to verify that lift thicknesses and final bedding dimensions comply with the specified requirements.
- C. Compaction testing will be performed in accordance with ASTM D2216, ASTM D2922, and/or ASTM D3017.
- D. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.
- E. Frequency of Tests: Perform compaction testing at a rate of one test per lift per 40 lineal feet of bedding placed, or portion thereof or as required by the Owner or his representative.

3.10 PROTECTION OF FINISHED WORK

- A. During the suspension of the work at night or other times, suitable stoppers shall be placed in the end pipes to prevent materials from entering the pipe.

- B. No sand, mud, mortar, concrete, or other materials shall be allowed on the inside of the sewer pipe. Upon completion, the sewer pipe shall substantially show a full circle of light between catch basins and shall be left straight, clean, smooth, and acceptable in every respect. Concrete shall be allowed to set before backfilling or walking overtop the pipe is allowed, and the greatest care shall be taken not to disturb the pipe bedding and joints.
- C. Protect pipe and cover material from damage or displacement until backfilling operation is in progress.

END OF SECTION 33 4100

SECTION 33 4913 - MANHOLES AND COVERS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Modular precast concrete manhole sections with tongue-and-groove joints and masonry transition to lid.
 - 2. Frames, covers, anchorages, and accessories.
 - 3. Placing manholes and appurtenances.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. Not used.

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) all updates.
- B. Geotechnical Report and all updates.
- C. Approved Erosion and Sedimentation Control Plan prepared by CEC.
- D. Section 31 2300 – Excavation, Backfilling, and Compaction.
- E. Section 32 1000 – Aggregate Materials.
- F. Section 32 1216 – Pavements and Surfacing.
- G. Section 33 3000 – Site Sanitary Sewerage System.
- H. Section 33 4100 – Site Storm Sewerage System.

1.04 REFERENCES

- A. ASTM A48 – Standard Specification for Gray Iron Castings.
- B. ASTM C478 – Standard Specification for Precast Reinforced Concrete Manhole Sections.
- C. ASTM C923 – Standard Specification for Resilient Connectors Between Reinforced Concrete Manhole Structures, Pipes, and Laterals.

- D. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Specifications (Publication 408, latest edition).

1.05 SUBMITTALS

- A. The Contractor will be responsible for selecting the supplier of the precast concrete manhole sections and providing the name of the supplier to the Owner or his representative prior to construction activities. The Owner or his representative may request information about the supplier and holds the right to direct the Contractor to use a supplier of the Owner's choice. Shop drawings must be submitted for review and approval of the Owner.
- B. Manufacturer's Installation Instructions: Indicate several procedures required to install manhole and accessories.
- C. Manufacturer's Certificate: Certify that products meet or exceed specified requirements.

1.06 REGULATORY REQUIREMENTS

- A. Not used.

1.07 COORDINATION

- A. Coordinate the work with other construction disciplines and utility connections.

1.08 PROJECT RECORD DOCUMENTS

- A. Accurately record actual locations of manholes, rim elevations, and all invert elevations.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Manhole Sections: Reinforced precast concrete in accordance with ASTM C478 with minimum compressive strength of 4,000 psi.
- B. The manholes shall be constructed in accordance with the requirements of Section 605 of PennDOT Specifications Publication 408 as referenced from the PennDOT Standards for Roadway Construction.

2.02 ACCESSORIES

- A. Frame and Cover: ASTM A48, Class 30B Cast Iron construction, machined flat bearing surface, removable lid. Lid shall have "Storm" identified on it.
- B. Manhole frame and cover shall provide a 27-inch diameter clear opening.
- C. Gaskets: Rubber gaskets in accordance with ASTM C923 at each joint.

2.03 FOUNDATION MATERIALS

- A. Foundation Aggregate: AASHTO No. 57 crushed stone conforming to Section 321000 of these specifications.

PART 3 - EXECUTION

3.01 EXAMINATION

- A. Verify items provided by other sections of Work are properly sized and located.
- B. Verify that built-in items are properly installed and located, and ready for roughing into Work.
- C. Verify that the excavation for the manhole is correct.
- D. Verify that the foundation consists of a minimum of a 4-inch thick compacted layer of AASHTO No. 57 crushed stone.

3.02 PREPARATION

- A. Verify location of structures with construction drawings.
- B. Coordinate placement of inlet and outlet pipe or boot sleeves with location of other manholes and structures.

3.03 PLACING MANHOLE SECTIONS

- A. Place manhole sections plumb and level on the foundation material. Trim to correct elevations.
- B. Set frames and covers level without tipping, to correct elevations in unpaved areas. In paved areas use adjustment rings and cement mortar to adjust manhole rim casting to finished grade elevation and slope to match finished pavement grade in paved areas.

END OF SECTION 33 4913

SECTION 33 5113 - GAS DISTRIBUTION PIPING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Gas distribution piping and related components outside the building for gas service.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.
- C. All Contractors, Subcontractors, Vendors, and the like shall be required to familiarize themselves with said provisions.

1.02 DEFINITIONS

- A. PE: Polyethylene

1.03 RELATED DRAWINGS, DOCUMENTS, AND SECTIONS

- A. Civil Drawing Package prepared by Civil & Environmental Consultants, Inc. (CEC) and all updates.
- B. Geotechnical Report and all updates.
- C. Approved Erosion and Sedimentation Control Plan prepared by CEC.
- D. Section 31 2333 – Trenching
- E. Section 32 1000 – Aggregate Materials

1.04 REFERENCES

- A. Commonwealth of Pennsylvania Department of Environmental Protection (PADEP) Erosion and Sedimentation Control Manual, latest edition.
- B. ASTM D698 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort.
- C. ASTM D1556 – Standard Test Method for Density and Unit Weight of Soil in Place by the Sand Cone Method.
- D. ASTM D2216 – Standard Test Method for Laboratory Determination of Water and Rock by Mass.
- E. ASTM D2922 – Standard Test Methods for Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth).
- F. ASTM D3017 – Standard Test Method for Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth).

- G. ASTM D4253 – Standard Test Methods for Maximum Index Density and Unit Weight and Unit Weight of Soils Using a Vibratory Table.
- H. ASTM D4254 – Standard Test Methods for Minimum Index Density and Unit Weight of Soils and Calculation of Relative Density.
- I. ASTM D2513 – Standard Specification for Polyethylene (PE) Gas Pressure Pipe and Fittings.
- J. AWWA C600 – Installation of Ductile Iron Mains and Appurtenances.
- K. AWWA M44 – Distribution Valves: Selection, Installation, Field Testing, and Maintenance.
- L. Commonwealth of Pennsylvania Department of Transportation (PennDOT) Construction Specifications Publication 408, latest edition.
- M. PennDOT Temporary Traffic Control Guidelines Publication 213, latest edition.
- N. Public Utility Company codes and regulations.

1.05 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Manufacturers Installation Instructions: Indicate special procedures required to install approved products.
- C. Field quality-control test reports.

1.06 REGULATORY REQUIREMENTS

- A. The work of sheeting, shoring, and bracing is the responsibility of the Contractor and shall at all times be in conformance with the latest requirements for construction standard for excavations (29 CFR Part 1926.650-.652 Subpart P) promulgated by OSHA.
- B. The Contractor shall notify individual utilities of intent to commence construction around existing utility lines. Contractors shall call 1-800-242-1776 (PA One-Call) a minimum of three and no more than ten working days prior to the start of work.

1.07 COORDINATION

- A. Coordinate connection to existing gas lines with the Gas Company.
- B. Coordinate gas line installation with other utility installations and relocations.
- C. Coordinate the work with the termination of gas line connections outside the building, connections to existing gas lines, and trenching.
- D. Coordinate with the inspection of and testing of all new gas lines with the Gas Company.

1.08 PROJECT RECORD DOCUMENTS

- A. Not used.

PART 2 - PRODUCTS

2.01 GAS LINE PIPE MATERIALS, FITTINGS, AND APPURTENANCES

- A. PE Pipe: All PE gas pipe, joints, and fittings shall satisfy the requirements of Gas Company. As a minimum, all PE pipe and fittings shall be thermoplastic gas pressure pipe and fittings that satisfy the requirements of ASTM D2513. All joints shall be mechanical or compression fit, or fusion welded.

2.02 GAS VALVES

- A. Gas Valves shall be in accordance with Gas Company construction and materials specifications.

2.03 GAS METERS

- A. Gas meters will be furnished by the Gas Company.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

- A. General: Use pipe, fittings, and joining methods for piping systems according to the following applications.
- B. Transition couplings and special fittings with pressure ratings at least equal to piping pressure rating may be used, unless otherwise indicated.
- C. Do not use flanges or unions for underground piping.
- D. Flanges, unions, grooved-end-pipe couplings, and special fittings may be used, instead of joints indicated, on aboveground piping and piping in vaults.

3.02 PIPING INSTALLATION

- A. Install pipe, joints, and fittings in accordance with the manufacturer's instructions and Gas Company requirements. The gas service line shall consist of one continuous length of pipe between the curb stop and the meter riser or point of connection, unless otherwise approved by Gas Company. The Contractor shall provide excess piping to allow for proper testing and connection of the gas service line.
- B. Maintain separation of gas lines from other utilities in accordance with the requirements of Gas Company and other utilities.
- C. Place pipe on minimum 6-inch deep bed of bedding material. The pipe shall be uniformly supported throughout its entire length by the bedding material. Pipe shall not be installed on wet, frozen, soft, or yielding surfaces. In no case will the supporting of pipes on blocks or earth mounds be permitted.
- D. Install pipe to elevations determined in the field by the Contractor and approved by the Owner or his representative.
- E. Route pipe in a straight line.
- F. Install pipe to allow for expansion and contraction without stressing pipe or joints.

- G. Bury piping with depth of cover over top at least 1.5 feet.
- H. Install piping by tunneling or jacking, or combination of both, under streets and other obstructions that cannot be disturbed.
- I. Carefully examine each length of pipe before laying and do not lay defective pipe.
- J. Install trace wire and early warning detection tape continuously over top of pipe.
- K. During suspension of work at night or other times, suitable stoppers shall be placed in the end of conduit to prevent moisture and materials from entering the conduit. All open ends of the conduit shall be sealed with stoppers or bulkheads firmly held in place in a manner acceptable to the Owner. Open ends of unfinished conduit lines shall be securely plugged or closed at the end of each day's work or when the line is left temporarily at any other time.
- L. No sand, mud, mortar, concrete or other materials shall be allowed on the inside of the conduit. Upon completion, the conduit shall substantially show a full circle of light between appurtenances, and shall be left straight, clean, smooth, and acceptable in every respect. Concrete shall be allowed to set before backfilling or walking overtop the conduit is allowed, and the greatest care shall be taken not to disturb the conduit bedding and joints.

3.03 VALVE INSTALLATION

- A. Comply with AWWA C600 and AWWA M44. Install each underground valve on solid bearing with stem pointing up and with valve box. Center and plumb valve box over valve. Set box cover flush with finished grade. Prevent shock or stress from being transmitted through valve box to valve.
- B. Paint valves and valve boxes with red anti-rust primes and one coat of epoxy paint.

3.04 GAS METER INSTALLATION

- A. Gas Company will be responsible for sizing, furnishing, and connecting the gas meters.

3.05 CONNECTIONS

- A. The Contractor shall coordinate his work with the Building Contractor. The Contractor is responsible for installing the gas service lines to within 5 feet of the building. However, the Contractor shall provide excess piping to allow for proper testing and connection. The Contractor shall include the cost of any excess piping with his bid for installing the gas lines. Refer to the architectural drawings for the exact location where the gas service line will pass through the building. If the gas service line is installed prior to completion of the plumbing by the Building Contractor, a suitable stopper shall be placed in the last pipe to prevent material from entering the pipe. The stopper location shall be adequately staked and flagged for future location.

3.06 FIELD QUALITY CONTROL

- A. The gas lines, trenches, and bedding and backfill materials shall be inspected by Gas Company before backfilling commences. The Contractor is responsible for coordinating the inspection with Gas Company. All gas lines and appurtenances shall be pressure tested in accordance with the manufacturer's recommendations and/or the requirements of Gas Company. Repairs to gas lines and appurtenances not meeting pressure test criteria shall be by, and at the expense of, the Contractor, and shall conform to the manufacturer's specifications and Gas Company's requirements. If the test is conducted after backfilling, rectifications shall include re-excavation and backfill after repairs and/or replacement. All costs of testing, including materials, labor, and supervision, shall be borne by the Contractor.

- B. The Contractor shall give proper notification to Gas Company to allow sufficient time for testing. Any work performed by the Contractor prior to the required testing will be performed at the Contractor's own risk. Any rectifications will be performed and paid for by the Contractor.
- C. Prepare reports of testing activities.
- D. If tests indicate work does not meet specified requirements, remove work, replace, and retest at no cost to Owner.
- E. Protect pipe and cover material from damage or displacement until backfilling operation is in progress.

3.07 IDENTIFICATION

- A. Install continuous underground detectable warning tape during backfilling of trench for underground gas-distribution piping. Locate below finished grade, directly over piping.

END OF SECTION 33 5113

SECTION 32 9119 - LANDSCAPE GRADING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Final grade topsoil for finish landscaping.
- B. Related Sections:
 - 1. Section 31 2213 - Rough Grading: Site contouring.
 - 2. Section 31 2316.13 - Trenching: Backfilling trenches.
 - 3. Section 31 2323 - Fill: Backfilling at building areas.
 - 4. Section 32 0513 - Soils for Exterior Improvements.
 - 5. Section 32 9219 - Seeding and Soil Supplements: Finish ground cover.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Topsoil:
 - 1. Basis of Measurement: By square yard.
 - 2. Basis of Payment: Includes excavating existing topsoil, supplying topsoil materials, stockpiling, preparing and scarifying substrate surface, placing where required, and rolling.

1.3 SUBMITTALS

- A. Section 01 3300 - Submittal Procedures: Submittal procedures
- B. Materials Source: Submit name of imported materials source.
- C. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.4 QUALITY ASSURANCE

- A. Furnish each topsoil material from single source throughout the Work.
- B. Perform Work in accordance with relevant Federal, State, County, and Municipal standards.

PART 2 - PRODUCTS

2.1 MATERIAL

- A. Topsoil: As specified in Section 31 0513.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 01 7300 - Execution Requirements: Verification of existing conditions before starting work.
- B. Verify building and trench backfilling have been inspected.
- C. Verify substrate base has been contoured and compacted.

3.2 PREPARATION

- A. Protect landscaping and other features remaining as final Work.
- B. Protect existing structures, fences, sidewalks, utilities, paving, and curbs.

3.3 SUBSTRATE PREPARATION

- A. Eliminate uneven areas and low spots.
- B. Remove debris, roots, branches, stones, in excess of 2 inch in size. Remove contaminated subsoil.
- C. Scarify surface to depth of 6 inches where topsoil is scheduled. Scarify in areas where equipment used for hauling and spreading topsoil has compacted subsoil.

3.4 PLACING TOPSOIL

- A. Place topsoil in areas where seeding is required. Place topsoil during dry weather.
- B. Fine grade topsoil to eliminate rough or low areas. Maintain profiles and contour of subgrade.
- C. Remove roots, weeds, rocks, and foreign material while spreading.
- D. Manually spread topsoil close to plant material, structures, and other site features to prevent damage.
- E. Lightly compact placed topsoil.
- F. Leave stockpile area and site clean and raked, ready to receive landscaping.
- G. Leave stockpile area and site clean and raked, ready to receive landscaping.

3.5 TOLERANCES

- A. Section 01 4000 - Quality Requirements: Tolerances.
- B. Top of Topsoil: Plus, or minus 1/2 inch.

3.6 PROTECTION OF INSTALLED WORK

- A. Section 01 7300 - Execution Requirements: Requirements for protecting finished Work.
- B. Prohibit construction traffic over topsoil.

END OF SECTION 32 9119

SECTION 32 9219 - SEEDING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Fertilizing.
 - 2. Seeding.
 - 3. Mulching.
 - 4. Maintenance.
- B. Related Sections:
 - 1. Section 31 2213 - Rough Grading: Rough grading of site.
 - 2. Section 31 2316.13 - Trenching: Rough grading over cut.
 - 3. Section 32 0513 - Soils for Exterior Improvements: Topsoil material.
 - 4. Section 32 9113 - Soil Preparation
 - 5. Section 32 9119 - Landscape Grading: Preparation of subsoil and placement of topsoil in preparation for the Work of this section.

1.2 UNIT PRICE - MEASUREMENT AND PAYMENT

- A. Grassed Areas:
 - 1. Basis of Measurement: By square yard.
 - 2. Basis of Payment: Includes seeding, watering and maintenance to specified time limit.

1.3 REFERENCES

- A. ASTM International:
 - 1. ASTM C602 - Standard Specification for Agricultural Liming Materials.

1.4 DEFINITIONS

- A. Weeds: Vegetative species other than specified species to be established in given area.

1.5 SUBMITTALS

- A. Product Data: Submit data for seed mix, fertilizer, mulch, and other accessories.
- B. Manufacturer's Certificate: Certify products meet or exceed specified requirements.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: Include maintenance instructions, cutting method and maximum grass height; along with types, application frequency, and recommended coverage of fertilizer.

1.7 QUALITY ASSURANCE

- A. Provide seed mixture in containers showing percentage of seed mix, germination percentage, inert matter percentage, weed percentage, year of production, net weight, date of packaging, and location of packaging.
- B. Perform Work according to Pennsylvania Department of Environmental Protection standards.

1.8 QUALIFICATIONS

- A. Seed Supplier: Company specializing in manufacturing Products specified in this section with minimum three years documented experience.
- B. Installer: Company specializing in performing work of this section with minimum three years documented experience.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver grass seed mixture in sealed containers. Seed in damaged packaging is not acceptable.
- B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.

1.10 MAINTENANCE SERVICE

- A. Maintain seeded areas immediately after placement until grass is well established and exhibits vigorous growing condition.

PART 2 - PRODUCTS

2.1 SEED MIXTURE

- A. Description:
 - 1. See Seeding Schedule on Construction Drawings.

2.2 ACCESSORIES

- A. Mulching Material: Oat or wheat straw, free from weeds, foreign matter detrimental to plant life, and dry. Hay is acceptable.
- B. Fertilizer: Commercial grade; recommended for grass; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis.
- C. Lime: ASTM C602, Class T agricultural limestone containing a minimum 80 percent calcium carbonate equivalent.
- D. Water: Clean, fresh and free of substances or matter capable of inhibiting vigorous growth of grass.
- E. Erosion Fabric: Jute matting, open weave.
- F. Stakes: Softwood lumber, chisel pointed.
- G. String: Inorganic fiber.

2.3 SOURCE QUALITY CONTROL

- A. Analyze to ascertain percentage of nitrogen, phosphorus, potash, soluble salt content, organic matter content, and pH value.
- B. Provide recommendation for fertilizer and lime application rates for specified seed mix as result of testing.
- C. Testing is not required when recent tests and certificates are available for imported topsoil. Submit these test results to testing laboratory. Indicate, by test results, information necessary to determine suitability.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Verify existing conditions before starting work.
- B. Verify prepared soil base is ready to receive the Work of this section.

3.2 FERTILIZING

- A. Apply lime at application rate recommended by soil analysis. Work lime into top 6 inches of soil.
- B. Apply fertilizer at application rate recommended by soil analysis.
- C. Apply after smooth raking of topsoil and prior to roller compaction.
- D. Do not apply fertilizer at same time or with same machine used to apply seed.
- E. Mix fertilizer thoroughly into upper 2 inches of topsoil.
- F. Lightly water soil to aid dissipation of fertilizer. Irrigate top level of soil uniformly.

3.3 SEEDING

- A. Apply seed at rate shown in schedule evenly in two intersecting directions. Rake in lightly.
- B. Do not seed areas in excess of that which can be mulched on same day.
- C. Planting Season: See Schedule.
- D. Do not sow immediately following rain, when ground is too dry, or when winds are over 12 mph.
- E. Roll seeded area with roller not exceeding 112 lbs./linear foot.
- F. Immediately following seeding and compacting, apply mulch to thickness of 1/8 inches. Maintain clear of shrubs and trees.
- G. Apply water with fine spray immediately after each area has been mulched. Saturate top 4 inches of soil.

3.4 SEED PROTECTION

- A. Identify seeded areas with stakes and string around area periphery. Set string height to 24 inches. Space stakes at 120 inches.
- B. Cover seeded slopes where grade is 4 inches per foot or greater with erosion fabric. Roll fabric onto slopes without stretching or pulling.
- C. Lay fabric smoothly on surface, bury top end of each section in 6 inch deep excavated topsoil trench. Overlap edges and ends of adjacent rolls minimum 12 inches. Backfill trench and rake smooth, level with adjacent soil.
- D. Secure outside edges and overlaps at 36 inch intervals with stakes.
- E. Lightly dress slopes with topsoil to ensure close contact between fabric and soil.
- F. At sides of ditches, lay fabric laps in direction of water flow. Lap ends and edges minimum 6 inches.

3.5 MAINTENANCE

- A. Mow grass at regular intervals to maintain at maximum height of 2-1/2 inches. Do not cut more than 1/3 of grass blade at each mowing. Perform first mowing when seedlings are 40 percent higher than desired height.
- B. Neatly trim edges and hand clip where necessary.
- C. Immediately remove clippings after mowing and trimming. Do not let clippings lay in clumps.
- D. Water to prevent grass and soil from drying out.
- E. Roll surface to remove minor depressions or irregularities.
- F. Control growth of weeds. Apply herbicides. Remedy damage resulting from improper use of herbicides.
- G. Immediately reseed areas showing bare spots.
- H. Repair washouts or gullies.
- I. Protect seeded areas with warning signs during maintenance period.

3.6 SCHEDULE

- A. See Construction Drawings.

END OF SECTION 32 9219

SECTION 32 9300 – PLANTS AND PLANTING

PART 1 - GENERAL

1.1 SUMMARY

- A. Section Includes:
 - 1. Preparation of subsoil and topsoil.
 - 2. Topsoil bedding.
 - 3. Trees, plants, and ground cover.
 - 4. Mulch.
 - 5. Fertilizer.
 - 6. Pruning.
 - 7. Maintenance.
- B. Related Sections:
 - 1. Section 31 2323 - Fill: Rough grading of site.
 - 2. Section 31 0513 - Soils for Exterior Improvements: Topsoil material.
 - 3. Section 32 9119 - Landscape Grading: Preparation of subsoil and placement of topsoil in preparation for the Work of this section.
 - 4. Section 32 9219 - Seeding and Soil Supplements.

1.2 REFERENCES

- A. American National Standards Institute:
 - 1. ANSI A300 - Tree Care Operations - Tree, Shrub and Other Woody Plant Maintenance - Standard Practices.
 - 2. ANSI Z60.1 - Nursery Stock.
- B. Forest Stewardship Council:
 - 1. FSC Guidelines - Forest Stewardship Council Guidelines.

1.3 DEFINITIONS

- A. Weeds: Vegetative species other than specified species to be established in given area.
- B. Plants: Living trees, plants, and ground cover specified in this Section, and described in ANSI Z60.1.

1.4 SUBMITTALS

- A. Section 01 3300 - Submittal Procedures: Requirements for submittals.
- B. Product Data: Submit list of plant material sources, data for fertilizer and other accessories.
- C. Submit typewritten instructions recommending procedures to be established by Owner for continued maintenance after contract work is complete for one full year, including watering requirements, fertilizing, pruning, etc. Submit prior to expiration of required maintenance period(s).

1.5 CLOSEOUT SUBMITTALS

- A. Section 01 7700 - Closeout Requirements: Requirements for submittals.
- B. Operation and Maintenance Data: Include pruning objectives, types and methods; types, application frequency, and recommended coverage of fertilizer.

1.6 QUALITY ASSURANCE

- A. Tree Pruning: ANSI A300 Pruning Standards for Woody Plants.
- B. Perform Work according to Municipality standards.
- C. If specified landscape material is not obtainable, submit proof of non-availability to Owner's Representative, together with proposal for use of equivalent material in character and value.
- D. Provide trees and shrubs of size shown or specified. Trees and shrubs of larger size may be used with approval of the Owner's Representative. Undersized plants are unacceptable.

1.7 QUALIFICATIONS

- A. Nursery: Company specializing in growing and cultivating plants with three years documented experience.
- B. Installer: Company specializing in installing and planting plants with three years documented experience.
- C. Maintenance Services: Performed by installer.

1.8 PRE-INSTALLATION MEETINGS

- A. Section 01 3113 – Project Meetings: Pre-installation meeting.
- B. Convene minimum one week prior to commencing work of this section.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Section 01 6100 - Product Requirements: Requirements for transporting, handling, storing, and protecting products.
- B. Deliver fertilizer in waterproof bags showing weight, chemical analysis, and name of manufacturer.
- C. Protect and maintain plant life until planted.
- D. Deliver plant life materials immediately prior to placement. Keep plants moist.
- E. Plant material damaged as a result of delivery, storage or handling will be rejected.
- F. Notify the Owner's Representative of the delivery schedule at least 48 hours in advance so the plants may be inspected upon arrival at the job site. Remove unacceptable plants from the job immediately.

1.10 ENVIRONMENTAL REQUIREMENTS & JOB CONDITIONS

- A. Section 01 6100 - Product Requirements: Environmental conditions affecting products on site.
- B. Do not install plant life when ambient temperatures may drop below 35 degrees F or rise above 90 degrees F.
- C. Do not install plant life when wind velocity exceeds 30 mph.
- D. Utilities: Determine location of underground utilities and perform work in a manner which will avoid possible damage. Hand excavate, as required. Stake utility locations prior to staking of trees. Trees may have to be shifted because of utility conflict. Stake trees. Secure Owner's Representative's acceptance of the tree staking prior to tree installation. Contractor to coordinate with Owner's Representative regarding existing subsurface improvements/structures and utilities.
- E. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Owner's Representative before planting.

- F. Optional Tree Guying and Staking: The guying and staking of trees is not required as scope of work items of this contract. At the Contractor's option he/she may elect to install these items without any additional cost to the Owner. Should the Contractor elect to guy and stake trees, methods and materials shall be as herein specified and as shown on the current drawings. Do not wrap trees.

1.11 COORDINATION

- A. Section 01 3113 – Project Coordination: Requirements for coordination.

1.12 WARRANTY

- A. Section 01 7836 - Warranties: Requirements for warranties.
- B. Furnish one year manufacturer warranty for trees, plants, and ground cover.

1.13 MAINTENANCE SERVICE

- A. Section 01 7300 - Closeout Requirements: Requirements for maintenance service.
- B. Maintain plant life for three months after Date of Substantial Completion.
- C. Maintain plant life immediately after placement until plants are well established and exhibit vigorous growing condition. Continue maintenance until termination of warranty period.
- D. Maintenance includes:
 - 1. Cultivation and weeding plant beds and tree pits.
 - 2. Irrigating sufficient to saturate root system.
 - 3. Pruning, including removal of dead or broken branches.
 - 4. Disease control.
 - 5. Maintaining wrapping, guys, turnbuckles, and stakes. Adjust turnbuckles to keep guy wires tight. Repair or replace accessories when required.
 - 6. Replacement of mulch.

PART 2 - PRODUCTS

2.1 TREES, PLANTS, AND GROUND COVER

- A. Planting Stock:
 - 1. Species: According to Standardized Plant Names, official code of American Joint Committee on Horticulture Nomenclature.
 - 2. Identification: Label individual plants or each bundle of plants when tied in bundles.
 - 3. Plants: No. 1 Grade conforming to "American Standard for Nursery Stock" of American Association of Nurserymen (AAN); well-branched, vigorous and balanced root and top growth; free from disease, injurious insects, mechanical wounds, broken branches, decay and other defects.
 - 4. Trees: Furnish with reasonably straight trunks, well balanced tops, and single leader.
 - 5. Deciduous plants: Furnish in dormant state, except those specified as container grown.
- B. Trees, Plants and Ground Cover: Species and size identifiable in plant schedule, grown in climatic conditions similar to those in locality of the Work.

2.2 SOIL MATERIALS

- A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, taken from drained site; free of subsoil, clay or impurities, plants, weeds and roots; minimum pH value of 5.4 and maximum 7.0; organic matter to exceed 1.5%, magnesium to exceed 100 units; phosphorus to exceed 150 units; potassium to exceed 120 units; soluble salts/conductivity not to exceed 900 ppm/0.9 mmhos/cm in soil.

2.3 SOIL AMENDMENT MATERIALS

- A. When soil tests indicate soil amendment, apply soil conditioners or fertilizers to amend soil to specified conditions.
 - 1. Tree Fertilizer: Containing fifty percent of elements derived from organic sources; of proportion necessary to eliminate deficiencies of topsoil, as indicated in analysis.
- B. Peat Moss: Shredded, loose, sphagnum moss; free of lumps, roots, inorganic material or acidic materials; minimum of 85 percent organic material measured by oven dry weight, pH range of 4 to 5; moisture content of 30 percent.
- C. Lime: Ground limestone, dolomite type, minimum 95 percent carbonates.
- D. Water: Clean, fresh, and free of substances or matter capable of inhibiting vigorous growth of plants.

2.4 MULCH MATERIALS

- A. Mulching Material: Composted, shredded hardwood bark, dark brown in color.

2.5 ACCESSORIES

- A. Wrapping Materials: Burlap.
- B. Stakes: Softwood lumber, pointed end.
- C. Cable, Wire, Eye Bolts and Turnbuckles: Non-corrosive, of sufficient strength to withstand wind pressure and resulting movement of plant life.
- D. Plant Protectors: Rubber sleeves over cable to protect plant stems, trunks, and branches.

2.6 TOP SOIL MIX

- A. Top Soil Mix: Uniform mixture of 1 part peat and 3 parts topsoil by volume.

2.7 SOURCE QUALITY CONTROL

- A. Section 01 4000 - Quality Requirements: Testing, inspection and analysis requirements.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Section 01 7300 - Execution Requirements: Verification of existing conditions before starting work.
- B. Verify prepared subsoil are ready to receive work.
- C. Saturate soil with water to test drainage.

3.2 PREPARATION OF SUBSOIL

- A. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas.
- B. Remove foreign materials, weeds and undesirable plants and their roots. Remove contaminated subsoil.
- C. Scarify subsoil to depth of 3 inches where plants are to be placed. Repeat cultivation in areas where equipment, used for hauling and spreading topsoil, has compacted subsoil.

- D. Dig pits and beds three times wider than plant root system.

3.3 PLACING TOPSOIL

- A. Spread topsoil to minimum depth of 6 inches over area to be planted. Rake smooth.
- B. Place topsoil during dry weather and on dry unfrozen subgrade.
- C. Remove vegetable matter and foreign non-organic material from topsoil while spreading.
- D. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.
- E. Install topsoil into pits and beds intended for plant root balls, to minimum thickness of 6 inches.

3.4 PLANTING

- A. Place plants for best appearance for review and final orientation by Architect/Engineer.
- B. Set plants vertical.
- C. Remove non-biodegradable root containers.
- D. Set plants in pits or beds, partly filled with prepared plant mix, at minimum depth of 6 inches under each plant. Remove burlap, ropes, and wires, from top half of root ball.
- E. Place bare root plant materials so roots lie in natural position. Backfill soil mixture in 6-inch layers. Maintain plant life in vertical position.
- F. Saturate soil with water when pit or bed is half full of topsoil and again when full.

3.5 PLANT RELOCATION AND RE-PLANTING

- A. None.

3.6 TREE PRUNING

- A. When pruning trees is permitted, lightly prune trees according to ANSI A300 Maintenance Pruning Type: Crown Cleaning.

3.7 FIELD QUALITY CONTROL

- A. Section 01 4000 - Quality Requirements: Field inspecting, testing, adjusting, and balancing.
- B. Plants will be rejected when ball of earth surrounding roots has been disturbed or damaged prior to or during planting.

END OF SECTION 32 9300