



Wold Architects and Engineers
332 Minnesota Street, Suite W2000
Saint Paul, MN 55101
woldae.com | 651 227 7773

Project Manual II

Divisions 21 - 33

HOPKINS CITY HALL REMODEL

CITY OF HOPKINS
182172

Hopkins, MN
November 15, 2018

SECTION 00 01 10

PROJECT MANUAL TABLE OF CONTENTS
Book 2 of 2

<u>Section No.</u>	<u>Title</u>
<u>Division 21</u>	<u>Fire Suppression</u>
21 05 00	Common Work Results for Fire Suppression
21 10 00	Water-Based Fire-Suppression Systems
<u>Division 22</u>	<u>Plumbing</u>
22 05 00	Common Work Results For Plumbing
22 05 19	Meters and Gages For Plumbing Piping
22 05 23	General-Duty Valves For Plumbing Piping
22 05 29	Hangers And Supports For Plumbing Piping and Equipment
22 05 53	Identification For Plumbing Piping and Equipment
22 07 00	Plumbing Insulation
22 11 16	Domestic Water Piping
22 11 19	Domestic Water Piping Specialties
22 13 16	Sanitary Waste And Vent Piping
22 13 19	Sanitary Waste Piping Specialties
22 14 13	Storm Drainage Piping
22 14 23	Storm Drainage Piping Specialties
22 40 00	Plumbing Fixtures
<u>Division 23</u>	<u>Heating, Ventilating and Air Conditioning</u>
23 05 00	Common Work Results For HVAC
23 05 13	Common Motor Requirements For HVAC Equipment
23 05 19	Meters And Gages For HVAC Piping
23 05 23	General-Duty Valves For HVAC Piping
23 05 29	Hangers And Supports For HVAC Piping And Equipment
23 05 53	Identification For HVAC Piping And Equipment
23 05 93	Testing and Balancing
23 07 00	HVAC Insulation
23 09 00	Building Automation System
23 09 50	Variable Frequency Motor Controllers
23 09 93	BAS Sequence of Operations
23 11 23	Natural-Gas Piping
23 21 13	Hydronic Piping
23 21 23	Hydronic Pumps
23 23 00	Refrigerant Piping
23 31 13	Ductwork
23 33 00	Air Duct Accessories
23 34 16	Air Handling
23 36 00	Air Terminal Units
23 37 13	Diffusers, Registers, and Grilles
23 81 24	Split-System Air-Conditioners
23 82 33	Heating Terminal Units
<u>Division 24-25</u>	Not Used
<u>Division 26</u>	<u>Electrical</u>
26 05 00	Common Work Results for Electrical
26 05 19	Electrical Power Conductors and Cables
26 05 26	Grounding and Bonding for Electrical Systems
26 05 29	Hangers and Supports for Electrical Systems
26 05 33	Raceway and Boxes for Electrical Systems

<u>Section No.</u>	<u>Title</u>
<u>Division 26</u>	
26 05 53	<u>Electrical</u> Identification for Electrical Systems
26 09 23	Lighting Control Devices
26 09 43	Network Lighting Controls
26 24 13	Switchboards
26 24 16	Panelboards
26 27 26	Wiring Devices
26 28 13	Fuses
26 28 16	Enclosed Switches and Circuit Breakers
26 29 13	Enclosed Controllers
26 51 19	Interior Lighting
26 56 19	Exterior Lighting
26 72 00	Demolition for Electrical Systems
<u>Division 27</u>	
27 05 00	Common Work Results for Communications
27 11 00	Communications Equipment Room Fittings
27 13 00	Communications Backbone Cabling
27 15 00	Communications Horizontal Cabling
27 40 00	Council Chambers Audio-Visual Systems
27 51 19	Sound Masking Systems
<u>Division 28</u>	
28 05 00	Common Work Results for Electronic Safety and Security
28 05 13	Conductors and Cables for Electronic Safety and Security
28 31 11	Fire-Alarm System
<u>Division 29-30</u>	Not Used
<u>Division 31</u>	
31 00 00	<u>Earth Work</u> Earthwork
31 23 25	Drainage Aggregate
31 25 00	Erosion Control
31 34 19	Geosynthetic Wall Reinforcement
<u>Division 32</u>	
32 12 16	Asphaltic Concrete Paving
32 13 13	Exterior Concrete Work
32 17 23	Pavement Marking
32 32 23	Segmental Retaining Wall
32 38 00	Site Furnishings
32 80 00	Irrigation System
32 92 23	Sodding
32 93 00	Trees and Plants
<u>Division 33-49</u>	Not Used

SECTION 21 05 00

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.

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.

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 plumbing installations.
- B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- C. Coordinate requirements for access panels and doors for plumbing items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 08 Section "Access Doors and Frames."
- D. The fire protection contractor shall coordinate all work and routing with other trades prior to installation of system to ensure proper sequencing of work without delaying or impairing other trades in their performance of work. The fire protection contractor shall schedule work to meet the Project schedule. The fire protection contractor shall remove and reinstall any and all piping and sprinkler heads that are in conflict with other mechanical trades at the fire protection contractor's expense and at no additional cost to the owner.
- E. The fire protection contractor shall coordinate all new and existing areas of work requiring fire protection work with both mechanical and architectural plans. All areas or work shall be provided with new fire protection. In general, the fire protection contractor shall provide a new and/or extend the existing system as required to provide a complete and functioning fire protection system for complete coverage of the entire building including all occupied/unoccupied spaces, storage areas, mechanical rooms, electrical rooms, penthouse equipment rooms, etc.
- F. The fire protection contractor shall avoid all routing of sprinkler mains thru stairwells unless absolutely necessary and prior approved by the architect.
- G. The fire protection contractor shall follow the routing of new and/or existing piping with the space, chases, soffits, etc to avoid any exposed piping or routing conflicts.
- H. The fire protection contractor shall coordinate all routing of mains thru stairwells, clear-stories, open vestibules, etc with the architect prior to installation. If routing is not approved prior to installation the fire protection contractor shall be responsible for all cost related to moving the piping.
- I. The fire protection contractor shall coordinate all routing of exposed mains on finished walls as to route from one

elevation to another due to ceiling heights, structure, etc. The contractor shall clearly document routing on plans and meet with architect on site to verify routing prior to installation. If exposed piping routing is not approved prior to installation the fire protection contractor shall be responsible for all cost related to moving the piping.

- J. The plans do not give exact details as to elevations of lines, exact locations, etc., and do not show all the offsets, control lines, pilot lines and other location details. Carefully lay out work at the site to conform to the Architectural and Structural conditions, to provide proper grading of lines, to avoid all obstructions, to conform to the details of installation supplied by the manufacturers of the equipment to be installed, and thereby to provide an integrated satisfactory operation installation
- K. If a discrepancy is discovered between engineering and architectural Drawings/Specifications, whether with respect to a significant variance between location, new/existing areas of required coverage, variation in quantity, or violation of code requirements, the contractor shall figure the work based on the most stringent requirements to complete the installation and obtain clarification from the Architect before installation.
- L. Sprinkler Contractor to rework the existing sprinkler system as required, add or subtract sprinkler heads and piping to match the new remodeled areas. The new sprinkler work will be installed as per all local and state codes

1.08 INTERPRETATION OF PLANS

- A. In general, the Drawings are to scale. However, to determine exact locations of walls and partitions, the Contractor shall consult the architectural and/or structural Drawings which are dimensioned. Drawings shall not take precedence over field measurements.
- B. Drawings are diagrammatic only. They are intended to indicate size and/or capacity where stipulated, approximate location and/or direction, and approximate general arrangement of one phase of work to another, but not the exact detail of construction. All work shall be constructed from field measurements taken at the site. This shall include all rises, drops and offsets necessary to avoid structural members or equipment and materials installed by other trades. The contractor shall coordinate the ductwork and piping layout before construction. No additional costs will be allowed for piping and ductwork fabrications without field verification of available space. If it is found, before installation, that a more convenient, suitable or workable arrangement of any or all phases of construction would result by altering the arrangement indicated on the Drawings, the architect/engineer may require the contractor to change the arrangement of his work without additional cost to the owner.
- C. The drawings and specifications are intended to supplement each other. Any items shown on the drawings and not mentioned in the specifications, or vice versa, shall be executed the same as if mentioned and shown.
- D. The greatest quantity or more expensive work shall govern where there is a conflict noted anywhere on the drawings and/or specifications.

1.09 COORDINATION DRAWINGS

- A. Review contract documents and prepare coordination model drawings as an informational supplemental submittal in accordance with Division 1, 21, 22, and 23 requirements. Provide drawings of all areas of the project. Architectural models of the building will be made available upon request. Detailed mechanical models will not be made available. Facilitate coordination meetings and revise drawings as required to resolve work conflicts.
- B. The Division 23 contractor will coordinate the preparation of drawings by other trades including steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems. The Division 23 contractor will create composite Model drawings showing the work of all other trades. The Division 23 contractor will facilitate coordination meetings as scheduled and coordinated by the General Contractor or Construction Manger to review potential conflicts and propose specific solutions. Any proposed revisions to the Contract Documents shall be noted on the coordination drawings for review by the Architect and Engineer.

- C. All contractors (including steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems) are required to attend a minimum of (3) three coordination meetings on site to resolve any coordination issues prior to start of construction.
- D. If the coordination drawings are not complete and/or coordinated prior to the work being started no extra cost shall be incurred by the owner due to coordination issue and it shall be the responsibility of the contractors to make the necessary modifications to the system to meet the requirements. All modifications shall be approved by the engineer/architect but at the cost to the contractor.
- E. The composite model drawings of all trades shall detail all structural building elements, mechanical equipment, and work of other trades. Indicate locations where space is limited for installation, access for service, and where sequencing and coordination of installations are of importance to the efficient flow of work. The composite drawings shall include at a minimum the following. Where required for clarity multiple composite drawings may have to be submitted for each area.
 - 1. Clearances for maintaining ceiling heights.
 - 2. Clearances for installation of material and equipment for all trades.
 - 3. Clearances for installing and maintaining insulation.
 - 4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - 5. Equipment connections and support details.
 - 6. Penetrations thru block walls and Pre-cast walls.
 - 7. Exterior wall and foundation penetrations.
 - 8. Fire-rated wall and floor penetrations.
 - 9. Sizes and locations of required concrete pads and bases.
 - 10. Valve stem movement.
 - 11. Dimensional locations of pipe sleeves passing through floor/roof slabs.
 - 12. Locations of wall and ceiling access panels where required for access to mechanical equipment.
 - 13. Reflected ceiling plans to integrate installations of light fixtures, grilles, registers, and diffusers, sprinklers, communication systems, and other ceiling mounted components.
 - 14. Both new and existing structural elements.

1.10 COST BREAKDOWN

- A. Submit a cost breakdown for each claim according to General Conditions of the Contract. Include project name, location, Architect/Engineer, Contractor and date.
 - 1. List the cost breakdown for labor and material separately and include a total.
 - 2. Breakout and detail the cost according to specification sections.

1.11 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1 Section "Project Record Documents." In addition to the requirements specified in Division 1, refer to specific sections for additional record documentation.

1.12 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 Section "Operating, Maintenance, and Warranty Data". Submit copies for review by Architect/Engineer. In addition to the requirements specified in Division 1, include the following information:
 - 1. Descriptive summary of function, normal system 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. Warranty information for all mechanical items shall be included in one tabbed section.

1.13 FIRE SAFETY PRECAUTIONS

- A. The Contractors shall exercise extreme care to maintain and exercise adequate fire safety precautions throughout the work. This shall include providing sufficient fire fighting devices, watchmen, standby helpers or other precautions during construction, in use of temporary heat, welding, brazing, sweating, testing or other phases of work.
- B. At all times, access shall be maintained for fire department trucks to the building.
- C. All welding brazing, cutting and sweating operations performed in vicinity of or accessible to combustible materials shall be adequately protected to make certain that sparks or hot slag does not reach the combustible material and start a fire.
- D. All glass, glazed materials and other finish, in the vicinity of welding, brazing and cutting, shall be masked by the Contractor performing the welding work.
- E. When necessary to do cutting, welding, brazing, sweating and similar work in vicinity of wood, in shafts, or vicinity of any combustible material (and the combustible material cannot be removed), the materials shall be adequately protected with fire resistant blankets or similar approved coverings. In addition, a helper shall be stationed nearby with proper fire extinguishers (provided by the Contractor performing the work) to guard against sparks and fire.
- F. Whenever combustible materials have been exposed to sparks, molten metal, hot slag or splatter, a person shall be kept at the place of work to make sure the smoldering fires have not been started. Whenever cutting or welding operations are carried on in a vertical pipe shaft, a person to act as a fireguard shall be employed to examine all floors below the point of cutting or welding. This fireguard shall be kept on duty after completion of work to guard against fires and shall examine each level after this time, prior to leaving. There shall be no exceptions to this requirement and failure to comply will be construed as negligence.

1.14 PERSONAL SAFETY REQUIREMENTS

- A. The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions required in connection with his work, including regulations of the Occupational Safety and Health Administration (OSHA) and other governing agencies.

PART 2: PRODUCTS

2.01 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.

2.02 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. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAg1, silver alloy for refrigerant piping, unless otherwise indicated.
- F. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.

2.03 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Sealing Elements: EPDM 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. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.04 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.

2.05 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.

2.06 GROUT

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

PART 3: EXECUTION

3.01 FIRE-SUPPRESSION DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove fire-suppression systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 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.
- M. Sleeves are not required for core-drilled holes.
- N. 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 Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - b. 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.
 - 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.
- O. 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.

- P. 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.
- Q. 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.
- R. Verify final equipment locations for roughing-in.
- S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

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. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.04 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.

3.05 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."

3.06 ERECTION OF METAL SUPPORTS AND ANCHORAGES

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

3.07 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

3.08 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 05 00

SECTION 21 10 00

WATER-BASED FIRE SUPPRESSION SYSTEMS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section include the following fire suppression systems inside the building.
 - 1. Wet-pipe sprinkler systems.
- B. Related Sections include the following:
 - 1. Division 21 Section "Clean-Agent Fire Extinguishing Systems" for extinguishing systems.
 - 2. Division 28 Section "Fire Detection and Alarm" for alarm devices not specified in this Section.

1.03 SYSTEM DESCRIPTIONS

- A. 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. Hose connections are included if indicated.
- B. 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.
- C. Preaction Sprinkler System: Automatic sprinklers are attached to piping containing air. Actuation of fire-detection system in same area as sprinklers opens deluge valve, permitting water to flow into piping and to discharge from sprinklers that have opened.

1.04 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 the authorities having jurisdiction.
 - 1. Margin of safety for available water flow and pressure: 10 percent, including losses through water-service piping, valves, and backflow preventors.
 - 2. Refer to drawings for sprinkler occupancy hazard classification.

1.05 SPRINKLER DENSITIES

- A. Densities indicated herein are minimum requirements as set forth by the Owner's insurance company and NFPA. If local requirements mandate other densities, then the greater density requirement shall prevail.
- B. For Light hazard Occupancies the sprinkler system shall be hydraulically designed for .10 GPM per square foot over the most remote 1500 square feet with 100 GPM hose stream allowance.

- C. For Ordinary Hazard Group 1 Occupancies the sprinkler system shall be hydraulically designed for .15 GPM per square foot over the most remote 1500 square feet with 250 GPM hose stream allowance.
- D. For Ordinary Hazard Group 2 Occupancies the sprinkler system shall be hydraulically designed for .20 GPM per square foot over the most remote 1500 square feet with 250 GPM hose stream allowance.
- E. For Extra Hazard Group 1 Occupancies the sprinkler system shall be hydraulically designed for .30 GPM per square foot over the most remote 2500 square feet with 500 GPM hose stream allowance.
- F. For Extra Hazard Group 2 Occupancies the sprinkler system shall be hydraulically designed for .40 GPM per square foot over the most remote 2500 square feet with 500 GPM hose stream allowance.

1.06 HYDRAULIC DESIGN BASIS

- A. Provide system design and hydraulic calculations based on flow test measurements from tests conducted recently at a fire hydrant adjacent to the project site. Contractor shall verify pressure and flow prior to submitting bid.
- B. Contractor to prepare and be responsible for final hydraulic calculations including selection of design criteria and accuracy of water supply information, unless otherwise noted on the drawings or specified herein.
- C. Total demand pressure, including hose steams, to be within available water supply pressure with a minimum safety factor of 10 psig.
- D. The contractor shall provide engineering drawings showing risers, cross mains, branch main spacing, zones and head location and quantity. If more or less heads are required to obtain agency approval, the contract price will not be adjusted. The subtracted or added heads will be considered incidental to the installation.
- E. Provide wet pipe, dry pipe, or preaction type sprinkler systems as indicated on the drawings, complete with fire department connections throughout building.
- F. Methods used and information given on hydraulic calculations shall meet the criteria of NFPA Standard 13, with the following exceptions:
 - 1. Where sprinklers are located above or below the ducts, walkways or other obstructions, all levels of sprinklers to be included in the calculations. This requirement does not refer to sprinklers above and below ceilings.
 - 2. Floor area covered by sprinkler to be determined by using distance between sprinkler and wall, or half the distance between sprinklers, whichever is greater. Distance to be determined in two directions, parallel with branch line and perpendicular to branch line. Multiply longest parallel distance by longest perpendicular distance.
- G. Provide the following coordination with the Architectural Reflected Ceiling Plans:
 - 1. Sprinklers to be Contractor located except where shown on architectural reflected ceiling plans and mechanical drawings.
 - 2. Locations shown on reflected ceiling plans override locations shown on mechanical drawings.
 - 3. All sprinkler heads shall be installed at the quarter points of the ceiling grids and shall line-up in a straight line within the space.
 - 4. Refer to architectural drawings for locations of all fire rated walls and floors.
 - 5. All full height floor to ceiling wardrobe cabinets and storage closets shown on the architectural plans shall be sprinklered.

1.07 SUBMITTALS

- A. Upon substantial completion of the system layout and hydraulic calculations, submit a reproducible drawing and one set of prints and calculations to the Engineer for review prior to completing the submittal. The Engineer will review the system layout and return a print marked to show changes required before the final submittal is made.

- B. The final shop drawing submittal shall be in accordance with the State Building Codes and shall include full size drawings of the complete piping and head layout indicating sprinkler zones, area hazard ratings, piping material, head types and method of hanging, hydraulic calculations for each zone, all product data, and welders certificates. The hydraulic calculations must prove the remote area for each zone. Submit supplemental calculations for all non-typical areas.
- C. Upon completion of the shop drawings, submit to the reviewing agencies for approval. The reviewing authorities may include the following:
 - 1. State Fire Marshal
 - 2. City/Local Fire Marshal
 - 3. Health and Building Department
- D. Submit one set of shop drawings to the Owner's insurance carrier.
- E. Submit seven (7) copies of the shop drawing submittal to the Engineer. Two (2) of the seven (7) copies submitted shall be stamped "approved" by each of the reviewing agencies. "Approved" copies submitted shall include copies of the agencies reviewer comments.
- F. The drawings must be stamped and signed by a Professional Engineer.
- G. Upon substantial completion of the project, submit contract closeout submittals to include two sets of as-builts drawings, operating and maintenance manuals, as-built hydraulic calculations, and "Material and Test Certificates" for above and below ground piping.
- H. As built hydraulic calculations must be submitted to prove remote area criteria is met with all included field modifications.

1.08 QUALITY ASSURANCE

- A. Installer Qualifications: Installation and alterations of fire protection piping, equipment, specialties, and accessories, and repair and servicing of equipment shall be performed only by a qualified installer. The term qualified means experienced in such work (experienced shall mean having a minimum of 5 previous projects similar in size and scope of this project), familiar with all precautions required, and has complied with all the requirements of the authority having jurisdiction. Upon request, submit evidence of such qualifications to the Architect.
- B. Qualifications for Welding Processes and Operators: Comply with the requirements of AWS D10.9, "Specifications for Qualifications of Welding Procedures and Welders for Piping and Tubing, Level AR-3."
- C. Regulatory Requirements: Comply with the requirements of the following codes:
 - 1. State Uniform Fire Code
 - 2. NFPA 13 - Standard for the Installation of Sprinkler Systems.
 - 3. UL and FM Compliance: Fire protection system materials and components shall be Underwriter's Laboratories listed and labeled, and Factory Mutual approved for the application anticipated.
 - 4. International Building Code with State amendments.
 - 5. NFPA 14 – Standpipe Systems

1.09 COORDINATION

- A. Coordinate layout and installation of sprinklers with other construction that penetrates ceilings, including light fixtures, HVAC equipment, and partition assemblies.

1.010 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. The quantity of each type of sprinkler head shall be proportionate to the type installed on the project with no less than 6 of each type. Sprinkler head storage cabinet locations and quantities shall meet the Fire Marshals approval.
 - 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.
 - a. Minimum 6 spare heads
 - b. 300-1000: 12 spare heads
 - c. Greater than 1,000: 24 spare heads

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering fire protection system products which may be incorporated in the work include the following:
 - 1. Listed Fire Protection Valves
 - a. Central Sprinkler Corp.
 - b. Global Safety Products, Inc.
 - c. Milwaukee Valve Company
 - d. NIBCO
 - e. Mueller Company
 - f. Grinnell Fire Protection
 - g. Stockham
 - h. Victaulic Co. of America
 - 2. Check Valves:
 - a. Central Sprinkler Corp.
 - b. Crane Company
 - c. Globe Fire Sprinkler Corp.
 - d. Grinnell Fire Protection
 - e. Hammond Valve
 - f. Mueller Company
 - g. NIBCO
 - h. Potter-Roemer
 - i. Reliable Automatic Sprinkler Company
 - j. Stor Sprinkler Inc.
 - k. Stockham.
 - l. Victaulic Company
 - m. Watts Industries
 - 3. Grooved Mechanical Couplings:
 - a. Victaulic Company of America

- b. Gruvlok
 - c. Star Fittings
 - d. Central Grooved Piping Products
4. Fire Department Connection:
- a. Central Sprinkler Corp.
 - b. Guardian Fire Equipment, Inc.
 - c. Elkhart Brass Manufacturing, Inc.
 - d. Potter Roemer
 - e. Reliable Automatic Sprinkler Company
 - f. United Brass Works, Inc.
5. Sprinkler Heads:
- a. Central Sprinkler Corp.
 - b. Globe Fire Equipment Co.
 - c. Guardian Automatic Sprinkler Co., Inc.
 - d. Reliable Automatic Sprinkler Co., Inc.
 - e. Star Sprinkler Corp.
 - f. Viking Corp.
6. Fire Protection Specialties
- a. ADT Security System, Inc.
 - b. ITT McDonnell and Miller
 - c. Grinnell Corp.
 - d. Potter Electrical Signal Co.
 - e. Viking Corp.
 - f. Watts Industries

2.02 PIPE AND TUBING MATERIALS

- A. General: Refer to Part 3 Article "PIPE APPLICATIONS" for identification of systems where the below specified pipe and fitting materials are used.
- B. Ductile Iron Pipe: AWWA C151
- 1. Mechanical-Joint, Ductile-Iron Pipe: with mechanical-joint bell end and plain end.
 - a. Mechanical-Joint, Ductile-Iron Fittings: AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern]
 - b. Glands, Gaskets, and Bolts: AWWA C111, ductile- or gray-iron gland, rubber gasket, and steel bolts and nuts.
 - 2. Push-on-Joint, Ductile-Iron Pipe: AWWA C151, with push-on-joint bell end and plain end.
 - a. Push-on-Joint, Ductile-Iron Fittings: [AWWA C110, ductile- or gray-iron standard pattern or AWWA C153, ductile-iron compact pattern]
 - b. Gaskets: AWWA C111, rubber.
 - 3. Grooved-End, Ductile-Iron Pipe: AWWA C151, with factory- or field-formed, radius-cut-grooved ends according to AWWA C606.
 - a. Grooved-End Fittings: ASTM A 536, ductile-iron casting with OD matching ductile-iron-pipe OD.

- b. 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, rubber gasket with center leg, and steel bolts and nuts.
 - c. 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 rubber gasket listed for use with housing, and steel bolts and nuts.
- C. Schedule 40 Steel Pipe: ASTM A 53/A 53M, ASTM A 135, or ASTM A 795, hot-dip galvanized where indicated.
- 1. Pipe shall have a minimum wall thickness of 0.109. Pipe with a wall thickness less than 0.109 will not be used.
 - 2. Threaded-end, factory or field-formed.
 - a. Cast-Iron Threaded Flanges: ASME B16.1.
 - b. Malleable-Iron Threaded Fittings: ASME B16.3.
 - c. Gray-Iron Threaded Fittings: ASME B16.4.
 - d. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
 - e. Steel Threaded Couplings: ASTM A 865 hot-dip galvanized-steel pipe where indicated.
 - 3. Plain-end.
 - a. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
 - b. Steel Flanges and Flanged Fittings: ASME B16.5.
 - 4. Grooved-end, factory or field form square-cut or roll formed.
 - a. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
 - b. 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, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.
- D. Threadable Thinwall Steel Pipe: ASTM A135 or ASTM A 795, hot-dip galvanized where indicated.
- 1. Threaded-end, factory or field-formed.
 - a. Cast-Iron Threaded Flanges: ASME B16.1.
 - b. Malleable-Iron Threaded Fittings: ASME B16.3.
 - c. Gray-Iron Threaded Fittings: ASME B16.4.
 - d. Steel Threaded Pipe Nipples: ASTM A 733, made of ASTM A 53/A 53M or ASTM A 106, Schedule 40, seamless steel pipe hot-dip galvanized where indicated. Include ends matching joining method.
 - e. Steel Threaded Couplings: ASTM A 865 hot-dip galvanized-steel pipe where indicated.
 - 2. Plain-end.
 - a. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
 - b. Steel Flanges and Flanged Fittings: ASME B16.5.
 - 3. Grooved-end, factory or field form square-cut or roll formed.
 - a. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
 - b. 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, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

- E. Schedule 10 Steel Pipe (where approved by NFPA, State Fire Marshall and local authorities): ASTM A135 or ASTM 795 in NPS 5 and smaller, and NFPA 13-specified wall thickness in NPS 6 to NPS 10. Hot-dip galvanized where indicated.
 - 1. Plain-end.
 - a. Steel Welding Fittings: ASTM A 234/A 234M, and ASME B16.9 or ASME B16.11.
 - b. Steel Flanges and Flanged Fittings: ASME B16.5.
 - 2. Grooved-end, factory or field form square-cut or roll formed.
 - a. Grooved-End Fittings: UL-listed, ASTM A 536, ductile-iron casting with OD matching steel-pipe OD.
 - b. 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, prelubricated rubber gasket listed for use with housing, and steel bolts and nuts.

2.03 LISTED FIRE-PROTECTION VALVES

- A. Valves shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Valves shall have 250-psig 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, nonrising stem, operating nut, and flanged ends.
 - 2. Indicator Posts: UL 789, horizontal-wall type, cast-iron body, with operating wrench or hand wheel (per local authority), extension rod, locking device, and cast-iron barrel.
- C. Ball Valves: Comply with UL 1091, except with ball instead of disc.
 - 1. NPS 1-1/2 and Smaller: Bronze body with threaded ends.
 - 2. NPS 2 and NPS 2-1/2: Bronze body with threaded ends or ductile-iron body with grooved ends.
 - 3. NPS 3: Ductile-iron body with grooved ends.
- D. Butterfly Valves: UL 1091.
 - 1. NPS 2 and Smaller: Bronze body with threaded ends.
 - 2. NPS 2-1/2 and Larger: Bronze, cast-iron, or ductile-iron body; wafer type or with flanged or grooved ends.
- E. Check Valves NPS 2 and Larger: UL 312, swing type, cast-iron body with flanged or grooved ends.
- F. Gate Valves: UL 262, OS&Y type.
 - 1. NPS 2 and Smaller: Bronze body with threaded ends.
 - 2. NPS 2-1/2 and Larger: Cast-iron body with flanged ends.
- G. Indicating Valves: UL 1091, with integral indicating device and ends matching connecting piping.
 - 1. Indicator: Visual.
 - 2. NPS 2 and Smaller: Ball or butterfly valve with bronze body and threaded ends.
 - 3. NPS 2-1/2 and Larger: Butterfly valve with cast- or ductile-iron body; wafer type or with flanged or grooved ends.

2.04 GENERAL-DUTY VALVES

- A. Ball Valves NPS 2 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 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 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, solid wedge, and threaded ends.
- D. Globe Valves NPS 2 and Smaller: MSS SP-80, Type 2, Class 125 minimum, with bronze body, nonmetallic disc, and threaded ends.

2.05 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 pressure rating if valves are components of high-pressure piping system.
 - 1. 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 gages, and fill-line attachment with strainer.
 - a. Drip Cup Assembly: Pipe drain with check valve to main drain piping.

2.06 SPRINKLERS

- A. Sprinklers shall be UL listed or FMG approved, with 175-psig minimum pressure rating. Sprinklers shall have 250-psig pressure rating if sprinklers are components of high-pressure piping system.
- B. Automatic Sprinklers: With heat-responsive element complying with the following:
 - 1. UL 199, for nonresidential applications.
 - 2. UL 1767, for early-suppression, fast-response applications.
- C. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.
- D. Sprinkler types, features, and options as follows: Provide quick response sprinklers where required by code.
 - 1. Concealed ceiling sprinklers, including cover plate.
 - 2. Institution sprinklers, made with a small, breakaway projection.
 - 3. Pendent, dry-type sprinklers.
 - 4. Recessed sprinklers, including escutcheon.
 - 5. Sidewall sprinklers.
 - 6. Sidewall, dry-type sprinklers.
 - 7. Upright sprinklers.
- E. Sprinkler Finishes: Chrome plated, bronze, and painted.
- F. 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.

- G. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler. The sprinkler head and guard assembly shall be UL listed.

2.07 FIRE DEPARTMENT CONNECTIONS

- A. 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 & STANDPIPE."
 - 1. Type: Flush, with quantity of inlets required and square or rectangular escutcheon plate.
 - 2. Finish: Polished Brass.

2.08 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 inlet and NPS 1 drain connections.
- 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.
- 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.
- 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.
- 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.
- 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.

2.09 PRESSURE GAGES

- A. Description: UL 393, 3-1/2- to 4-1/2-inch- diameter, dial pressure gage with range of 0 to 250 psig.
 - 1. Water System Piping: Include caption "WATER" or "AIR/WATER" on dial face.
 - 2. Air System Piping: Include caption "AIR" or "AIR/WATER" on dial face.

PART 3: EXECUTION

3.01 PREPARATION

- A. Perform fire-hydrant flow test according to NFPA 13, NFPA 14 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 EXAMINATION

- A. Examine rough-in for fire equipment to verify actual locations of piping connections prior to installing.
- B. Do not proceed until unsatisfactory conditions have been corrected.

3.04 PIPE JOINT CONSTRUCTION

- A. Ship 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 above ground applications, unless otherwise indicated.
- D. Underground Service Entrance Piping: Ductile-iron with push-on joint pipe and fittings and restrained joints.
- E. Service Entrance Piping: Ductile-iron with mechanical joint pipe and fittings or grooved end pipe and fittings and restrained joints.
- F. Dry-Pipe-System Fittings: UL listed for dry-pipe service
- G. Standard-pressure, wet pipe sprinkler system, 175 psig maximum working pressure.
 - 1. Non-corrosive areas with exposed piping subject to abuse or vandalism including but not limited to gymnasiums.
 - a. NPS 1 ½” and smaller: Schedule 40 with threaded, welded or grooved ends.
 - b. NPS 2” and larger: Schedule 10 with welded or grooved ends.
 - 2. Corrosive areas with exposed piping subject to abuse or vandalism including but limited to locker rooms and pools.
 - a. NPS 1 ½” and smaller: Schedule 40 with threaded or grooved end.
 - b. NPS 2” and larger: Schedule 10, hot dip galvanized with grooved ends.
 - 3. All other supervised or concealed areas.
 - a. NPS 1 ½” and smaller: Threadable thin wall, with threaded, welded or grooved ends.
 - b. NPS 2” and larger: Schedule 10, with welded or grooved ends.

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 and NFPA 14]
 - 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 and NFPA 14].
 - 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 "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 with wall thickness less than Schedule 40 unless approved by authorities having jurisdiction and threads are checked by a ring gage 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: Square-cut or 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.
- D. Dissimilar-Metal Piping Joints: Construct joints using dielectric fittings compatible with both piping materials.
 1. NPS 2 and Smaller: Use dielectric unions, couplings, or nipples.
 2. NPS 2-1/2 to NPS 4: Use dielectric flanges.
 3. NPS 5 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. Refer to Division 22 Section "Facility Water Distribution Piping" for exterior piping.
- B. Install shutoff valve, check valve, pressure gage, and drain at connection to water service.

3.08 PIPING INSTALLATION

- A. Refer to Division 21 Section "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
- D. Install underground copper service-entrance piping according to NFPA 24.
- 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 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 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 drain valves on standpipes.
- L. Install ball drip valves to drain piping between fire department connections and check valves. Drain to floor drain or outside building.
- M. Install alarm devices in piping systems.
- N. Hangers and Supports: Comply with NFPA 13 for hanger materials.
 - 1. Install standpipe system piping according to NFPA 14.
 - 2. Install sprinkler system piping according to NFPA 13 and minimum spacing below.
 - 3. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Min. Rod Dia. - Inches
Up to ¾"	4	3/8
1" to 2"	6	3/8
2½" to 4"	6	½
5" and Greater	4	7/8

- O. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.
- P. Install pressure gages on riser or feed main, at each sprinkler test connection, and at top of each standpipe. Include pressure gages with connection not less than NPS 1/4 and with soft metal seated globe valve, arranged for draining pipe between gage and valve. Install gages to permit removal, and install where they will not be subject to freezing.
- Q. Fill wet-standpipe system piping with water.
- R. Fill wet-pipe sprinkler system piping with water.

3.09 VALVE INSTALLATION

- A. Install listed fire-protection valves, unlisted general-duty valves, specialty valves and trim, controls, and specialties according to [NFPA 13 and NFPA 14] 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. Valves for Wall-Type Fire Hydrants: Install nonrising-stem gate valve in water-supply pipe.

- D. Install check valve in each water-supply connection. Install backflow preventers instead of check valves in potable-water supply sources.
- 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.

3.10 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: Fully Concealed sprinklers with cover plate.
 - 3. High Profile Rooms and Areas such as but not limited to Court Rooms, Council Chambers, Decorative Lobbies, etc: Conceal sprinklers with cover plate.
 - 4. Wall Mounting: Sidewall sprinklers.
 - 5. Security, Cell, and Jail areas: Provide institutions style quick response flush mount sprinklers.
 - 6. Spaces Subject to Freezing (vestibules, perimeter stair areas, loading docks, etc): concealed, dry sprinklers or sidewall, dry sprinklers.
 - 7. 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.
 - c. Flush Sprinklers: Bright chrome, with painted white escutcheon.
 - d. Recessed Sprinklers: Bright chrome, with bright chrome escutcheon.
- B. Provide sprinkler guards at all heads installed at 7'-0" or less, at all heads located in gymnasiums, multipurpose gym areas, and/or all areas subject to objects being in contact with heads.

3.11 SPRINKLER INSTALLATION

- A. Install sprinklers aligned and within 2" of the center or quarter points of suspended ceilings.
- 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.

3.12 HOSE-CONNECTION INSTALLATION

- A. Install hose connections adjacent to standpipes, unless otherwise indicated.
- B. Install freestanding hose connections for access and minimum passage restriction.
- C. Install NPS 1-1/2 hose-connection valves with flow-restricting device, unless otherwise indicated.
- D. Install NPS 2-1/2 hose connections with quick-disconnect NPS 2-1/2 by NPS 1-1/2 reducer adapter and flow-restricting device, unless otherwise indicated.

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 "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. Fire alarm connections are specified in Division 28.
- G. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- H. 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 and NFPA 14]

3.16 COORDINATION

- A. This Contractor shall notify the Engineer to any points of conflict between his work and that of other trades, so that the conflict may be resolved. Work installed by this Contractor which interferes with the work of other trades shall be removed and reinstalled at this Contractor's expense when so directed by the Engineer or his representative. It shall be understood that no extras to the contract will be permitted to accomplish the above results.

3.17 OPERATION AND INSTRUCTIONS

- A. All valves and riser mains shall be fitted with approved enamel signs indicating use, in accordance with the requirements of the applicable current NFPA and FMIA standards.
- B. Upon completion of the system, this Contractor shall furnish the Owner a Certificate of Approval from the legal authority having jurisdiction, or in lieu thereof, a certified copy of same.
- C. Upon completion and approval of the system, this Contractor shall provide an experienced Engineer to instruct the Owner's operational staff in all details of operating and maintaining the system. The Contractor shall provide four (4) sets of typewritten operation instructions, parts lists and service manuals of all equipment, wiring diagrams, control diagrams and test reports suitably bound.
- D. Provide a small scale plan of the building, indicating the locations of all control valves, low point drains, and inspector's test connections. The plan shall be neatly drawn, framed under glass, and permanently mounted on the wall adjacent to the sprinkler main zone risers.

3.18 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.
 - 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. Flush, test, and inspect standpipe systems according to NFPA 14, "System Acceptance" Chapter.
 - 8. Coordinate with fire alarm tests. Operate as required.
 - 9. Coordinate with fire-pump tests. Operate as required.
 - 10. Verify that equipment hose threads are same as local fire department equipment.
- B. Report test results promptly and in writing to Architect and authorities having jurisdiction.

3.19 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.

3.20 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."

3.21 CHANGES TO THE SYSTEM

- A. Changes to preliminary plans directed to accommodate specific head locations required by Architect or changes required for coordination or code compliance shall be made at no cost to the Owner.
- B. The Fire Protection Contractor shall include with his proposal the following:
- C. Unit price per head for addition or subtraction of heads before installation of system, including overhead and profit.
- D. Unit price for labor for additional work including overhead and profit.
- E. Should changes be made after bidding, but before approval of shop drawings, then the change shall be made for more or less heads based upon the quoted unit price only, with no other allowance.
- F. Where changes are made after approval of the sprinkler shop drawings for the areas involved, then the change shall be made by this Contractor, and he shall submit a breakdown showing costs for more or less heads and materials and labor adjustments, all based upon the unit prices quoted above.

END OF SECTION 21 10 00

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. This Section includes the following:

1. Coordination
2. Interpretation of Plans
3. Coordination Drawings.
4. Cost Breakdown
5. Substitutions and Prior Approval Requests
6. Record Documents
7. Maintenance Manuals
8. Fire Safety Precautions
9. Personal Safety Requirements
10. Testing, Adjusting and Balancing
11. Equipment Rebates
12. Renovation Projects
13. Temporary Equipment Operation
14. Piping materials and installation instructions common to most piping systems.
15. Plumbing demolition.
16. Equipment installation requirements common to equipment sections.
17. Painting and finishing.
18. Concrete bases.
19. Supports and anchorages.

1.03 GENERAL

- A. This Section includes mechanical items common to all of this division specification sections.
- B. Provide services, skilled and common labor, and all apparatus and materials required for the complete installation as shown and within the intent of the contract documents, field conditions, and code requirements.
- C. The intention of these Contract Documents is to call for finished work, fully tested and ready for operation. Any components or labor not mentioned in the Contract Documents but required for functioning systems shall be provided. Should there appear to be any discrepancies or questions of intent, the Contractor shall refer the matter to the Architect/Engineer for decision before start of any related work.
- D. The drawings show the general arrangement of systems and equipment but do not show all required fittings and offsets that may be necessary to connect pipes and ductwork to equipment, and to coordinate with other trades. Provide all necessary fittings, offsets and runs based on field measurements and at no additional cost. Coordinate with other trades for space available and relative location of equipment and accessories. Pipe and duct location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

1.04 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 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.

1.05 WARRANTY

- A. Provide guarantee and maintain the stability of workmanship and materials used and keep same in good operating condition for a period of minimum or one year after final completion of the work (unless specified otherwise) as evidenced by the issuance of the final certificate by the Architect.
- B. Correct any deficiencies/defects of any kind immediately and; at the Contractors expense due to faulty workmanship or materials that arise during the above mentioned period of time. Corrections shall be done to the satisfaction of the Engineer/Architect. Such reconstruction and/or repairs shall include damages to the finishes or the building resulting from the original defect.

1.06 COORDINATION

- A. Coordinate mechanical work with that of other trades in order to:
 - 1. Avoid interferences between general construction, mechanical, electrical, structural and other specialty trades.
 - 2. Maintain clearances and advise other trades of clearance requirements for operation, repair, removal and testing of mechanical equipment.
 - 3. Indicate aisle-ways and access-ways required on coordinated shop drawings for roof equipment area, mechanical equipment rooms, data and telecomm rooms, corridors, ceiling spaces, shafts, corridors, ceiling space, laboratories, etc.
- B. Understanding of Work:
 - 1. Study, examine, and compare of the contract documents, including drawings and specifications. The Subcontractor shall have a full understanding of how the work in this part is scheduled, phased, and installed with work of other trades.
 - 2. Include in this installation piping, ductwork, devices, and equipment that are necessary for complete and operating systems as specified and as required.
 - 3. Connect piping and ductwork from fixtures, outlets, and devices full size to the nearest suitable main or riser.

4. Certain installations may be presented as typical, and full details are not repeated for each case. Subcontractor shall provide complete installation as if full details apply to each and every case, and make adjustments to typical details to suit each specific installation as part of the basic work.
 5. Installation of work presented on the diagrams are applicable to the plans, and work depicted on the plans are applicable to the diagrams.
 6. If there is a discrepancy in the drawings or specifications, the contractor shall figure the work based on the most stringent requirements to complete the installation and obtain clarification from the Architect before installation.
- C. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
1. Coordinate mechanical systems, equipment, and materials installation with other building components.
 2. Verify dimensions by field measurements.
 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
 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 mechanical 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. Work shall be above ceilings or ceiling line.
 7. Coordinate installation and connection of mechanical 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.
 8. 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. Coordinate with individual system requirements.
 9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
 10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as is practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
 11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
 12. Coordinate with the locations of electrical panels and avoid installing piping and ductwork over them. Electrical panels are purposely located and have priority for location. The contractor is responsible for required piping and ductwork offsets to insure that the panels are located as designed and for other conditions.
 13. Perform system modification recommended by Test and Balance Agency after recommendations are accepted by the Engineer

1.07 INTERPRETATION OF PLANS

- A. In general, the Drawings are to scale. However, to determine exact locations of walls and partitions, the Contractor shall consult the architectural and/or structural Drawings which are dimensioned. Drawings shall not take precedence over field measurements.
- B. Drawings are diagrammatic only. They are intended to indicate size and/or capacity where stipulated, approximate location and/or direction, and approximate general arrangement of one phase of work to another, but not the exact detail of construction. All work shall be constructed from field measurements taken at the site. This shall include all rises, drops, elbows, offsets, etc as necessary to avoid structural members or equipment and materials installed by other trades. The contractor shall coordinate the ductwork and piping layout before construction. No additional costs will be allowed for piping and ductwork fabrications without field verification of available space. If it is found, before installation, that a more convenient, suitable or workable arrangement of any or all phases of construction would result by altering the arrangement indicated on the Drawings, the architect/engineer may require the contractor to change the arrangement of his work without additional cost to the owner.

- C. The drawings and specifications are intended to supplement each other. Any items shown on the drawings and not mentioned in the specifications, or vice versa, shall be executed the same as if mentioned and shown.
- D. The greatest quantity or more expensive work shall govern where there is a conflict noted anywhere on the drawings and/or specifications.

1.08 COORDINATION DRAWINGS

- A. Review contract documents and prepare coordination model drawings as an informational supplemental submittal in accordance with Division 1, 21, 22, and 23 requirements. Provide drawings of all areas of the project. Architectural models of the building will be made available upon request. Detailed mechanical models will not be made available. Facilitate coordination meetings and revise drawings as required to resolve work conflicts.
- B. The Division 23 contractor shall coordinate the preparation of drawings by other trades including steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems. The Division 23 contractor shall create composite Model drawings showing the work of all other trades. The Division 23 contractor shall facilitate coordination meetings as scheduled and coordinated by the General Contractor or Construction Manger to review potential conflicts and propose specific solutions. Any proposed revisions to the Contract Documents shall be noted on the coordination drawings for review by the Architect and Engineer.
- C. All contractors (including steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems) are required to attend a minimum of (3) three coordination meetings on site to resolve any coordination issues prior to start of construction.
- D. If the coordination drawings are not complete and/or coordinated prior to the work being started no extra cost shall be incurred by the owner due to coordination issue and it shall be the responsibility of the contractors to make the necessary modifications to the system to meet the requirements. All modifications shall be approved by the engineer/architect but at the cost to the contractor.
- E. The composite model drawings of all trades shall detail all structural building elements, mechanical equipment, and work of other trades. Indicate locations where space is limited for installation, access for service, and where sequencing and coordination of installations are of importance to the efficient flow of work. The composite drawings shall include at a minimum the following. Where required for clarity multiple composite drawings may have to be submitted for each area.
 - 1. Clearances for maintaining ceiling heights.
 - 2. Clearances for installation of material and equipment for all trades.
 - 3. Clearances for installing and maintaining insulation.
 - 4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - 5. Equipment connections and support details.
 - 6. Penetrations thru block walls and Pre-cast walls.
 - 7. Exterior wall and foundation penetrations.
 - 8. Fire-rated wall and floor penetrations.
 - 9. Sizes and locations of required concrete pads and bases.
 - 10. Valve stem movement.

11. Dimensional locations of pipe sleeves passing through floor/roof slabs.
12. Locations of wall and ceiling access panels where required for access to mechanical equipment.
13. Reflected ceiling plans to integrate installations of light fixtures, grilles, registers, and diffusers, sprinklers, communication systems, and other ceiling mounted components.
14. Both new and existing structural elements.

1.9 COST BREAKDOWN

- A. Submit a cost breakdown for each claim according to General Conditions of the Contract. Include project name, location, Architect/Engineer, Contractor and date.
 1. List the cost breakdown for labor and material separately and include a total.
 2. Breakout and detail the cost according to specification sections.

1.10 SUBSTITUTIONS AND PRIOR APPROVAL REQUESTS

- A. Equipment manufacturers where indicated on the drawings are the basis of design. The contractor accepts responsibility for all design implications when providing approved equipment other than the design basis.
- B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics than the basis of design may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified at the cost of the contractor. If minimum energy rating or efficiencies are specified, equipment shall comply with those requirements. Cost implications to other trades are the responsibility of the contractor.
- C. Dimensional and Wight Changes: Substituted equipment with dimensions or weight different than the basis of design may be furnished provided such proposed equipment is approved in writing. The contractor is responsible for verifying and coordinating proposed equipment such that it maintains the design intent for access and serviceability and reserves space for future equipment where required. Cost implications to other trades are the responsibility of the contractor.
- D. Bids shall be based on the exact materials specified, those listed scheduled on the drawings, or on materials which have been accepted as equivalent. The specified/scheduled products have been used in the design of the project and the preparation of the drawings and specifications as such establish minimum standards of function, dimension, appearance and quality necessary and requisite for this project, which substitutes must meet to be considered acceptable. The burden of proof of equality rests with the party making the request.
- E. Requests for substitution shall be in writing and shall be received by the Engineer not later than 10 days before bid opening date. Materials not specified or accepted as equivalent shall not be acceptable for installation.
- F. Each prior approval request for substitution shall include and meet the following requirements:
 1. The name and model of the material or equipment for which an equivalent is being proposed and a complete description of the proposed equivalent including drawings, cuts sheets, equipment performance capacity and test data, equipment weights, electrical and any other information necessary for a complete evaluation.
 2. A written comparison listing any deviations from the scheduled equipment and/or the specification requirements must also be provided prior to any proposed substitution will be evaluated.
 3. A written statement setting forth any changes in other materials, equipment, electrical, structural and/or other Work in which incorporation of the equivalent may be required shall be included.

4. Material and/or equipment requests which do not meet the above requirements will not be evaluated or approved.
 5. The burden of proof of the merit of the proposed equivalent is upon the proposer. Any and all extra costs associated with the equipment change and affecting architectural, structural, mechanical, plumbing or electrical work shall be responsibility of the entity requesting the substitution.
 6. The Engineer's decision of approval or disapproval of a proposed equivalent is final.
- G. Final approval of all equipment shall be contingent on shop drawing acceptance, compliance with the specifications and performance criteria as scheduled and acceptable installation. General approval to bid a product does not relieve the Supplier or Contractor of meeting specific specification requirements.
 - H. The Mechanical Contractor shall pay, provide, install and be responsible for extra materials required or any other trade due to this use of alternate accepted equipment which has installation requirements different than the specified equipment. The Mechanical Contractor shall pay other trades for any extra work they are involved in due to this substitution of equipment.
 - I. If substitutions of controls or equipment require any changes in the architectural, structural, mechanical, plumbing or electrical work from that shown on the drawings, the extra cost of the equipment or architectural, structural, mechanical, plumbing or electrical work shall be responsibility of the Contractor requesting the substitution. All substitutions shall be prior approved by the Architect or Engineer before purchase by the contractor.
 - J. Where any redesign of electrical, mechanical or other work is required due to substitution, arrangement or equipment layout other than herein specified or shown:
 1. Arrange for required redesign by Architect and Engineer.
 2. Pay all costs for such redesign.

1.11 SUBMITTALS

- A. Refer to individual product and equipment specification sections for detailed submittal requirements.
- B. The mechanical and electrical contractor shall have an onsite meeting prior to installation to review all shop drawings and verify all electrical requirements with the electrical contractor. The mechanical contractor shall be responsible for coordinating and setting up meeting and sharing of mechanical equipment electrical requirements with electrical contractor prior to when construction is set to begin and equipment is to be ordered.
- C. The electrical contractor shall sign off on all mechanical shop drawings for electrical requirements prior to ordering equipment.

1.12 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1 Section "Project Record Documents." In addition to the requirements specified in Division 1, at a minimum the contractors shall:
 1. Maintain an on-site set of drawings to record actual revisions to the work being performed on site. Revisions shall be shown on the documents legibly to reflect actual on-site changes to the documents.
 2. Revisions shall be show on the documents in a contrasting color (red).
 3. Revisions shall be updated to the on-site plan daily.
 4. Ensure all revisions and documentation is complete and accurate, enabling future reference by Owner.
- B. Refer to specific sections for additional record documentation.

1.13 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 Section "Operating, Maintenance, and Warranty Data". Submit copies for review by Architect/Engineer. In addition to the requirements specified in Division 1, include the following information:
1. Descriptive summary of function, normal system 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. Warranty information for all mechanical items shall be included in one tabbed section.

1.14 FIRE SAFETY PRECAUTIONS

- A. The Contractors shall exercise extreme care to maintain and exercise adequate fire safety precautions throughout the work. This shall include providing sufficient fire fighting devices, watchmen, standby helpers or other precautions during construction, in use of temporary heat, welding, brazing, sweating, testing or other phases of work.
- B. At all times, access shall be maintained for fire department trucks to the building.
- C. All welding brazing, cutting and sweating operations performed in vicinity of or accessible to combustible materials shall be adequately protected to make certain that sparks or hot slag does not reach the combustible material and start a fire.
- D. All glass, glazed materials and other finish, in the vicinity of welding, brazing and cutting, shall be masked by the Contractor performing the welding work.
- E. When necessary to do cutting, welding, brazing, sweating and similar work in vicinity of wood, in shafts, or vicinity of any combustible material (and the combustible material cannot be removed), the materials shall be adequately protected with fire resistant blankets or similar approved coverings. In addition, a helper shall be stationed nearby with proper fire extinguishers (provided by the Contractor performing the work) to guard against sparks and fire.
- F. Whenever combustible materials have been exposed to sparks, molten metal, hot slag or splatter, a person shall be kept at the place of work to make sure the smoldering fires have not been started. Whenever cutting or welding operations are carried on in a vertical pipe shaft, a person to act as a fireguard shall be employed to examine all floors below the point of cutting or welding. This fireguard shall be kept on duty after completion of work to guard against fires and shall examine each level after this time, prior to leaving. There shall be no exceptions to this requirement and failure to comply will be construed as negligence.

1.15 EQUIPMENT REBATES

- A. The contractor shall be responsible for applying for and leading the rebate application process for all eligible equipment / systems within the project on behalf of the owner.
- B. The contractor shall provide all receipts, invoicing, counts, site data, etc as required to procure equipment rebates
- C. The contractor shall forward the filled out application and all necessary rebate "back-up" requirements to the owner at the completion of the project.

1.16 PERSONAL SAFETY REQUIREMENTS

- A. The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions required in connection with his work, including regulations of the Occupational Safety and Health Administration (OSHA) and other governing agencies.

1.17 TESTING, ADJUSTING AND BALANCING

- A. All domestic hot water circulation systems will be balanced by an independent test and balance agency hired by the mechanical contractor. The scope of the testing and balancing work includes functional performance testing of all mechanical systems. Deficiency reports will be distributed directly to the contractor on an ongoing basis. Exceptions taken to specific direction issued by the testing agency shall be brought to the attention of the engineer by the installing contractor.
- B. The Contractor shall be certain that all systems are ready for proper operation prior to balancing and adjusting with clean filter and other system elements, e.g., coils. Temperature control calibration, electrical interface, etc., shall also be complete prior to balancing and adjusting. All equipment shall be freshly oiled. The Contractor shall instruct his employees and subcontractors to leave all balancing devices in a wide open position and free all operating arms and adjustments so that they can be easily operated. The contractor shall write a letter to the testing agency indicating that each of the areas defined by the construction schedule is complete and ready for balancing.
- C. The Contractor shall provide and coordinate the services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting, and balancing period.
- D. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall operate the systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB.
- E. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the Owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.
- F. The Drawings and Specifications indicate valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB Firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.

1.18 RENOVATION PROJECTS

- A. Project Conditions: Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner to minimize conflicts with the Owner's operations.
- B. The Contractor shall study all drawings and specifications, visit the site, and get acquainted with the existing conditions and the requirements of the plans and specifications. No claim will be recognized for extra compensation due to the failure of the Contractor to be familiarized with the conditions and extent of the proposed work. The Contractor shall execute all alterations, additions, removals, relocations or new work, etc., as indicated or required to provide a complete installation in accordance with the intent of the drawing and specifications.
- C. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated.

- D. Driveways and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials. Schedule deliveries to minimize use of driveways and entrances. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.
- E. Continuity of Services: The building will be in use during construction operations. Maintain existing systems in operation within all rooms of building at all times. Schedules for various phases of contract work shall be coordinated with all other trades and with Owner. Provide, as part of contract, temporary plumbing and mechanical and electrical connections and relocations as required to accomplish the above.
- F. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services. Notify Owner at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions. Indicate method of providing temporary utilities. Do not proceed with utility interruptions without Owner's written permission.
- G. Cutting And Patching
 - 1. Refer to Division 1 Section "Execution" for cutting and patching requirements.

1.19 TEMPORARY HEAT/EQUIPMENT OPERATION

- A. Provide temporary gas meter and connections to equipment provided by the General Contractor as required for temporary heat.
- B. Warranties:
 - 1. The Contractor shall provide extended warranties for all equipment and mechanical system components operated prior to the date of substantial completion. The Contractor shall obtain in writing from the manufacturer extended warranties for all equipment such that the Owner's warranty starts at the date of substantial completion in accordance with the General Division 1 requirements. Any additional costs shall be the burden of the Contractor.

PART 2: PRODUCTS

2.01 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- B. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 - 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- C. Electrical Characteristics for Plumbing Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. Required electrical modifications must be approved by the Electrical Engineer and be provided at no additional cost to the Owner. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.

2.02 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. Storage of materials and equipment shall not impede the work of other contracts.
- D. Handling of equipment and products shall be according to manufacturers instructions and in compliance with the articles of their warranty.
- E. Protect products from weather, unless product is slated for exterior installation. If outdoor storage is necessary, support products off the ground or pavement in watertight enclosures.

2.03 COORDINATION

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

2.04 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.

2.05 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.

2.06 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.
- B. Plastic-to-Metal Transition Fittings: One-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
- 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.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
- E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.07 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- 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.
- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.08 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 1. Sealing Elements: EPDM 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. Include two for each sealing element.

3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.09 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.

2.010 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. Provide with polished chrome plated finish.

2.011 GROUT

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

PART 3: EXECUTION

3.01 PLUMBING DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing systems, equipment, and components indicated to be removed.
 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 3. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 4. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 5. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or

unserviceable portions and replace with new products of equal capacity and quality.

3.02 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. Select system components with pressure rating equal to or greater than system operating pressure.
- L. Install escutcheons for penetrations of walls, ceilings, and floors:
- M. Sleeves are not required for core-drilled holes.
- N. 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 Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - b. 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.
 - 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.

- O. 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.
- P. 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.
- Q. 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.
- R. Verify final equipment locations for roughing-in.
- S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

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. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.

- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.
- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. ABS Piping: Join according to ASTM D 2235 and ASTM D 2661 Appendixes.
 - 3. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 4. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 5. PVC Nonpressure Piping: Join according to ASTM D 2855.
 - 6. PVC to ABS Nonpressure Transition Fittings: Join according to ASTM D 3138 Appendix.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Nonpressure Piping Gasketed Joints: Join according to ASTM D 3212.
- L. 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.
- M. Fiberglass Bonded Joints: Prepare pipe ends and fittings, apply adhesive, and join according to pipe manufacturer's written instructions.

3.04 PIPING CONNECTIONS

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

3.05 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

- A. Install equipment to allow maximum possible headroom unless specific mounting heights are not indicated.
- B. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- C. Install plumbing equipment to facilitate service, maintenance, and repair or replacement of components. Connect

equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.

- D. Install equipment to allow right of way for piping installed at required slope.

3.06 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.

3.07 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.

3.08 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.

3.09 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.

3.10 GROUTING

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

END OF SECTION 22 05 00

SECTION 22 05 19

METERS AND GAGES 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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. Section Includes:

1. Thermometers.
2. Gages.
3. Test plugs.

- B. Related Sections:

1. Division 22 Section "Domestic Water Piping" for domestic and fire-protection water service meters inside the building.
2. Division 23 Section "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. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For each type of product indicated; include performance curves.
- C. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

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. Trerice, H. O. Co.
 3. Weiss Instruments, Inc.
 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.

- B. Case: Die-cast aluminum or brass, 7 inches long.
- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 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 Div.
 2. KOBOLD Instruments, Inc.
 3. Marsh Bellofram.
 4. Trerice, H. O. Co.
 5. Weiss Instruments, Inc.
 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Liquid-filled type, drawn steel or cast aluminum 5" diameter.
- C. Element: Bourdon tube or other type of pressure element.
- D. Movement: Mechanical, connecting element and pointer.
- E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- F. Pointer: Red metal.
- G. Window: Glass.
- H. Ring: Brass in unfinished areas including mechanical rooms; stainless steel in finished areas.
- I. Connector: Adjustable type, 180 degrees in vertical plane, 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 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.04 PRESSURE GAGES

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

1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 2. Marsh Bellofram.
 3. Palmer - Wahl Instruments Inc.
 4. Trerice, H. O. Co.
 5. Weiss Instruments, Inc.
 6. Winters Instruments.
- B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.
1. Case: Dry type drawn steel or cast aluminum 2" diameter.
 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 3. Pressure Connection: Brass, NPS 1/4, 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, nonreflective aluminum with permanently etched scale markings.
 6. Pointer: Red metal.
 7. Window: Glass.
 8. Ring: Brass in unfinished areas including mechanical rooms; stainless steel in finished areas.
 9. Accuracy: Grade B, plus or minus 2 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 Gages: ASME B40.100, indicating-dial type.
1. Case: Drawn steel or cast aluminum, 4½" diameter with holes for panel mounting.
 2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
 3. Pressure Connection: Brass, NPS 1/4, 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, nonreflective aluminum with permanently etched scale markings.
 6. Pointer: Red metal.
 7. Window: Glass.
 8. Ring: Brass in unfinished areas including mechanical rooms; stainless steel in finished areas.
 9. Accuracy: Grade B, plus or minus 2 percent of middle half.
 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-Gage Fittings:
1. Valves: NPS 1/4 brass or stainless-steel needle type.
 2. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.05 TEST PLUGS

- A. 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.
- B. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- C. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for water service at 20 to 200 deg F shall be CR.
 2. Insert material for water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3: EXECUTION

3.01 THERMOMETER APPLICATIONS

- A. Install thermometers in the outlet of each domestic, hot-water storage tank where indicated.
- B. Provide the following temperature ranges for thermometers:
 - 1. Domestic Hot Water: 30 to 240 deg F with 2-degree scale divisions.
 - 2. Domestic Cold Water: 0 to 100 deg F with 2-degree scale divisions.

3.02 GAGE APPLICATIONS

- A. Install pressure gage at water service entrance at inlet and discharge of each pressure reducing valve, and as indicated.
- B. Pressure gage ranges shall be twice the normal operating pressure.

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 one-third of diameter of pipe and in vertical position in piping tees where thermometers are indicated.
- D. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- E. Install remote-mounting pressure gages on panel.
- F. Install needle-valve and snubber fitting in piping for each pressure gage.
- 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 gages adjacent to machines and equipment to allow service and maintenance for thermometers, gages, machines, and equipment.
- K. Adjust faces of thermometers and gages to proper angle for best visibility.

END OF SECTION 22 05 19

SECTION 22 05 23

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

1.02 SUMMARY

- A. Section Includes:

1. Bronze ball valves.
2. Iron ball valves.
3. Iron, single-flange butterfly valves.
4. Bronze lift check valves.
5. Bronze swing check valves.
6. Bronze gate valves.
7. Iron gate valves.
8. Bronze globe valves.

- B. Related Sections:

1. Division 22 plumbing piping Sections for specialty valves applicable to those Sections only.
2. Division 22 Section "Identification for Plumbing Piping and Equipment" for valve tags and schedules.
3. Division 33 water distribution piping Sections for general-duty and specialty valves for site construction piping.

1.03 DEFINITIONS

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

1.04 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For each type of valve indicated.

1.05 QUALITY ASSURANCE

- A. Source Limitations for Valves: Obtain each type of valve from single source from single manufacturer.
- B. ASME Compliance:
 - 1. ASME B16.10 and ASME B16.34 for ferrous valve dimensions and design criteria.
 - 2. ASME B31.1 for power piping valves.
 - 3. ASME B31.9 for building services piping valves.
- 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. Lead Free Requirements: All plumbing pipes, fittings, valves, fixtures, and other components in systems providing water for human consumption shall be 'lead-free' in accordance with the "Reduction of Lead in Drinking Water Act" and the "Safe Drinking Water Act", where the term 'lead-free' is defined to mean – "not containing more than 0.2 percent lead when used with respect to solder and flux; and not more than a weighted average of 0.25 percent lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures."

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 handwheels or stems as lifting or rigging points.

PART 2: PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.

- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
 - 4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
- E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Gate Valves: With rising stem.
 - 2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
 - 3. Butterfly Valves: With extended neck.
- F. Valve-End Connections:
 - 1. Flanged: With flanges according to ASME B16.1 for iron valves.
 - 2. Grooved: With grooves according to AWWA C606.
 - 3. Solder Joint: With sockets according to ASME B16.18.
 - 4. Threaded: With threads according to ASME B1.20.1.
- G. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE BALL VALVES

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

- e. Body Material: Bronze.
- f. Ends: Threaded.
- g. Seats: PTFE or TFE.
- h. Stem: Stainless steel.
- i. Ball: Stainless steel, vented.
- j. Port: Full.

2.03 GROOVED-END STAINLESS STEEL BUTTERFLY VALVES

A. 300 CWP, Stainless Steel, Grooved-End Butterfly Valves with EPDM Seat and Stainless Steel Disk:

- 1. Manufacturers:
 - a. Victaulic (Style 461)
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. CWP Rating: 300 psi
 - b. Body: Stainless Steel
 - c. Body Design: Suitable for bidirectional and dead-end service at full rated pressure.
 - d. Ends: Grooved
 - e. Seat: EPDM, pressure responsive.
 - f. Stem: 17-4PH stainless steel conforming to ASTM A564
 - g. Disc: Stainless Steel
 - h. Disc Design: Disc shall be offset from the stem centerline to allow full 360 degree seating

2.04 GROOVED-END COPPER BUTTERFLY VALVES

A. 300 CWP, Brass, Copper Tube Sized Grooved-End Butterfly Valves with Aluminum-Bronze Disk:

- 1. Manufacturers:
 - a. Victaulic (Style 608N)
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
- 2. Description:
 - a. CWP Rating: 300 psi
 - b. Body: Brass castings conforming to UNS C87850
 - c. Body Design: Suitable for bidirectional and dead-end service at full rated pressure.
 - d. Ends: Grooved
 - e. Seat: Grade CHP fluoroelastomer, pressure responsive.
 - f. Stem: EPDM
 - g. Disc: Aluminum-bronze
 - h. Disc Design: Disc shall be offset from the stem centerline to allow full 360 degree seating

2.05 BRONZE LIFT CHECK VALVES

A. Class 125, Lift Check Valves with Nonmetallic Disc:

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

2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 200 psig.
 - c. Body Design: Vertical flow.
 - d. Body Material: ASTM B 61 or ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: NBR, PTFE, or TFE.

2.06 BRONZE SWING CHECK VALVES

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

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.

2. Description:
 - a. Standard: MSS SP-80, Type 3.
 - b. CWP Rating: 300 psig.
 - c. Body Design: Horizontal flow.
 - d. Body Material: ASTM B 62, bronze.
 - e. Ends: Threaded.
 - f. Disc: Bronze.

2.07 BRONZE GATE VALVES

A. Class 150, NRS Bronze Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kitz Corporation.
 - b. Milwaukee Valve Company.
 - c. Powell Valves.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: Solid wedge; bronze.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron.

2.08 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Powell Valves.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

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

2.9 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Powell Valves.
 - f. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: PTFE or TFE.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine valve interior for cleanliness, freedom from foreign matter, and corrosion. Remove special packing materials, such as blocks, used to prevent disc movement during shipping and handling.

- B. Operate valves in positions from fully open to fully closed. Examine guides and seats made accessible by such operations.

- C. Examine threads on valve and mating pipe for form and cleanliness.
- D. Examine mating flange faces for conditions that might cause leakage. Check bolting for proper size, length, and material. Verify that gasket is of proper size, that its material composition is suitable for service, and that it is free from defects and damage.
- E. Do not attempt to repair defective valves; replace with new valves.

3.02 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Provide ball valve type isolation shutoff valve at all branch water lines serving each toilet room group. Locate shutoff valve outside of toilet room area and within an accessible space.
- D. Provide all domestic water branches containing 3 or more fixtures with an isolation valve.
- E. Provide all individual fixtures with an isolation valve.
- F. Install valves in horizontal piping with stem at or above center of pipe.
- G. Install valves in position to allow full stem movement.
- H. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Lift Check Valves: With stem upright and plumb.

3.03 ADJUSTING

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

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball, butterfly, or gate valves.
 - 2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 - 3. Throttling Service: Globe or ball valves.
 - 4. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:

1. For Copper Tubing, NPS 2 and Smaller: Threaded or solder ends.
2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends.
3. For Copper Tubing, NPS 5 and Larger: Flanged ends.

3.05 DOMESTIC, HOT- AND COLD-WATER VALVE SCHEDULE

A. Pipe NPS 2 and Smaller:

1. Bronze Valves: May be provided with solder-joint or threaded ends.
2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
3. Bronze Swing Check Valves: Class 150, bronze disc.
4. Bronze Gate Valves: Class 150, NRS.
5. Bronze Globe Valves: Class 150, nonmetallic disc.

B. Pipe NPS 2-1/2 to NPS 4:

1. Iron Valves: May be provided with threaded ends or flanged ends.
2. Iron Ball Valves: Class 150

C. Pipe NPS 5 and Larger:

1. Iron Ball Valves: Class 150.
2. Iron, Single-Flange Butterfly Valves: 200 CWP, EPDM, aluminum, bronze disc.

END OF SECTION 22 05 23

SECTION 22 05 29

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

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 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.

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. Refer to specification section 22 05 00 for additional requirements.
- B. 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.

C. Shop Drawings: Show fabrication and installation details and include calculations for the following:

1. Trapeze pipe hangers. Include Product Data for components.
2. Metal framing systems. Include Product Data for components.
3. Pipe stands. Include Product Data for components.
4. Equipment supports.

D. Welding certificates.

1.06 EXTRA MATERIALS

A. Provide material and installation costs for (10) additional 4" clevis hangers with insulation saddles and all associated rods, clips, bolts, supports, and building attachments for 4" insulated piping. Actual routing, installation and sizes are to be field verified at location required and ordered only after approval from the Engineer.

1.07 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 D1.4, "Structural Welding Code--Reinforcing Steel."

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. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

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. Coatings: Manufacturer's standard finish unless bare metal surfaces are indicated.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.04 INSULATION INSERT

- A. Description: 100-psig minimum, compressive-strength insulation insert.
- B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insulation insert shall cover the entire point of contact with the pipe hanger or bracket.
- E. For Clevis or Band Hangers: Insulation insert shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.05 INSULATION SHIELD

- A. Description: 16 gauge galvanized sheet metal formed to fit contour of pipe insulation.
- B. Shield Length: Minimum 12”.

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.
- B. Mechanical-Expansion Anchors: Insert-wedge-type stainless steel, for use in hardened portland cement concrete with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

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.
- C. Low-Type, Single-Pipe Stand: One-piece stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Base: Stainless steel.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 3. 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. Bases: One or more plastic.

2. Vertical Members: Two or more protective-coated-steel channels.
 3. Horizontal Member: Protective-coated-steel channel.
 4. 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.

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, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, 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. 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 noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 2. Carbon- or Alloy-Steel, Double-Bolt Pipe Clamps (MSS Type 3): For suspension of pipes, NPS 3/4 to NPS 24, requiring clamp flexibility and up to 4 inches of insulation.

3. Steel Pipe Clamps (MSS Type 4): For suspension of cold and hot pipes, NPS 1/2 to NPS 24, if little or no insulation is required.
 4. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 5. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 6. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 7. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 8. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 9. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 10. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 11. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 12. Clips (MSS Type 26): For support of insulated pipes not subject to expansion or contraction.
 13. Pipe Saddle Supports (MSS Type 36): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange.
 14. Pipe Stanchion Saddles (MSS Type 37): For support of pipes, NPS 4 to NPS 36, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
 15. Adjustable, Pipe Saddle Supports (MSS Type 38): For stanchion-type support for pipes, NPS 2-1/2 to NPS 36, if vertical adjustment is required, with steel pipe base stanchion support and cast-iron floor flange.
- 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.
 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.
- 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 deg 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 deg 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. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.

- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.
- M. Use mechanical-expansion anchors instead of building attachments where required in concrete construction.
- N. 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-69 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-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. Insulation Insert Installation: Install in pipe hanger for all insulated piping 2" and larger.
- E. Insulation Shield: Install insulation shields at all hanger locations for insulated piping.
- F. 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.
- G. 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.
- H. Pipe Positioning System Installation: Install support devices to make rigid supply and waste piping connections to each plumbing fixture. Refer to Division 22 Section "Plumbing Fixtures" for plumbing fixtures.
- I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. 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.

- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. 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 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.
- N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. 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.
- P. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above or below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - b. 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 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 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: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 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 05 29

SECTION 22 05 53

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

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. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For each type of product indicated.
- C. Samples: For color, letter style, and graphic representation required for each identification material and device.
- D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- E. Valve numbering scheme.
- F. 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 or stainless steel, 0.025-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 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 deg F (71 deg C).
 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-by-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 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. 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. Pretensioned Pipe Labels: Precoiled, semirigid 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 or stainless steel, 0.025-inch minimum thickness, and having predrilled or stamped holes for attachment hardware.
 - 2. Fasteners: Brass wire-link, 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 surfaces 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; inside of sink cabinets; machine rooms; accessible maintenance spaces such as shafts, tunnels, under cabinets 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. At each side of penetrations through all walls, floors, ceilings, and inaccessible enclosures.
 - 4. At access doors, manholes, and similar access points that permit view of concealed piping.
 - 5. Near major equipment items and other points of origination and termination.
 - 6. Spaced at maximum intervals of 50 feet along each run. Reduce intervals to 25 feet in areas of congested piping and equipment.
 - 7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
 - 8. Where major devices, valves, dampers, etc are above ceiling, provide equipment identification on ceiling grid to assist in locating device. Include direction arrow to identify specific tile.
- C. Pipe Label Color Schedule:
 - 1. Domestic Water Piping:
 - a. Background Color: Green.
 - b. Letter Color: White.
 - 2. Sanitary Waste and Storm Drainage 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: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:
 - 1. Valve-Tag Size and Shape:
 - a. Cold Water: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - 2. Valve-Tag Color:
 - a. Cold Water: Natural.
 - b. Hot Water: Natural.
 - 3. Letter Color:
 - a. Cold Water: Black.
 - b. Hot Water: Black.

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 05 53

SECTION 22 07 00

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. Flexible elastomeric
 - b. Mineral fiber
 - c. Polyolefin
- 2. Insulating cements.
- 3. Adhesives.
- 4. Mastics.
- 5. Lagging adhesives.
- 6. Sealants.
- 7. Factory-applied jackets.
- 8. Field-applied jackets.
- 9. Tapes.
- 10. Securements.
- 11. Corner angles.

- B. Related Sections include the following:

- 1. Division 21 Section "Fire-Suppression Systems Insulation."
- 2. Division 23 Section "HVAC Insulation."

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).

- B. Shop Drawings:

- 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.
- 2. Detail attachment and covering of heat tracing inside insulation.
- 3. Detail insulation application at pipe expansion joints for each type of insulation.
- 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
- 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
- 6. Detail application of field-applied jackets.
- 7. Detail application at linkages of control devices.
- 8. Detail field application for each equipment type.

- C. Qualification Data: For qualified Installer.

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 "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. Flexible Elastomeric (FE): Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials; thermal conductivity (avg) of 0.27 Btu/hr-ft²-°F or lower at mean temperature of 75°F; 3.0 lbs./ft³ density (ASTM D/622); 0.08 perm-in permeability (ASTM E96); 0.2% water absorption (ASTM C209).

- G. Mineral-Fiber Blanket Insulation (MF): Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- H. Mineral-Fiber, Preformed Pipe Insulation (MF): Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- I. Mineral-Fiber, Pipe and Tank Insulation (MF): Mineral or glass fibers bonded with a thermosetting resin. Semirigid 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 3.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- J. Polyolefin (P): Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F; 1.5 lbs./ft³ density (ASTM D1622); 0.0 perm-in permeability (ASTM E96); 0.0% water absorption (ASTM C209).

2.02 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

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. Flexible Elastomeric and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.04 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. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.
 - 4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
 - 1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 - 3. Solids Content: 63 percent by volume and 73 percent by weight.
 - 4. Color: White.

2.05 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
 - 1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over equipment and pipe insulation.
 - 2. Service Temperature Range: Minus 50 to plus 180 deg F.
 - 3. Color: White.

2.06 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
 - 1. Materials shall be compatible with insulation materials, jackets, and substrates.
 - 2. Fire- and water-resistant, flexible, elastomeric sealant.
 - 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 - 4. Color: White.

2.07 FACTORY-APPLIED JACKETS

- A. Insulation system schedules indicate factory-applied jackets on various applications. When factory-applied jackets are indicated, comply with the following:
 - 1. ASJ: White, kraft-paper, fiberglass-reinforced scrim with aluminum-foil backing; complying with ASTM C 1136, Type I.
 - 2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I.
 - 3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II.

2.08 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, as follows:
 - 1. Shall comply with ASTM C921, Type I, for applications where the equipment or pipes operate below ambient temperature at least part of the time or where a vapor barrier is required.
 - 2. Shall comply with ASTM C921, Type II, for applications where equipment or pipes operate above ambient temperatures or where a vapor retarder is not required.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; roll stock ready for shop or field cutting and forming. Minimum 30ml thickness.
 - 1. Adhesive: As recommended by jacket material manufacturer.

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

C. Metal Jacket:

1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - b. Finish and thickness are indicated in field-applied jacket applications.
 - 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.

2.09 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 11.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 6.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: White vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 1. Width: 2 inches.
 2. Thickness: 6 mils.

3. Adhesion: 64 ounces force/inch in width.
4. Elongation: 500 percent.
5. Tensile Strength: 18 lbf/inch in width.

D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.

1. Width: 2 inches.
2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.10 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304 0.015 inch thick, 1/2 inch wide with wing seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch thick, 1/2 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. 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.
2. 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.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch-thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

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. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.

3.03 PIPING INSULATION APPLICATION

- A. Indoor Piping System Insulation: Insulate with insulation types and thickness as listed in Table below. If more than one pipe material is listed for a piping system, selection from materials listed is the contractor's option.
 1. Potable cold water, hot water, and hot water circulating piping.
 2. Interior aboveground, horizontal and vertical storm water piping. Storm water piping includes all drawings connected to both primary and overflow roof drains including drain bodies.
 3. Plumbing vents within 20 lineal feet of roof outlet.
 4. Condensate drain piping from cooling coils.
 5. Make-up water piping to HVAC equipment and systems.
 6. P-trap and 5 lineal feet of sanitary piping from AHU condensate drains.

TABLE NO. 22 07 00-1: MINIMUM PIPE INSULATION

PIPING SYSTEM	TYPE OF (1) INSULATION	1¼" & SMALLER	1½" TO 2"	2½" & LARGER
Cold Water Piping	MF, FE	½"	1"	1"
HW Piping	MF	1"	1½"	1½"
HW Circulating Piping	MF	1"	1½"	1½"
HW Piping (above 160)	MF	1"	1½"	2"
HW Circulating Piping (above 160)	MF	1"	1½"	2"
Storm Drains	MF	½"	1"	1"
Plumbing Vents	MF, FE	½"	1"	1"
Condensate Drains	FE, P	½"	1"	1"
Make-up Water Piping	MF,FE	½"	1"	1"
Hot Drain Piping	MF	½"	1"	1"
P-Trap and Sanitary Piping	MF, FE	½"	1"	1"

NOTES:

- I. Insulation material abbreviations:
 - a. Mineral Fiber (MF)
 - b. Flexible Elastomeric (FE)
 - c. Polyolefin (P)
- B. Refer to Division 23 Section 22 05 29 "Hangers and Supports for Piping and Equipment" for insulation insert and insulation shield requirements.
- C. Provide insulation kit equal to Truebro Inc. model # 102 Handi-Lav Guard insulation for all exposed hot and cold water and waste piping and fittings.
- D. Outdoor Piping System Insulation: Increase insulation thicknesses indicated for indoor applications by ½". All outdoor insulation shall be mineral fiber or polyolefin. Provide with weather barrier aluminum jacket.
- E. All exposed indoor piping insulation shall be covered with a field installed paintable PVC jacket.
- F. Insulation Omitted: Omit insulation for the following:
 1. Interior air conditioner condensate drain piping in mechanical rooms provided piping is less than 3 lineal feet and is located within 12" of floor.
 2. Chrome-plated pipes and fittings unless there is a potential for personnel injury.

3.04 EQUIPMENT INSULATION APPLICATIONS

- A. Insulation materials and thicknesses are identified within this specification section. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Heat-exchanger (water-to-water for domestic water heating service) insulation shall be one of the following:
 1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
 2. Mineral-Fiber Pipe and Tank: 2 inches thick.
- D. Steam-to-hot-water converter insulation shall be one of the following:
 1. Mineral-Fiber Board: 2 inches thick and 3-lb/cu. ft. nominal density.
 2. Mineral-Fiber Pipe and Tank: 2 inches thick.

- E. Domestic hot-water storage tank insulation shall be one of the following:
 - 1. Mineral-Fiber Board: 4 inches thick and 3-lb/cu. ft. nominal density.
 - 2. Mineral-Fiber Pipe and Tank: 4 inches thick.

3.05 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, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.
- L. Install insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.

3. Overlap jacket longitudinal seams at least 1-1/2 inches. Install insulation with longitudinal seams at bottom of pipe. Clean and dry surface to receive self-sealing lap. 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.

3.06 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" 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."

3.07 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 overcompress 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 prestressed 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 prestressed 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. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.

3.08 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.
 - a. Fiberglass inserts with a thickness and density equal to the adjacent pipe insulation with a pre-formed PVC fitting cover may be used in lieu of preformed or mitered fitting covers.
 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 gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, vessels, and equipment. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Provide 16 gauge galvanized sheet metal insulation shields at all hanger locations. Shields shall be a minimum 12" in length and formed to fit pipe contour.

3.09 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.

3.10 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.

3.11 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube 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 polyolefin 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 polyolefin 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 cut sections of polyolefin pipe and sheet insulation to valve body.
 2. 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.

3.12 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.
- B. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- C. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

END OF SECTION 22 07 00

SECTION 22 11 16

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

1.02 SUMMARY

- A. Section Includes:
 - 1. Under-building slab and aboveground domestic water pipes, tubes, fittings, and specialties inside the building.
 - 2. Encasement for piping.
 - 3. Specialty valves.
 - 4. Flexible connectors.
 - 5. Water meters furnished by utility company for installation by Contractor.
 - 6. Water meters.
 - 7. Escutcheons.
 - 8. Sleeves and sleeve seals.
 - 9. Wall penetration systems.

1.03 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For the following products:
 - 1. Specialty valves.
 - 2. Dielectric fittings.
 - 3. Flexible connectors.
- C. Coordination Drawings: Refer to coordination drawing requirements of 22 05 00.
- D. Field quality-control and test and inspection reports.

1.04 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with NSF 61 for potable domestic water piping and components.

1.05 PROJECT CONDITIONS

- A. Interruption of Existing Water Service: Do not interrupt water service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary water service according to requirements indicated:

1. Notify Owner no fewer than two days in advance of proposed interruption of water service.

PART 2: PRODUCTS

2.01 PIPING MATERIALS

- A. Comply with requirements in "Piping Applications" Article for applications of pipe, tube, fitting materials, and joining methods for specific services, service locations, and pipe sizes.

2.02 COPPER TUBE AND FITTINGS

- A. Hard Copper Tube: ASTM B 88, Type L water tube, drawn temper.
 1. Cast-Copper Solder-Joint Fittings: ASME B16.18, pressure fittings.
 2. Wrought-Copper Solder-Joint Fittings: ASME B16.22, wrought-copper pressure fittings.
 3. Bronze Flanges: ASME B16.24, Class 150, with solder-joint ends.
 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.
 5. Copper-Tube Extruded-Tee Connections: ASTM F 2014.
- B. Soft Copper Tube: ASTM B 88, Type K water tube, annealed temper. Copper Solder-Joint Fittings complying with ASME B16.22, wrought-copper pressure fittings.

2.03 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. Standard-Pattern, Mechanical-Joint Fittings: AWWA C110, ductile or gray iron.
- 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. Standard-Pattern, Push-on-Joint Fittings: AWWA C110, ductile or gray iron.
 - a. Gaskets: AWWA C111, rubber.

2.04 PIPING JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: AWWA C110, rubber, flat face, 1/8 inch thick or ASME B16.21, nonmetallic and asbestos free, unless otherwise indicated; full-face or ring type unless otherwise indicated.
- B. Metal, Pipe-Flange Bolts and Nuts: ASME B18.2.1, carbon steel unless otherwise indicated.
- C. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- D. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing unless otherwise indicated.

2.05 SPECIALTY VALVES

- A. Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for general-duty metal valves.

- B. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for balancing valves, drain valves, backflow preventers, and vacuum breakers.

2.06 TRANSITION FITTINGS

- A. General Requirements:
 - 1. Same size as pipes to be joined.
 - 2. Pressure rating at least equal to pipes to be joined.
 - 3. End connections compatible with pipes to be joined.
- B. Fitting-Type Transition Couplings: Manufactured piping coupling or specified piping system fitting.
- C. Sleeve-Type Transition Coupling: AWWA C219.
- D. Plastic-to-Metal Transition Fittings: CPVC one-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert and one solvent-cement-socket or threaded end.
- E. Plastic-to-Metal Transition Unions: CPVC four-part union. Include brass threaded end, solvent-cement-joint or threaded plastic end, rubber O-ring, and union nut.

2.07 DIELECTRIC FITTINGS

- A. General Requirements: Assembly of copper alloy and ferrous materials or ferrous material body with separating nonconductive insulating material suitable for system fluid, pressure, and temperature.
- B. Dielectric Unions: 150 psig at 180 degrees F., solder-joint copper alloy and threaded ferrous.
- C. Dielectric Flanges: Factory-fabricated, bolted, companion-flange assembly. Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.
- D. Dielectric-Flange Kits: 150 psig rated, non-conducting materials for field assembly.
 - 1. Gasket: Neoprene or phenolic.
 - 2. Bolt Sleeves: Phenolic or polyethylene.
 - 3. Washers: Phenolic with steel backing washers.
- E. Dielectric Couplings: 300 psig at 225 degrees F., galvanized steel coupling.
 - 1. End Connections: Female threaded.
 - 2. Lining: Inert and noncorrosive, thermoplastic.
- F. Dielectric Nipples: ASTM F1545, 300 psig at 225 degrees F., electroplated steel nipple.
 - 1. End Connections: Male threaded.
 - 2. Lining: Inert and noncorrosive, propylene.

2.08 FLEXIBLE CONNECTORS

- A. Bronze-Hose Flexible Connectors: Corrugated-bronze tubing with bronze wire-braid covering and ends brazed to inner tubing.
 - 1. Working-Pressure Rating: Minimum 200 psig.
 - 2. End Connections NPS 2 and Smaller: Threaded copper pipe or plain-end copper tube.
 - 3. End Connections NPS 2-1/2 and Larger: Flanged copper alloy.

2.09 WATER METERS

- A. Provide water meter in accordance with all local utility requirements. The mechanical contractor shall provide the local utility with water flow requirements and coordinate sizing per the local utility. Any additional water meters required shall comply with requirements of this section.
- B. Turbine-Type Water Meters:
 - 1. Description:
 - a. Standard: AWWA C701.
 - b. Pressure Rating: 150-psig working pressure.
 - c. Body Design: Turbine; totalization meter.
 - d. Registration: In gallons or cubic feet as required by utility company.
 - e. Case: Bronze.
 - f. End Connections for Meters NPS 2 and Smaller: Threaded.
 - g. End Connections for Meters NPS 2-1/2 and Larger: Flanged.
- C. Compound-Type Water Meters:
 - 1. Description:
 - a. Standard: AWWA C702.
 - b. Pressure Rating: 150-psig working pressure.
 - c. Body Design: With integral mainline and bypass meters; totalization meter.
 - d. Registration: In gallons or cubic feet as required by utility company.
 - e. Case: Bronze.
 - f. Pipe Connections: Flanged.

2.10 ESCUTCHEONS

- A. General: Manufactured ceiling, floor, and wall escutcheons and floor plates.
- B. One Piece, Cast Brass: Polished, chrome-plated finish with setscrews.
- C. One Piece, Deep Pattern: Deep-drawn, box-shaped brass with chrome-plated finish.
- D. Split Casting, Cast Brass: Polished, chrome-plated finish with concealed hinge and setscrew.
- E. One-Piece Floor Plates: Cast-iron flange with holes for fasteners.
- F. Split-Casting Floor Plates: Cast brass with concealed hinge.

2.11 SLEEVES

- A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
- 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.

2.12 SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
 - 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.

2.13 GROUT

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

PART 3: EXECUTION

3.01 PIPING APPLICATIONS

- A. Above Ground: Install Type L, drawn copper tube with wrought copper fittings and solder joints for pipe sizes 4 inches and smaller. Install Type L, drawn copper tube with brazed joints for pipe sizes 5 inches and larger.
- B. Under Building Slab: Install Type K, annealed temper copper tube for pipe sizes 2 inches and smaller. Do not install with joints below ground.
- C. Below Ground Water Service Pipe: Push-on-joint, ductile-iron pipe; standard pattern mechanical joint fittings and mechanical joints.
- D. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below unless otherwise indicated.
- E. Flanges and unions may be used for aboveground piping joints unless otherwise indicated.

3.02 JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipes, tubes, 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.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged.
- D. Brazed Joints: Join copper tube and fittings according to CDA's "Copper Tube Handbook," "Brazed Joints"

Chapter.

- E. Soldered Joints: Apply ASTM B 813, water-flushable flux to end of tube. Join copper tube and fittings according to ASTM B 828 or CDA's "Copper Tube Handbook."
- F. Ductile-Iron-Piping Grooved Joints: Cut groove end of pipe. Assemble coupling with housing, gasket, lubricant, and bolts. Join ductile-iron pipe and grooved-end fittings according to AWWA C606 for ductile-iron-pipe, cut-grooved joints.
- G. Flanged Joints: Select appropriate asbestos-free, nonmetallic gasket material in size, type, and thickness suitable for domestic water service. Join flanges with gasket and bolts according to ASME B31.9.
- H. Dissimilar-Material Piping Joints: Make joints using adapters compatible with materials of both piping systems.

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 ball valves for piping NPS 2 and smaller. Use butterfly, ball, or gate valves with flanged ends for piping NPS 2-1/2 and larger.
 - 2. Throttling Duty: Use ball or globe valves for piping NPS 2 and smaller. Use butterfly or ball valves with flanged ends for piping NPS 2-1/2 and larger.
 - 3. Hot-Water Circulation Piping, Balancing Duty: Calibrated balancing valves.
 - 4. Drain Duty: Hose-end drain valves.
- B. Use check valves to maintain correct direction of domestic water flow to and from equipment.

3.04 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of domestic water piping. 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.
- B. Install copper tubing under building slab according to CDA's "Copper Tube Handbook."
- C. Install ductile-iron piping under building slab with restrained joints according to AWWA C600 and AWWA M41.
- D. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside the building at each domestic water service entrance. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages and Division 22 Section "Domestic Water Piping Specialties" for drain valves and strainers.
- E. Install shutoff valve immediately upstream of each dielectric fitting.
- F. Install water-pressure-reducing valves downstream from shutoff valves. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for pressure-reducing valves.
- G. Install domestic water piping level and plumb.
- H. The mechanical contractor shall provide the local utility with water flow requirements and coordinate sizing per the local utility. Install water-meter installation according to utility company's requirements.
- I. Install piping concealed from view and protected from physical contact by building occupants unless otherwise

indicated and except in equipment rooms and service areas.

- J. 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.
- K. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal, and coordinate with other services occupying that space.
- L. Install piping adjacent to equipment and specialties to allow service and maintenance.
- M. Install piping to permit valve servicing.
- N. Install nipples, unions, special fittings, and valves with pressure ratings the same as or higher than system pressure rating used in applications below unless otherwise indicated.
- O. Install piping free of sags and bends.
- P. Install fittings for changes in direction and branch connections.
- Q. Install unions in copper tubing at final connection to each piece of equipment, machine, and specialty.
- R. Install pressure gages on suction and discharge piping from each plumbing pump and packaged booster pump. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for pressure gages.
- S. Install thermostats in hot-water circulation piping. Comply with requirements in Division 22 Section "Domestic Water Pumps" for thermostats.
- T. Install thermometers on inlet and outlet piping from each water heater. Comply with requirements in Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers.

3.05 VALVE INSTALLATION

- A. General-Duty Valves: Comply with requirements in Division 22 Section "General-Duty Valves for Plumbing Piping" for valve installations.
- B. 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 and smaller. Use butterfly or gate valves for piping NPS 2-1/2 and larger.
- C. Install drain valves for equipment at base of each water riser, at low points in horizontal piping, and where required to drain water piping. Drain valves are specified in Division 22 Section "Domestic Water Piping Specialties."
 - 1. Hose-End Drain Valves: At low points in water mains, risers, and branches.
 - 2. Stop-and-Waste Drain Valves: Instead of hose-end drain valves where indicated.
- D. Install calibrated balancing valves in each hot-water circulation return branch and discharge side of each pump and circulator. Set calibrated balancing valves partly open to restrict but not stop flow. Comply with requirements in Division 22 Section "Domestic Water Piping Specialties" for calibrated balancing valves.

3.06 TRANSITION FITTING INSTALLATION

- A. Install transition couplings at joints of dissimilar piping.
- B. Transition Fittings in Underground Domestic Water Piping:
 - 1. NPS 1-1/2 and Smaller: Fitting-type coupling.
 - 2. NPS 2 and Larger: Sleeve-type coupling.

- C. Transition Fittings in Aboveground Domestic Water Piping NPS 2 and Smaller: Plastic-to-metal transition fittings or unions.

3.07 DIELECTRIC FITTING INSTALLATION

- A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.
- B. Dielectric Fittings for NPS 2 and Smaller: Use dielectric couplings or nipples.
- C. Dielectric Fittings for NPS 2-1/2 to NPS 4: Use dielectric flanges or flange kits.
- D. Dielectric Fittings for NPS 5 and Larger: Use dielectric flange kits.

3.08 FLEXIBLE CONNECTOR INSTALLATION

- A. Install flexible connectors in suction and discharge piping connections to each domestic water pump and in suction and discharge manifold connections to each domestic water booster pump.
- B. Install bronze-hose flexible connectors in copper domestic water tubing.

3.09 WATER METER INSTALLATION

- A. Rough-in domestic water piping and install water meters according to utility company's requirements.

3.10 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support products and installation.
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: Field fabricated, heavy duty trapeze. Fabricate from steel shapes and rod diameters as required for loads per MSS SP-58 and MSS SP-69. Verify rod diameter with structural engineer for multiple pipe trapeze hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install supports for vertical copper tubing every 10 feet.
- E. Install supports for vertical steel piping every 15 feet.
- F. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4"	4	4	3/8
1" to 2"	6	6	3/8
2 1/2" to 4"	6	6	1/2
5" and Greater	4	4	7/8

- G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions and prior approved spacing by the structural engineer.

3.11 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; extend and connect to the following:
 - 1. Domestic Water Booster Pumps: Cold-water suction and discharge piping.
 - 2. Water Heaters: Cold-water inlet and hot-water outlet piping in sizes indicated, but not smaller than sizes of water heater connections.
 - 3. Plumbing Fixtures: Cold- and hot-water supply piping in sizes indicated, but not smaller than required by plumbing code. Comply with requirements in Division 22 plumbing fixture Sections for connection sizes.
 - 4. 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 and larger.

3.12 ESCUTCHEON INSTALLATION

- A. Install escutcheons for all penetrations of walls, ceilings, and floors. Escutcheons in areas exposed to view shall have a chrome plated finish.
- B. Provide chrome plated escutcheons for all piping penetration under sinks and within cabinets.

3.13 SLEEVE INSTALLATION

- A. General Requirements: Install sleeves for all pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
- B. Sleeves are not required for core-drilled holes.
- C. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
- D. Install sleeves in new partitions, slabs, and walls as they are built.
- E. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
- F. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
- G. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.
- H. Seal space outside of sleeves in concrete slabs and walls with grout.
- I. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

- J. Install sleeve materials according to the following applications:
1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
 2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe or stack sleeve fittings.
 - a. Extend sleeves 2 inches above finished floor level.
 - b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. 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.
 3. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - a. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
 - b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
 5. Sleeves for Piping Passing through Exterior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
 - c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 6. Sleeves for Piping Passing through Interior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6.
- K. 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" for firestop materials and installations.

3.14 SLEEVE SEAL INSTALLATION

- A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
- B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.15 IDENTIFICATION

- A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.16 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Piping Inspections:
 - 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 one day 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. Reinspection: If authorities having jurisdiction find that piping will not pass tests or inspections, make required corrections and arrange for reinspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- C. Piping Tests: The following minimum tests shall be performed. Review procedures with the local jurisdiction and provide any additional tests or procedures required.
 - 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 a 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 1.5 times the normal 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 for corrective action required.
- D. Domestic water piping will be considered defective if it does not pass tests and inspections.
- E. Submit test and inspection reports.

3.17 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 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.

3.18 CLEANING

- A. Provide the following minimum cleaning and disinfecting procedures as follows. Notify the Engineer seven (7) days in advance of disinfection procedures.
 1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction; if methods are not prescribed, use procedures 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 11 16

SECTION 22 11 19

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

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.
- B. Related Sections include the following:
 - 1. Division 22 Section "Meters and Gages for Plumbing Piping" for thermometers, pressure gages, and flow meters in domestic water piping.
 - 2. Division 22 Section "Domestic Water Piping" for water meters.
 - 3. Division 22 Section "Plumbing Fixtures" for field installed components provided with plumbing fixtures.

1.03 PERFORMANCE REQUIREMENTS

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

1.04 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For each type of product indicated.
- C. Shop Drawings: Diagram power, signal, and control wiring.
- D. Field quality-control test reports.

- E. 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 Standard: Comply with NSF 61, "Drinking Water System Components--Health Effects," for fixture materials that will be in contact with potable water.
- C. Lead Free Requirements: All plumbing pipes, fittings, valves, fixtures, and other components in systems providing water for human consumption shall be 'lead-free' in accordance with the "Reduction of Lead in Drinking Water Act" and the "Safe Drinking Water Act", where the term 'lead-free' is defined to mean – "not containing more than 0.2 percent lead when used with respect to solder and flux; and not more than a weighted average of 0.25 percent lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures."

PART 2: PRODUCTS

2.01 VACUUM BREAKERS

- A. Pipe-Applied, Atmospheric-Type Vacuum Breakers:
 - 1. Standard: ASSE 1001.
 - 2. Size: NPS 1/4 to NPS 3, as required to match connected piping.
 - 3. Body: Bronze.
 - 4. Inlet and Outlet Connections: Threaded.
 - 5. Finish: Rough bronze in mechanical or boiler room. Chrome plated in all other areas.
- B. Hose-Connection Vacuum Breakers:
 - 1. Standard: ASSE 1011.
 - 2. Body: Bronze, nonremovable, with manual drain.
 - 3. Outlet Connection: Garden-hose threaded complying with ASME B1.20.7.
 - 4. Finish: Rough bronze in mechanical rooms or boiler rooms. Chrome plated in all other areas.
- C. Pressure Vacuum Breakers:
 - 1. Standard: ASSE 1020.
 - 2. Operation: Continuous-pressure applications.
 - 3. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
 - 4. Size: Full line size as indicated on drawings.
 - 5. Valves: Ball type, on inlet and outlet.

2.02 BACKFLOW PREVENTERS

- A. Reduced-Pressure-Principle Backflow Preventers
 - 1. Standard: ASSE 1013.
 - 2. Operation: Continuous-pressure applications.
 - 3. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
 - 4. Size: Full line size as indicated on drawings.

5. Body: Bronze for NPS 2 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.
 6. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
 7. Configuration: Designed specifically for horizontal or vertical flow as installed.
 8. Accessories:
 - a. Valves: Ball type with threaded ends on inlet and outlet of NPS 2 and smaller; outside screw and yoke gate-type with flanged ends on inlet and outlet of NPS 2-1/2 and larger.
 - b. Air-Gap Fitting: ASME A112.1.2, matching backflow-preventer connection.
- B. Beverage-Dispensing-Equipment Backflow Preventers:
1. Standard: ASSE 1022.
 2. Operation: Continuous-pressure applications.
 3. Size: NPS 1/4 or NPS 3/8.
 4. Body: Stainless steel.
 5. End Connections: Threaded.
- C. Hose-Connection Backflow Preventers:
1. Standard: ASSE 1052.
 2. Inlet Size: NPS 1/2 or NPS 3/4.
 3. Outlet Size: Garden-hose thread complying with ASME B1.20.7.
 4. Capacity: At least 3-gpm flow.
- D. Additional Backflow Preventer Requirements:
1. Hose thread water outlets must be provided with ASSE 1052 non-removable hose bibb-type backflow preventers, ASSE 1011 non-removable hose bibb type vacuum breakers, or ASSE 1001 atmospheric vacuum breakers installed at least 6 inches above the highest point of usage on the discharge side of the last control valve (see Minnesota Rules, Chapter 4714, Sections 603.5.7 and 301.1.2).
 2. Wall hydrants must meet ASSE standard 1019 (see Table 603.2). Where permitted by the administrative authority, wall hydrants may utilize non-removable ASSE 1052 backflow preventers or non-removable ASSE 1011 vacuum breakers and provision is made to protect from freezing (see Minnesota Rules, Chapter 4714, Sections 603.5.7, 312.6, and 301.1.2).
 3. Domestic-type dishwashers must discharge indirectly through an ASSE 1021 or IAPMO PS23-2006a listed air gap fitting (see Minnesota Rules, Chapter 4714, Sections 414.3 and 807.4). The discharge may be routed to a waste receptor, to a wye branch fitting on a kitchen sink tailpiece, or to the dishwasher connection of a food waste grinder. If discharging to a sink tailpiece or food waste grinder, the flood-level marking on the air gap fitting must be at or above the flood level of the sink or drainboard, whichever is higher.
 4. Commercial dishwashers must discharge to the drainage system through a 1-inch minimum air gap or directly to the sanitary drain if a floor drain without a backwater valve is installed on the individual dishwasher drainage branch (see Minnesota Rules, Chapter 4714, Sections 414.3, 704.3 and 801.1).
 5. The water supply connection to a commercial dishwashing machine shall be protected by an air gap or a backflow prevention device in accordance with Section 603.3.2, Section 603.3.5, or Section 603.3.6 of Minnesota Rules, Chapter 4714.0100.

6. Beverage dispensers, carbonated beverage machines, and coffee makers must be supplied through an air gap or an ASSE 1022 backflow preventer. No copper tubing may be installed downstream of the backflow preventer serving a post-mix carbonator to preclude copper poisoning (see Minnesota Rules, Chapter 4714, Section 603.5.12).

2.03 WATER PRESSURE-REDUCING VALVES

A. Water Regulators:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Conbraco Industries, Inc.
 - b. Watts Industries, Inc.; Water Products Div.
 - c. Zurn Plumbing Products Group; Wilkins Div.
2. Standard: ASSE 1003.
3. Pressure Rating: Initial working pressure of 150 psig.
4. Size: Full line size as indicated on drawing.
5. Design Flow Rate: Refer to drawings.
6. Design Inlet Pressure: Refer to drawings.
7. Design Outlet Pressure Setting: Refer to drawings.
8. Body: Bronze for NPS 2 and smaller; cast iron with interior lining that is FDA approved for NPS 2-1/2 and NPS 3.
9. Valves for Booster Heater Water Supply: Include integral bypass.
10. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and NPS 3.

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 Div.
 - d. NIBCO INC.
 - e. Taco, Inc.
 - f. Watts Industries, Inc.; Water Products Div.
2. Type: Ball valve with two readout ports and memory setting indicator.
3. Body: Bronze,
4. Size: Same as connected piping, but not larger than NPS 2.

B. Cast-Iron 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 Div.
 - d. NIBCO INC.
 - e. Watts Industries, Inc.; Water Products Div.
2. Type: Adjustable with Y-pattern globe valve, two readout ports, and memory-setting indicator.
 3. Size: Same as connected piping, but not smaller than NPS 2-1/2.

2.05 STRAINERS FOR DOMESTIC WATER PIPING

A. Y-Pattern Strainers:

1. Pressure Rating: 125 psig minimum, unless otherwise indicated.
2. Body: Bronze for NPS 2 and smaller; cast iron with interior lining complying with AWWA C550 or FDA-approved, epoxy coating and for NPS 2-1/2 and larger.
3. End Connections: Threaded for NPS 2 and smaller; flanged for NPS 2-1/2 and larger.
4. Screen: Stainless steel with round perforations, unless otherwise indicated.
5. Drain: Factory-installed, hose-end drain valve.

2.06 OUTLET BOXES

A. Clothes Washer Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
3. Faucet: Combination, valved fitting or separate hot- and cold-water, valved fittings complying with ASME A112.18.1. Include garden-hose thread complying with ASME B1.20.7 on outlets.
4. Supply Shutoff Fittings: Ball valves, copper, water tubing.
5. Drain: Standpipe and P-trap for direct waste connection to drainage piping. Refer to drawings for size required.
6. Inlet Hoses: Two 60-inch- long, rubber household clothes washer inlet hoses with female, garden-hose-thread couplings. Include rubber washers.
7. Drain Hose: One 48-inch- long, rubber household clothes washer drain hose with hooked end.

B. Icemaker Outlet Boxes:

1. Mounting: Recessed.
2. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Supply Shutoff Fitting: Ball valves and NPS 1/2 copper, water tubing.

2.07 HOSE BIBBS

A. Hose Bibbs:

1. Standard: ASME A112.18.1 for sediment faucets.
2. Body Material: Bronze.
3. Seat: Bronze, replaceable.
4. Supply Connections: Full line size as indicated on the drawings, threaded or soldered joints.
5. Outlet Connection: Garden-hose thread complying with ASME B1.20.7.
6. Pressure Rating: 125 psig.
7. Vacuum Breaker: Integral, nonremovable, drainable, hose-connection vacuum breaker complying with ASSE 1011.
8. Finish for Equipment Rooms: Rough bronze, or chrome or nickel plated.
9. Finish for Finished Rooms: Chrome or nickel plated.
10. Operation for Equipment Rooms: Wheel handle or operating key.
11. Operation for Finished Rooms: Wheel handle or Operating key.
12. Include operating key with each operating-key hose bibb.
13. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.08 WALL HYDRANTS

A. Nonfreeze Wall Hydrants:

1. Standard: ASME A112.21.3M for concealed-outlet, self-draining wall hydrants.
2. Pressure Rating: 125 psig.
3. Operation: Loose key.
4. Casing and Operating Rod: Of length required to match wall thickness. Include wall clamp.
5. Inlet: Full line size as indicated on the drawings.
6. Outlet: Concealed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
7. Box: Deep, flush mounting with cover.
8. Box and Cover Finish: Polished nickel bronze.
9. Outlet: Exposed, with integral vacuum breaker and garden-hose thread complying with ASME B1.20.7.
10. Nozzle and Wall-Plate Finish: Polished nickel bronze.
11. Operating Keys(s): Two with each wall hydrant.

2.9 WATER HAMMER ARRESTERS

A. Water Hammer Arresters:

1. Standard: ASSE 1010 or PDI-WH 201.
2. Type: Copper tube with piston.
3. Size: ASSE 1010, Sizes AA and A through F or PDI-WH 201, Sizes A through F.
4. Provide at all locations as described under installation section.

2.10 TRAP-SEAL PRIMER VALVES

A. Supply-Type, Trap-Seal Primer Valves:

1. Standard: ASSE 1018.
2. Pressure Rating: 125 psig minimum.
3. Body: Bronze.
4. Inlet and Outlet Connections: NPS 1/2 threaded, union, or solder joint.
5. Gravity Drain Outlet Connection: NPS 1/2 threaded or solder joint.
6. Finish: Chrome plated, or rough bronze for units used with pipe or tube that is not chrome finished.

2.11 EXPANSION TANKS

- A. Equal to Watts Deta diaphragm type pre-pressurized expansion tanks welded steel construction, tested and stamped by ASME for working pressure of 125 psig and precharged to the minimum operating pressure. Provide a minimum of 15 gallon expansion tank unless otherwise sized on the drawings. Diaphragm shall be field replaceable.

PART 3: EXECUTION

3.01 INSTALLATION

- A. Refer to Division 22 Section "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 breaks 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 gages 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 nonfreeze, nondraining-type post hydrants set in concrete or pavement.
- J. Install freeze-resistant yard hydrants with riser pipe set in concrete or pavement. Do not encase canister in concrete.
- K. Install water hammer arresters in water piping according to PDI-WH 201. Provide and install a water hammer arrester in an accessible location at the end of each water main, at the top of all main water supply risers, near individual special equipment, at water closet bathroom groups and where also specifically shown on the drawings. Where required, provide suitable recessed boxes with access panels.
- L. Install air vents at high points of water piping. Install drain piping and discharge onto floor drain.

- M. 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.
- N. Install drainage-type, trap-seal primer valves as lavatory trap with outlet piping pitched down toward drain trap a minimum of 1 percent, and connect to floor-drain body, trap, or inlet fitting.

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 "Grounding and Bonding for Electrical Systems."
- C. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

- A. Perform the following tests and prepare test reports:
 - 1. Test each pressure vacuum breaker on reduced-pressure-principle 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.

3.04 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 temperature-actuated water mixing valves.

END OF SECTION 22 11 19

SECTION 22 13 16

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

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.
- B. Related Sections include the following:
 - 1. Division 22 Section "Sanitary Sewerage Pumps."
 - 2. Division 22 Section "Chemical Waste Systems" for chemical-waste and vent piping systems.

1.03 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

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 EXTRA MATERIALS

- A. Provide material and installation costs for (10) additional 4" clevis hangers with insulation saddles and all associated rods, clips, bolts, supports, and building attachments for 4" insulated piping. Actual routing, installation and sizes are to be field verified at location required and ordered only after approval from the Engineer.

1.06 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For pipe, tube, fittings, and couplings.
- C. Field quality control inspection and test reports.

1.07 QUALITY ASSURANCE

A. Comply with the following Codes and Standards:

1. Plumbing Code Compliance: Comply with applicable State Codes.
2. ASTM A 888: Standard Specifications for Hubless Cast Iron Soil Pipe and Fittings.
3. ASTM A 74: Standard Specifications for Hub and Spigot Cast Iron Soil Pipe and Fittings.
4. ASTM C 564: Standard Specifications for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
5. ASTM C 1277: Standard Shielded Couplings for Hubless Cast Iron Pipe and Fittings.
6. ASTM C 1540: Heavy duty shielded couplings for Hubless Cast Iron Pipe and Fittings.
7. ASTM E 84: Standard Specifications for Surface Burning Characteristics

B. Piping material shall bear label, stamp, or other markings of specified testing agency.

PART 2: PRODUCTS

2.01 PIPING MATERIALS

A. Hubless Cast Iron Soil Pipe and Fittings: Conform to the requirements of ASTM A 74 and ASTM A888/CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.

1. Standard shielded couplings: Conform to ASTM C1277 assembly. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
2. Heavy duty shielded couplings: Conform to ASTM C1540. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
3. No-Hub Couplings: No-Hub couplings shall conform to CIPI Standard 310 (most current addition) and shall be listed by NSF International

B. Service Weight Hub and Spigot Cast Iron Soil Pipe and Fittings: Conform to the requirements of ASTM A 74 and ASTM A888/CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.

1. Standard shielded couplings: Conform to ASTM C1277 assembly. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
2. Heavy duty shielded couplings: Conform to ASTM C1540. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
3. No-Hub Couplings: No-Hub couplings shall conform to CIPI Standard 310 (most current addition) and shall be listed by NSF International

C. Galvanized Steel Pipe and Fittings: Conform to ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40.

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.

D. PVC sewer pipe and fittings. Conform to ASTM D2665 for pipe and fittings with solvent welded joints using solvents conforming to ASTM D2564.

E. Copper Tube: ASTM B 88, Type L Water Tube, drawn temper with ASTM B16.22 wrought copper solder joint fittings.

PART 3: EXECUTION

3.01 PIPE APPLICATIONS

- A. Above Ground: Install hubless cast iron soil pipe and fittings with heavy duty shielded couplings.
- B. Below Ground: Install PVC sewer pipe and fittings.
- C. Indirect Waste: Install Type L, drawn copper tube with wrought copper fittings and solder joints.
- D. Forced Main: Install Schedule 40 galvanized steel pipe and fittings.

3.02 EXAMINATION

- A. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- B. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.
- C. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.
- D. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.
- E. Review soil testing information provided to verify conditions are suitable for piping installations.
- F. Do not proceed until unsatisfactory conditions have been corrected.

3.03 UNDERGROUND PIPE INSTALLATION

- A. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.
- B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.
- C. Shape bottom of trench to fit bottom $\frac{1}{2}$ of the circumference of pipe. Fill unevenness with tamped granular sand backfill. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.
- D. Install underground building drains to conform with State Plumbing Code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual and Handbook. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- E. Install building drain pitched down at minimum slope of 1/4" per foot (2 percent) for all piping.
- F. Extend building drain to connect to sewer piping, of size and in location indicated for service entrance to building. Sewer piping is specified in a separate section of Division 2.
- G. Install sleeve and mechanical sleeve seal through foundation wall for watertight installation.
- H. Install 1" thick extruded polystyrene over underground building drain piping not under building. Width of insulation shall extend minimum of 12" beyond each side of pipe. Install directly over, and center on pipe center line.
- I. Make changes of direction using appropriate 45 degree wyes or long sweep bends. No change of direction in flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

3.04 JOINING PIPES AND FITTINGS

- A. Cast-Iron Soil Pipe: Hubless joints shall be supported and restrained in accordance with ASTM 1540/CISPI 310 standards.
- B. Soldered Joints: Use ASTM B813, water-flushable, lead-free flux; ASTM B32, lead-free-alloy solder, and ASTM B828 procedures, unless otherwise indicated.

3.05 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Install individual, straight, horizontal piping runs: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: MSS SP-69 and MSS SP-89, field-fabricated trapeze pipe hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor. Support vertical cast iron piping at a minimum of every 15 feet. Support vertical copper tubing at a minimum every 10 feet.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.
- E. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4"	4	4	3/8
1" to 2"	4	4	3/8
2 1/2" to 4"	4	4	1/2
5" and Greater	4	4	7/8

- F. All above grade horizontal plastic/PVC piping shall be supported at a maximum spacing no greater than 32 inches.
- G. Make changes in direction for drainage and vent piping using appropriate 45 degree wyes, half-wyes, or long sweep quarter, sixth, eighth, or sixteenth bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn tees where two fixtures are installed back to back and have a common drain. Straight tees, elbows, and crosses may be used on vent lines. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

3.06 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.

3.07 FIELD QUALITY CONTROL

A. Inspections:

1. Do not enclose, cover, or put into operation drainage and vent piping system until it has been inspected and approved by the authority having jurisdiction.
2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests in accordance with State and Local code requirements in the presence of the plumbing official.
 - a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the Minnesota Plumbing Code.
3. Reinspections: Whenever the piping system fails to pass the test or inspection, make the required corrections, and arrange for reinspected by the plumbing official.
4. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test:

1. Test for leaks and defects all new drainage and vent piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.
3. In the absence of State or Local code requirements, the following minimum level of testing shall be performed. Drainage and Venting System Testing Procedures:
 - a. Rough Plumbing: Except for outside leaders and perforated or open jointed drain tile, test the piping of plumbing drainage and venting systems upon completion of the rough piping installation as follows:
 - 1) Cast Iron Piping Systems:
 - a. Attach an air compressor or testing apparatus to any suitable opening and close all other inlets and outlets to the system by means of proper testing plugs. Plaster of paris shall not be used in roof terminals. Air shall be forced into the system until there is a uniform pressure of five pounds per square inch on the portion of the system being tested. The pressure shall remain constant for 15 minutes without the addition of air.
 - 2) Thermoplastic Piping Systems:
 - b. Tightly close all openings in the piping system, and fill with water to the point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before the inspection starts through completion of the inspection. Inspect all joints for leaks. The contractor shall pre-test the systems with air when necessary to avoid possible damage to finished materials and surfaces.

- b. Finished Plumbing: After the plumbing fixtures have been set and their traps filled with water, their connections shall be tested and proved gas and water-tight. Plug the stack openings on the roof and building drain where it leaves the building, and introduce air into the system equal to a pressure of 1" water column. Use a "U" tube or manometer inserted in the trap of a water closet to measure this pressure. Air pressure shall remain constant without the introduction of additional air throughout the period of inspection. Inspect all plumbing fixture connections for gas and water leaks.
- 4. Repair all leaks and defects using new materials and re-test system or portion thereof until satisfactory results are obtained.
- 5. Prepare reports for all tests and required corrective action.

3.08 ADJUSTING AND CLEANING

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

3.09 PROTECTION

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

END OF SECTION 22 13 16

SECTION 22 13 19

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

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.
- B. Related Sections include the following:
 - 1. Division 22 Section "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 "Plumbing Fixtures" for specialties provided with plumbing fixtures and requiring installation.

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. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and accessories for the following:
 - 1. Floor drains.
 - 2. Trench drains.
 - 3. Grease interceptors.
 - 4. Oil interceptors.
 - 5. Solids interceptors.
- 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. 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 CLEANOUTS

- A. Metal Cleanouts:
 - 1. Standard: ASME A112.36.2M cast iron for cleanout test tee.
 - 2. Size: Same as connected drainage piping.
 - 3. Body Material: Match connected piping material and connection method.
 - 4. Closure: Countersunk plug.
 - 5. Options – Floor Cleanouts
 - a. Finished floors with asphalt, vinyl, rubber or other composition tile: Bronze plug cleanout with nickel bronze frame and recessed cover. Josam 58010-12-22.
 - b. Unfinished floors and traffic areas: Bronze plug cleanout with cast iron frame and cover. Josam 58000-5-22.

- c. Finished walls and ceilings: Provide threaded bronze plug with seating flanges and four (4) square lugs for plug removal. Install plug with lead gasket. Provide nickel bronze square frame and cover with minimum opening size of 6"x 6". Josam 58640.
 - d. Unfinished area waste stacks: Provide threaded bronze plug with seating flange and four (4) square lugs for plug removal. Install plug with lead gasket.
 - e. Carpeted areas: Provide Josam 58000-14 with carpet marker.
 - f. Closure: Brass plug with straight threads and gasket.
 - g. Adjustable Housing Material: Cast iron with threads.
 - h. Frame and Cover Material:
 - 1) Finished Areas: Polished bronze.
 - 2) Unfinished Areas: Rough bronze.
 - i. Carpeted Areas: Stainless steel carpet marker with vandalproof screw.
6. Options – Wall Cleanouts
- a. Closure: Countersunk brass plug.
 - b. Closure Size: Same as cleanout size.
 - c. Wall Access: Round, flat, chrome plated brass coverplate with screw.

2.02 FLOOR DRAINS

- A. Subject to compliance with requirements, provide drainage systems form one of the following:
- 1. Josam Mfg. Co.
 - 2. Sioux Chief Mfg. Co.
 - 3. Tyler Pipe; Subs, of Tyler Corp.
 - 4. Zurn Industries Inc.; Hydromechanics Div.
 - 5. Watts Regulator Company
- B. All floor drains on grade shall be supplied with backwater valves unless otherwise noted
- C. General: Provide floor drains of size as indicated on drawings; and type, including features as scheduled.

2.03 ROOF FLASHING ASSEMBLIES

- A. Roof Flashing Assemblies:
- B. Description: Manufactured assembly made of 6.0-lb/sq. ft. thick, lead flashing collar and skirt extending at least 8 inches from pipe, with galvanized-steel boot reinforcement and counterflashing fitting.
- 1. Extended Vent Cap: With field-installed, vandal-proof vent cap.

2.04 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

- A. 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: 4-inch minimum water seal.
- b. NPS 2-1/2 and Larger: 5-inch minimum water seal.

B. 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 side inlet.

C. 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.

D. 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 2 inches 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.

E. 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.

F. 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.

2.05 FLASHING MATERIALS

- A. Lead Sheet: ASTM B 749, Type L51121, copper bearing, with the following minimum weights and thicknesses, unless otherwise indicated:
1. General Use: 4.0-lb/sq. ft., 0.0625-inch thickness.
 2. Vent Pipe Flashing: 3.0-lb/sq. ft., 0.0469-inch thickness.
 3. Burning: 6-lb/sq. ft., 0.0938-inch thickness.

- B. 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..
- C. 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 hot-dip galvanized, mill-phosphatized finish for painting if indicated.
- D. Elastic Membrane Sheet: ASTM D 4068, flexible, chlorinated polyethylene, 40-mil minimum thickness.
- E. Fasteners: Metal compatible with material and substrate being fastened.
- F. Metal Accessories: Sheet metal strips, clamps, anchoring devices, and similar accessory units required for installation; matching or compatible with material being installed.
- G. Solder: ASTM B 32, lead-free alloy.
- H. Bituminous Coating: SSPC-Paint 12, solvent-type, bituminous mastic.

PART 3: EXECUTION

3.01 INSTALLATION

- A. Refer to Division 22 Section "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. Use NPS 4 for larger drainage piping unless larger cleanout is indicated.
 - 2. Locate at each change in direction of piping greater than 45 degrees.
 - 3. An additional cleanout shall be provided in a drainage line for aggregate horizontal change of direction exceeding 135 degrees.
 - 4. Locate at minimum intervals of 50 feet for piping NPS 3 and smaller and 100 feet for larger piping.
 - 5. Locate a building cleanout before exiting the building.
 - 6. 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. Provide a cleanout at its upper terminal for each horizontal drain branch, including floor drain branches.
- F. Provide a cleanout at each waste and vent piping connection where new piping connects to existing for testing.

- G. Provide cleanouts whether or not specifically shown on the drawings in accordance with Minnesota Rules, Chapter 4714, Section 707.4
- H. Provide the following cleanouts whether or not specifically shown on the drawings (Refer to Minnesota Plumbing Code section 4715.1000).
 - 1. Provide a cleanout between the building drain and the building sewer.
 - 2. A cleanout shall be provided at or near the foot of each vertical riser.
 - 3. A cleanout shall be provided at or near the foot of all sanitary and vent piping locations where piping comes out of the ground.
 - 4. Each horizontal branch drain pipe shall be provided with a cleanout at its upper terminal.
 - 5. Floor set fixtures shall be provided with an integral cleanout or a cleanout installed as close as possible to the fixture on the horizontal branch serving the fixture.
 - 6. Provide a cleanout on a common vertical fixture drain or common vent serving two fixture traps that connect to a vertical drain at the same level.
 - 7. Cleanouts shall be the same nominal size, up to 4 inches, as the pipe serving the fixture.
 - 8. Distance between cleanouts in horizontal piping shall not exceed 50 feet for piping 3 inches or smaller and not over 100 feet for 4 inches and larger.
 - 9. Provide a Cleanout at all increases in pipe size.(i.e. 2" to 3" and 3" to 4", etc)
 - 10. Cleanouts shall be installed in accessible locations.
- I. 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.
 - 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.
- J. Install roof flashing assemblies on sanitary stack vents and vent stacks that extend through roof.
- K. Install flashing fittings on sanitary stack vents and vent stacks that extend through roof.
- 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 wood-blocking reinforcement for wall-mounting-type specialties.
- R. 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.
- B. Install piping adjacent to equipment to allow service and maintenance.
- C. Grease Interceptors: Connect inlet and outlet to unit, and connect flow-control fitting and vent to unit inlet piping. Install valve on outlet of automatic drawoff-type unit. Provide body manhole extension as required to install cover flush at finished floor level. Coordinate exact inlet invert elevations prior to ordering.
- D. Flammable Waste Interceptors: Connect inlet, outlet, vent, and gravity drawoff piping to unit; flow-control fitting and vent to unit inlet piping; and gravity drawoff and suction piping to oil storage tank. Provide body manhole extension as required to install cover flush at finished floor level. Coordinate exact inlet invert elevations prior to ordering.

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. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 - 2. 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. Fabricate and install flashing and pans, sumps, and other drainage shapes.

3.04 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect field-assembled their installation, including piping and electrical connections, and to assist in testing.
- 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.

3.05 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.

3.06 DEMONSTRATION

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

END OF SECTION 22 13 19

SECTION 22 14 13
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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

1.02 SUMMARY

- A. This Section includes the following storm drainage piping inside the building:

1. Pipe, tube, and fittings.
2. Special pipe fittings.

- B. Related Sections include the following:

1. Division 22 Section "Sump Pumps."

1.03 DEFINITIONS

- A. PVC: Polyvinyl chloride plastic.

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.
2. Storm Drainage, Force-Main Piping: 100 psig.

1.05 EXTRA MATERIALS

- A. Provide material and installation costs for (10) additional 6" clevis hangers with insulation saddles and all associated rods, clips, bolts, supports, and building attachments for 6" insulated piping. Actual routing, installation and sizes are to be field verified at location required and ordered only after approval from the Engineer.

1.06 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product Data: For pipe, tube, fittings, and couplings.
- C. Field quality control inspection and test reports.

1.07 QUALITY ASSURANCE

- A. Comply with the following Codes and Standards:

1. Plumbing Code Compliance: Comply with applicable State Codes.
 2. ASTM A 888: Standard Specifications for Hubless Cast Iron Soil Pipe and fittings.
 3. ASTM A 74: Standard Specifications for Hub and Spigot Cast Iron Soil Pipe and Fittings.
 4. ASTM C 564: Standard Specifications for Rubber Gaskets for Cast Iron Soil Pipe and Fittings.
 5. ASTM C 1277: Standard Shielded Couplings for Hubless Cast Iron Pipe and Fittings.
 6. ASTM C 1540: Heavy duty shielded couplings for Hubless Cast Iron Soil Pipe and Fittings.
- B. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- C. 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.

1.08 DELIVERY, STORAGE, AND HANDLING

- A. Store pipe in a manner to prevent sagging and bending.
- B. Do not store PVC or ABS pipe and fittings in direct sunlight for long periods.

1.09 SEQUENCING AND SCHEDULING

- A. Coordinate the installation of roof drains, flashing, and roof penetrations.
- B. Coordinate flashing materials installation for roofing, waterproofing, and adjoining substrate work.
- C. Coordinate with installation of storm sewer systems as necessary to interface building drains with drainage piping systems.

PART 2: PRODUCTS

2.01 PIPING MATERIALS

- B. Hubless Cast Iron Soil Pipe and Fittings: Conform to the requirements of ASTM A 74 and ASTM A888/CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.
1. Standard shielded couplings: Conform to ASTM C1277 assembly. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
 2. Heavy duty shielded couplings: Conform to ASTM C1540. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
 3. No-Hub Couplings: No-Hub couplings shall conform to CIPI Standard 310 (most current addition) and shall be listed by NSF International
- C. Service Weight Hub and Spigot Cast Iron Soil Pipe and Fittings: Conform to the requirements of ASTM A 74 and ASTM A888/CISPI 301. Pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute and be listed by NSF International.
1. Standard shielded couplings: Conform to ASTM C1277 assembly. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
 2. Heavy duty shielded couplings: Conform to ASTM C1540. Provide with stainless steel metal shield, stainless steel bands and tightening devices and ASTM C564 rubber sleeve with integral center pipe stop.
 3. No-Hub Couplings: No-Hub couplings shall conform to CIPI Standard 310 (most current addition) and shall be listed by NSF International

- A. Service Weight Hub and Spigot Cast Iron Soil Pipe and Fittings: Conform to ASTM A 74 and mark with the certified trademark of the independent third party/certification agency. Connecting gaskets shall conform to ASTM C564.3.
- B. Galvanized Steel Pipe and Fittings: Conform to ASTM A 53/A 53M, Type E or S, Grade A or B, Schedule 40.
 - 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.
- C. PVC sewer pipe and fittings. Conform to ASTM D2665 for pipe and fittings with solvent welded joints using solvents conforming to ASTM D2564.
- D. Copper Tube: ASTM B 88, Type L Water Tube, drawn temper with ASTM B16.22 wrought copper solder joint fittings.

PART 3: EXECUTION

3.01 PIPE APPLICATIONS

- D. Above Ground: Install hubless cast iron soil pipe and fittings with heavy duty shielded couplings.
- E. Below Ground: Install PVC sewer pipe and fittings.
- F. Indirect Waste: Install Type L, drawn copper tube with wrought copper fittings and solder joints.
- G. Forced Main: Install Schedule 40 galvanized steel pipe and fittings.

3.02 EXAMINATION

- A. Verify all dimensions by field measurements. Verify that all drainage and vent piping and specialties may be installed in accordance with pertinent codes and regulations, the original design, and the referenced standards.
- B. Verify all existing grades, inverts, utilities, obstacles, and topographical conditions prior to installations.
- C. Examine rough-in requirements for plumbing fixtures and other equipment having drain connections to verify actual locations of piping connections prior to installation.
- D. Examine walls, floors, roof, and plumbing chases for suitable conditions where piping and specialties are to be installed.
- E. Review soil testing information provided to verify conditions are suitable for piping installations.
- F. Do not proceed until unsatisfactory conditions have been corrected.

3.03 UNDERGROUND PIPE INSTALLATION

- A. Grade trench bottoms to provide a smooth, firm, and stable foundation, free from rock, throughout the length of the pipe.
- B. Remove unstable, soft, and unsuitable materials at the surface upon which pipes are to be laid and backfill with clean sand or pea gravel to indicated invert elevation.

- C. Shape bottom of trench to fit bottom $\frac{1}{2}$ of the circumference of pipe. Fill unevenness with tamped granular sand backfill. At each pipe joint dig bell holes to relieve the bell of the pipe of all loads, and to ensure continuous bearing of the pipe barrel on the foundation.
- D. Install underground building drains to conform with State Plumbing Code, and in accordance with the Cast Iron Soil Pipe Institute Engineering Manual and Handbook. Lay underground building drains beginning at low point of systems, true to grades and alignment indicated with unbroken continuity of invert. Place bell ends of piping facing upstream. Install required gaskets in accordance with manufacturer's recommendations for use of lubricants, cements, and other special installation requirements. Maintain swab or drag in line and pull past each joint as it is completed.
- E. Install building drain pitched down at minimum slope of 1/4" per foot (2 percent) for all piping.
- F. Extend building drain to connect to sewer piping, of size and in location indicated for service entrance to building. Sewer piping is specified in a separate section of Division 2.
- G. Install sleeve and mechanical sleeve seal through foundation wall for watertight installation.
- H. Install 1" thick extruded polystyrene over underground building drain piping not under building. Width of insulation shall extend minimum of 12" beyond each side of pipe. Install directly over, and center on pipe center line.
- I. Make changes of direction using appropriate 45 degree wyes or long sweep bends. No change of direction in flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

3.04 JOINING PIPES AND FITTINGS

- A. Cast-Iron Soil Pipe: Hubless joints shall be supported and restrained in accordance with ASTM 1540/CISPI 310 standards.
- B. Soldered Joints: Use ASTM B813, water-flushable, lead-free flux; ASTM B32, lead-free-alloy solder, and ASTM B828 procedures, unless otherwise indicated.

3.05 HANGER AND SUPPORT INSTALLATION

- A. Pipe hangers and supports are specified in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment." Install the following:
 - 1. Vertical Piping: MSS Type 8 or Type 42, clamps.
 - 2. Install individual, straight, horizontal piping runs: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: MSS SP-69 and MSS SP-89, field-fabricated trapeze pipe hangers.
- B. Install supports according to Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment."
- C. Support vertical piping and tubing at base and at each floor. Support vertical cast iron piping at a minimum of every 15 feet. Support vertical copper tubing at a minimum every 10 feet.
- D. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

- H. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to ¾"	4	4	3/8
1" to 2"	6	6	3/8
2½" to 4"	6	6	½
5" and Greater	4	4	7/8

- E. Make changes in direction for drainage and vent piping using appropriate 45 degree wyees, half-wyees, or long sweep quarter, sixth, eighth, or sixteenth bends. Sanitary tees or short quarter bends may be used on vertical stacks of drainage lines where the change in direction of flow is from horizontal to vertical, except use long-turn tees where two fixtures are installed back to back and have a common drain. Straight tees, elbows, and crosses may be used on vent lines. No change in direction of flow greater than 90 degrees shall be made. Where different sizes of drainage pipes and fittings are connected, use proper size, standard increasers and reducers. Reduction of the size of drainage piping in the direction of flow is prohibited.

3.06 VALVE INSTALLATION

- A. General valve installation requirements are specified in Division 22 Section "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 and smaller.
 2. Install gate valve for piping NPS 2-1/2 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 and where indicated on the drawings.
1. Horizontal Piping: Horizontal backwater valves.
 2. Install backwater valves in accessible locations.
 3. Backwater valve are specified in Division 22 Section "Storm Drainage Piping Specialties."

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. Pump Pumps: To sump pump discharge.

3.08 FIELD QUALITY CONTROL

- A. Inspections:
1. Do not enclose, cover, or put into operation drainage piping system until it has been inspected and approved by the authority having jurisdiction.

2. During the progress of the installation, notify the plumbing official having jurisdiction, at least 24 hours prior to the time such inspection must be made. Perform tests in accordance with State and Local code requirements in the presence of the plumbing official.
 - a. Rough-in Inspection: Arrange for inspection of the piping system before concealed or closed-in after system is roughed-in, and prior to setting fixtures.
 - b. Final Inspection: Arrange for a final inspection by the plumbing official to observe the tests specified below and to insure compliance with the requirements of the Minnesota Plumbing Code.
3. Reinspections: Whenever the piping system or portion thereof, fails to pass the test or inspection, make the required corrections, and arrange for reinspection by the plumbing official.
4. Reports: Prepare inspection reports, signed by the plumbing official.

B. Piping System Test:

1. Test for leaks and defects all new drainage piping systems and parts of existing systems, which have been altered, extended or repaired. If testing is performed in segments, submit a separate report for each test, complete with a diagram of the portion of the system tested.
2. Leave uncovered and unconcealed all new, altered, extended, or replaced drainage piping until it has been tested and approved. Expose all such work for testing, that has been covered or concealed before it has been tested and approved.
1. In the absence of State or Local code requirements, the following minimum level of testing shall be performed. Drainage and Venting System Testing Procedures:
 - a. Rough Plumbing: Except for outside leaders and perforated or open jointed drain tile, test the piping of plumbing drainage and venting systems upon completion of the rough piping installation as follows:
 - 1) Cast Iron Piping Systems:
 - a. Attach an air compressor or testing apparatus to any suitable opening and close all other inlets and outlets to the system by means of proper testing plugs. Plaster of paris shall not be used in roof terminals. Air shall be forced into the system until there is a uniform pressure of five pounds per square inch on the portion of the system being tested. The pressure shall remain constant for 15 minutes without the addition of air.
 - 2) Thermoplastic Piping Systems:
 - a) Tightly close all openings in the piping system, and fill with water to the point of overflow, but not less than 10 feet head of water. Water level shall not drop during the period from 15 minutes before the inspection starts through completion of the inspection. Inspect all joints for leaks. The contractor shall pre-test the systems with air when necessary to avoid possible damage to finished materials and surfaces.
3. Repair all leaks and defects using new materials and re-test system or portion thereof until satisfactory results are obtained.
4. Prepare reports for all tests and required corrective action.

3.09 ADJUSTING AND CLEANING

- A. Clean interior of piping. Remove dirt and debris as work progresses.
- B. Clean drain strainers and domes. Remove dirt and debris.

3.10 PROTECTION

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

END OF SECTION 22 14 13

SECTION 22 14 23

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

1.02 SUMMARY

- A. This Section includes the following storm drainage piping specialties:
 - 1. Backwater valves.
 - 2. Cleanouts.
 - 3. Roof drains.
 - 4. Miscellaneous storm drainage piping specialties.
 - 5. Flashing materials.
- B. Related Sections include the following:
 - 1. Division 22 Section "Sanitary Waste Piping Specialties" for backwater valves, floor drains, trench drains connected to sanitary sewer, grease interceptors, and oil 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. PUR: Polyurethane plastic.
- H. PVC: Polyvinyl chloride plastic.

1.04 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. 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 with the following features:
1. Standard: ASME A112.14.1.
 2. Size: Same as connected piping.
 3. Body: Cast iron.
 4. Cover: Cast iron with bolted or threaded access check valve.
 5. End Connections: Match pipe material and connections to storm system..
 6. Type Check Valve: Removable, bronze, swing check, factory assembled or field modified to hang closed.
 7. Extension: ASTM A 74, Service class; full-size, cast-iron, soil-pipe extension to field-installed cleanout at floor; replaces backwater valve cover.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Josam Company; Josam Div.
 2. MIFAB, Inc.
 3. Smith, Jay R. Mfr. Co.; Division of Smith Industries, Inc.
 4. Tyler Pipe; Wade Div.
 5. Watts Drainage Products Inc.
 6. Zurn Plumbing Products Group; Specification Drainage Operation.

2.02 CLEANOUTS

- B. Metal Cleanouts:
1. Standard: ASME A112.36.2M cast iron for cleanout test tee.
 2. Size: Same as connected drainage piping.
 3. Body Material: Match connected piping material and connection method.
 4. Closure: Countersunk plug.
 5. Options – Floor Cleanouts
 - a. Closure: Brass plug with straight threads and gasket.
 - b. Adjustable Housing Material: Cast iron with threads.
 - c. Frame and Cover Material:
 - 1) Finished Areas: Polished bronze.
 - 2) Unfinished Areas: Rough bronze.
 - 3) Carpeted Areas: Stainless steel carpet marker with vandalproof screw.
 6. Options – Wall Cleanouts
 - a. Closure: Countersunk brass plug.
 - b. Closure Size: Same as cleanout size.
 - c. Wall Access: Round, flat, chrome plated brass coverplate with screw.

2.03 ROOF DRAINS

- A. Roof Drains
1. Josam Mfg. Co.
 2. Smith (Jay R) Mfg. Co.
 3. Tyler Pipe; Subs. of Tyler Corp.

4. Zurn Industries Inc; Hydromechanics Div.
5. Watts Regular Company.

B. Roof Drains (Type RD-1):

1. Equal to Josam 21500
2. Standard: ASME A112.21.2M.
3. Pattern: Roof drain.
4. Body Material: Cast iron.
5. Dimensions of Body: Refer to drawings.
6. Combination Flashing Ring and Gravel Stop: Required.
7. Outlet: Bottom.
8. Dome Material: Cast iron with vandal proof fasteners.
9. Underdeck Clamp: Required.
10. Adjustable Extension Sleeve: Required.

C. Overflow Roof Train (Type ORD-1): Provide same as type RD-1 except with 4" collar.

D. Roof Drain Down Spout (DS-1): Provide cast iron exterior wall down spout equal to Josam 25010.

2.04 MISCELLANEOUS STORM DRAINAGE PIPING SPECIALTIES

A. Conductor Nozzles:

1. Description: Bronze body with threaded inlet and bronze wall flange with mounting holes.
2. Size: Same as connected conductor.

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 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 "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. Use NPS 4 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 and smaller and 100 feet for larger piping.
 4. Locate a building cleanout before exiting the building.
 5. A cleanout shall be provided at or near the foot of each vertical riser.
 6. Cleanouts shall be installed in accessible locations.
- C. For floor cleanouts for piping below floors, install cleanout deck plates with top flush with finished floor.
- D. Provide a cleanout at each waste and vent piping connection where new piping connects to existing for testing.
- E. For cleanouts located in concealed piping, install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall.
- 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. Install roof drains at low points of roof areas according to roof membrane manufacturer's written installation instructions. Roofing materials are specified in Division 07.
1. Install roof-drain flashing collar or flange so that there will be no leakage between drain and adjoining roofing. Maintain integrity of waterproof membranes where penetrated.
 2. Position roof drains for easy access and maintenance.
- H. Install sleeve flashing device with each riser and stack passing through floors with waterproof membrane.
- I. Install conductor nozzles at exposed bottom of conductors where they spill onto 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. Lead Sheets: Burn joints of lead sheets 6.0-lb/sq. ft., 0.0938-inch thickness or thicker. Solder joints of lead sheets 4.0-lb/sq. ft., 0.0625-inch thickness or thinner.
 2. 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 14 23

SECTION 22 40 00

PLUMBING FIXTURES

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 22 05 00 for additional equipment and project requirements

1.02 SUMMARY

- A. This Section includes:
 - 1. Water closets
 - 2. Urinals
 - 3. Flush valves
 - 4. Lavatories
 - 5. Stainless steel sinks
 - 6. Faucets
 - 7. Drains
 - 8. Wastes
 - 9. Service sinks
 - 10. Service receptors
 - 11. Water coolers
 - 12. Mixing valves
 - 13. Water filters
 - 14. Wall hydrants
 - 15. Supplies with angle stops
 - 16. Fixture by others
- B. Related Sections include the following:
 - 1. Division 22 Section "Domestic Water Piping Specialties" for backflow preventers, floor drains, and specialty fixtures not included in this Section.
- C. Products installed but not furnished under this Section include:
 - 1. Owner-supplied fixtures, as indicated.
 - 2. Accessories, appliances, appurtenances, and equipment specified in other sections, requiring plumbing services or fixture-related devices, as indicated.

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.

1.04 SUBMITTALS

- A. Refer to specification section 22 05 00 for additional requirements.
- B. Product data for each type of plumbing fixture specified, including fixture and trim, fittings, accessories, appliances, appurtenances, equipment, supports, construction details, dimensions of components, and finishes.
- C. Wiring diagrams for field-installed wiring of electrically operated units.
- D. Color Charts
- E. Operation and Maintenance Data: For plumbing fixtures to include emergency operation and maintenance manuals.

1.05 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. Faucet Washers and O-Rings: Equal to 10 percent of amount of each type and size installed.
 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 2 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. Flushometer Tank, Repair Kits: Equal to 5 percent of amount of each type installed, but no fewer than 2 of each type.
 6. Provide attic stock to the owner with one complete faucet and flushometer trim for each type of plumbing fixture installed and specified.
 7. Water-Closet Tank, Repair Kits: Equal to 5 percent of amount of each type installed.
 8. Toilet Seats: Equal to 5 percent of amount of each type installed.

1.06 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" as required by State Code 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. Lead Free Requirements: All plumbing pipes, fittings, valves, fixtures, and other components in systems providing water for human consumption shall be 'lead-free' in accordance with the "Reduction of Lead in Drinking Water Act" and the "Safe Drinking Water Act", where the term 'lead-free' is defined to mean – "not containing more than 0.2 percent lead when used with respect to solder and flux; and not more than a weighted average of 0.25 percent lead when used with respect to the wetted surfaces of pipes, pipe fittings, plumbing fittings, and fixtures."
- G. Select combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
- H. 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. Solid-Surface-Material Lavatories and Sinks: ANSI/ICPA SS-1.
 - 7. Stainless-Steel Commercial, Handwash Sinks: NSF 2 construction.
 - 8. Vitreous-China Fixtures: ASME A112.19.2M.
 - 9. Water-Closet, Flush Valve, Tank Trim: ASME A112.19.5.
 - 10. Water-Closet, Flushometer Tank Trim: ASSE 1037.
- I. 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.

J. Comply with the following applicable standards and other requirements specified for shower faucets:

1. Backflow Protection Devices for Hand-Held Showers: ASME A112.18.3M.
2. Combination, Pressure-Equalizing and Thermostatic-Control Antiscald 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 Antiscald Faucets: ASTM F 444.
9. Pipe Threads: ASME B1.20.1.
10. Pressure-Equalizing-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.
11. Sensor-Actuated Faucets and Electrical Devices: UL 1951.
12. Thermostatic-Control Antiscald Faucets: ASTM F 444 and ASSE 1016.

K. 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.

L. 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.

1.07 WARRANTY

A. Special Warranties: Manufacturer's standard form in which manufacturer agrees to repair or replace components of whirlpools that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Commercial Applications: One year from date of Substantial Completion.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver plumbing fixtures in manufacturer's protective packing, crating, and covering.

B. Store plumbing fixtures on elevated platforms in a dry location.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the following for each fixture type or component listed.
1. Vitreous China Fixtures:
 - a. American Standard
 - b. Sloan
 - c. Kohler
 - d. Zurn
 2. Stainless Steel Counter Sinks:
 - a. Elkay
 - b. Just
 3. Flushometer:
 - a. Sloan Optima
 4. Faucets:
 - a. Chicago
 - b. Delta
 - c. Zurn Aqua Spec
 - d. American Standard
 5. Mop Basin:
 - a. Fiat
 - b. Stern-Williams
 - c. Mustee
 - d. Acorn
 - e. Zurn
 6. Water Cooler:
 - a. Oasis
 - b. Sunroc
 - c. Halsey-Taylor
 - d. Elkay
 7. Enameled Cast Iron Fixtures:
 - a. American Standard
 - b. Sloan
 - c. Kohler
 - d. Zurn One
 8. ADA Trap Wrap:

- a. Truebro
- b. Handi Lav-Guard
- c. Brocer Products
- d. Trap Wrap
- e. Pro Wrap
- f. Zurn

9. Toilet Seats:

- a. Church
- b. Bereke
- c. Olsonite
- d. Sperzel
- e. Centoco

10. Plumbing Supports:

- a. Josam
- b. Wade
- c. Smith
- d. Zurn
- e. Watts

11. Mixing Valves:

- a. Delta Commercial
- b. Symmons
- c. Powers
- d. Leonard
- e. Lawler
- f. Haws

12. Traps and Supplies

- a. Zurn Traps and Supplies
- b. Chicago
- c. Brass Craft
- d. Central
- e. Royal
- f. Dearborn
- g. T&S

2.02 PLUMBING FIXTURES, GENERAL

- A. Provide plumbing fixtures and trim, fittings, other components, and supports as specified in "Plumbing Fixture Data Sheets" at the end of Part 3 of this Section.

2.03 FAUCETS

- A. Faucets General: Unless otherwise indicated, provide faucets that are cast brass with polished, heavy chrome-plate finish conforming to ASME A-112.18.1M. Lead content shall be less than 0.25%.

2.04 FITTINGS, EXCEPT FAUCETS

- A. Fittings General: Unless otherwise specified, provide fitting fabricated of brass, with polished heavy chrome plate finish.
- B. Escutcheons: Wall flange with set screw or sheet steel wall flange with friction clips, of depth adequate to conceal protruding roughing-in fittings.

2.05 SUPPLIES WITH ANGLE STOPS

- A. Construction: Polished chrome plated, precision-machined brass ball, one-piece brass body construction, blow-out proof brass stem. Plastic stems are not allowed. Lead content shall be less than 0.25%.
- B. Cartridge: Slow compression, renewable cartridges designed to close with water pressure.
- C. Supply Riser: 3/8" O.D. x 12" flexible copper, chrome plated supply riser.
- D. Handle: Removable, chrome plated, 2 1/4" metal loose key tee.
- E. Escutcheon: Chrome plated metal wall flange.
- F. Performance:
 - 1. 20-125 psi rated operating pressure.
 - 2. 40-140°F rated operating temperature.
- G. Codes: ASME A112.18.1M.

2.06 FLUSHOMETERS

- A. Provide flushometers compatible with fixtures, with features and of consumption indicated.
- B. Construction: Cast-brass body, brass or copper pipe or tubing inlet with wall flange and tailpiece with spud, screwdriver check stop, vacuum breaker, and brass lever handle actuation except where other variations are specified. Type shall be diaphragm operation except where other type is specified.
- C. Finish: Exposed metal parts shall be polished chrome-plated, except components installed in a concealed location may be rough brass or unfinished.
- D. The mechanical contractor shall verify all mounting heights and water/waste rough-in locations with architectural elevations prior to ordering equipment and/or installation. The contractor shall verify mounting requirements and clearances of flushometers with architectural grab bar locations. The contractor shall modify all mounting elevations as required to allow for installation of all grab bars and ADA requirements.
- E. Water Closet Flushometers: Furnish with the following features.
 - 1. Non-hold-open feature.
 - 2. Screw driver angle stop with seat bumper and cap.
 - 3. Metal oscillating handle actuation.
 - 4. Wall and spud flanges.
 - 5. Adjustable tailpiece.
 - 6. Vacuum breaker connection.
 - 7. Furnish flushometers with factory-set, field-adjustable water consumption per cycle:
 - a. Consumption: 1.6 gallons per flushing cycle.
- F. Urinal Flushometers: Furnish with the following features.

1. Non-hold-open feature.
2. Screw driver angle stop with cap.
3. Metal oscillating handle actuation.
4. Wall and spud flanges.
5. Adjustable tailpiece.
6. Vacuum breaker connection.
7. Furnish flushometers with factory-set, field-adjustable water consumption per cycle:
 - a. Consumption: 1.0 gallons per flushing cycle.

2.07 TOILET SEATS

- A. General: Provide toilet seats compatible with water closets, and of type, color, and features indicated.
- B. Toilet Seats: Heavy-duty, commercial/industrial type, elongated, open front, solid plastic, with self-sustaining check hinge, less cover.

2.8 WATER FILTER FOR WATER COOLERS

- A. Capacity of 3000 gallons, 1.5 GPM, 105 psi. Conform to NSF/ANSI 42 and 53 for chlorine taste, odor, particulate Class 1 and lead reduction. Filter shall be integral to water cooler and installed in the factory.

2.9 PLUMBING FIXTURE SUPPORTS

- A. Supports: ASME A112.6.1M, categories and types as required for wall-hanging fixtures specified, and wall reinforcement.
- B. Support categories are:
 1. Carriers: Supports for wall-hanging water closets and fixtures supported from wall construction. Water closet carriers shall have an additional faceplate and coupling when used for wide pipe spaces. Provide tiling frame or setting gage with carriers for wall-hanging water closets. Long barrel in vertical applications.
 2. Chair Carriers: Supports with steel pipe uprights for wall-hanging fixtures. Urinal chair carriers shall have bottom bearing plates.
 3. Chair Carriers, Heavy Duty: Supports with rectangular steel uprights for wall-hanging fixtures.
 4. Reinforcement: 2-inch by 4-inch wood blocking between studs or 1/4-inch by 6-inch steel plates attached to studs, in wall construction, to secure floor-mounted and special fixtures to wall.
- C. Support Types: Provide support of category specified, of type having features required to match fixture.
- D. Provide supports specified as part of fixture description, in lieu of category and type requirements above.
- E. Subject to compliance with requirements, provide plumbing fixture supports from one of the following:
 1. Josam Mfg. Co.
 2. Smith (Jay R.) Mfg. Co.
 3. Wade; Subs of Tyler Pipe Corp.
 4. Zurn Industries; Hydromechanics Division
 5. Watts Drainage

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine roughing-in for potable cold water and hot water supplies and soil, waste, and vent piping systems to verify actual locations of piping connections prior to installing fixtures.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Do not proceed until unsatisfactory conditions have been corrected.

3.02 APPLICATION

- A. Install plumbing fixtures and specified components, in accordance with designations and locations indicated on Drawings.
- B. Install supports for plumbing fixtures in accordance with categories indicated, and of type required:
 - 1. Carriers for following fixtures:
 - a. Wall-hanging water closets.
 - b. Wall-hanging fixtures supported from wall construction.
 - 2. Chair carriers for the following fixtures:
 - a. Wall-hanging urinals.
 - b. Wall-hanging lavatories and sinks.
 - c. Wall-hanging drinking fountains and electric water coolers.
 - 3. Heavy-duty chair carriers for the following fixtures:
 - a. Accessible lavatories.
 - b. Fixtures where specified.
 - 4. Reinforcement for the following fixtures:
 - a. Floor-mounted lavatories required to be secured to wall.
 - b. Floor-mounted sinks required to be secured to wall.
 - c. Recessed, box-mounted drinking fountains and water coolers.

3.03 INSTALLATION OF PLUMBING FIXTURES

- A. Install plumbing fixtures level and plumb, in accordance with fixture manufacturers' written installation instructions, roughing-in drawings, and referenced standards.
- B. Install floor-mounted, floor-outlet water closets with closet flanges and gasket seals.
- C. Install floor-mounted, back-outlet water closets with fittings and gasket seals.
- D. Install wall-hanging, back-outlet water closets with support manufacturer's tiling frame or setting gage.
- E. Install wall-hanging, back-outlet urinals with gasket seals.
- F. Fasten wall-hanging plumbing fixtures securely to supports attached to building substrate when supports are specified, and to building wall construction where no support is indicated.

- G. Fasten floor-mounted fixtures and special fixtures having holes for securing fixture to wall construction, to reinforcement built into walls.
- H. Fasten wall-mounted fittings to reinforcement built into walls.
- I. Fasten counter-mounting-type plumbing fixtures to casework.
- J. Secure supplies behind wall or within wall pipe space, providing rigid installation.
- K. Set shower receptors and mop basins in leveling bed of cement grout.
- L. Install stop valve in an accessible location in each water supply to each fixture.
- M. Install “cleanable” trap on fixture outlet except for fixtures having integral trap.
- N. All fixtures traps exposed shall be Adjustable “P” chrome plated brass trap.
- O. Install escutcheons at each wall, floor, and ceiling penetration in exposed finished locations and within cabinets and millwork. Use deep pattern escutcheons where required to conceal protruding pipe fittings.
- P. Seal fixtures to walls, floors, and counters using a sanitary-type, one-part, mildew-resistant, silicone sealant in accordance with sealing requirements specified in Division 7. Match sealant color to fixture color.
- Q. The mechanical contractor shall verify all mounting heights and water/waste rough-in locations with architectural elevations prior to ordering equipment and/or installation. The contractor shall verify mounting requirements and clearances of flushometers with architectural grab bar locations. The contractor shall modify all mounting elevations as required to allow for installation of all grab bars and ADA requirements.
- R. Provide insulation kit equal to Truebro Inc. model # 102 Handi-Lav Guard insulation for all exposed hot and cold water and waste piping and fittings.

3.04 CONNECTIONS

- A. Piping installation requirements are specified in other sections of Division 22 and 23. The Drawings indicate general arrangement of piping, fittings, and specialties. The following are specific connection requirements:
 1. Install piping connections between plumbing fixtures and piping systems and plumbing equipment specified in other sections of Division 22 and 23.
 2. Install piping connections indicated between appliances and equipment specified in other sections, direct connected to plumbing piping systems.

3.05 FIELD QUALITY CONTROL

- A. Inspect each installed fixture for damage. Replace damaged fixtures and components.
- B. Test fixtures to demonstrate proper operation upon completion of installation and after units are water pressurized. Replace malfunctioning fixtures and components, then retest. Repeat procedure until all units operate properly.

3.06 ADJUSTING AND CLEANING

- A. Operate and adjust faucets and controls. Replace damaged and malfunctioning fixtures, fittings, and controls.
- B. Operate and adjust disposers, hot water dispensers, and controls. Replace damaged and malfunctioning units and controls.

- C. Adjust water pressure at drinking fountains, electric water coolers, and faucets, shower valves, and flushometers having controls, to provide proper flow and stream.
- D. Replace washers or cartridges of leaking and dripping faucets and stops.
- E. Clean fixtures, fittings, and spout and drain strainers with manufacturers' recommended cleaning methods and materials.
- F. Review the data in Operating and Maintenance Manuals. Refer to Division 1 Section "Project Closeout."

3.07 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities, except when approved in writing by the Owner.
- C. Protect interceptors during construction period, to avoid clogging with construction materials and debris, and to prevent damage from construction debris and traffic.

3.08 PLUMBING FIXTURE SCHEDULE

General

- A. Item WC-1 - Water Closet (Wall Hung, Battery Operated Flush Valve, ADA Compliant)
 - 1) Fixture: American Standard #2257.101 "Afwall" elongated water saver water closet, white vitreous china, siphon jet action, 1 1/2" top spud, 1.6 GPF. Provide concealed toilet carrier.
 - 2) Seat: American Standard #5901.100SS solid plastic, open front with self-sustaining hinge for elongated bowl, white.
 - 3) Flush valve: Sloan Optima Plus G2 Model 8111 low consumption, battery operated flushometer.
- B. Item UR-1 - Urinal (Wall Hung, Battery Operated Flush Valve, ADA Compliant)
 - 1) Fixture: American Standard #6561.017 "Trimbrook" 1.0 GPH, white vitreous china, siphon jet, flushing rim, extended stall sides, 3/4" inlet top spud, 2" back outlet, supporting bolts. Mount fixture at ADA compliant height.
 - 2) Flush valve: Sloan Optima Plus G2 Model 8186-1 low consumption battery operated flushometer.
- C. Item L-1 – Wall Hung Lavatory (Manual Faucet, ADA Compliant)
 - 1) Fixture: American Standard #0355.012 "Lucerne" wall hung white vitreous china lavatory, 18-1/4" x 20-1/2", faucet holes on 4-inch centers, front overflow, concealed arms support.
 - 2) Faucet: Delta #501LF-HDF single handle, chrome plated faucet.
 - 3) Accessories: Provide 4-inch lavatory waste tailpiece, 1 1/4-inch diameter chrome plated grid strainer, chrome plated cast brass trap with cleanout plug and drain tubing with wall flange, 1/2-inch chrome plated angle valves and flex risers with wall flanges, supply and drain ADA insulation wrap. Provide Watts Thermostatic Mixing Valve LFUSG-B-M2.

D. Item SK-1 – Counter Set Stainless Steel Sink (15” x 17-1/2” x 5-1/2”, Gooseneck Faucet, Wristblade Handles, ADA Compliant)

- 1) Fixture: Elkay LRAD151755, type 304 stainless steel, 18 gauge, self-rimming, 3 ½-inch diameter outlet, two faucet holes, mounting hardware.
- 2) Faucet: Chicago Faucets #895-317GN2AE36ABCP chrome plated gooseneck faucet with wristblade handles and non-aerating outlet.
- 3) Accessories: Provide 4-inch lavatory waste tailpiece, 1 ¼-inch diameter chrome plated grid strainer, chrome plated cast brass trap and drain tubing with wall flange, ½-inch chrome plated angle valves and flex risers with wall flanges, supply and drain ADA insulation wrap. Provide Watts LFUSG-B mixing valve.

E. Item EWC-1 – Wall Hung Electric Water Cooler w/ Bottle Filling Station

- 1) Fixture: Elkay Model LZS8WSSK wall mounted electric water cooler and bottle filler with stainless steel cabinet and contoured basin, flexible bubbler to prevent accidental injuries; front push button operation, and an inline flow regulator. Cooling system shall be in cabinet and shall include a fin and tube type condenser with 4.3 watt permanently sealed and lubricated fan, ½ HP, R-134a compressor, with thermal overload protection, to cool 8 gallons per hour, with 90 degree ambient air, of water from 80 to 50 degrees F. Unit shall be assembled with lead free components. Provide mounting hardware. Refer to Architectural drawings for mounting height.
- 2) Waste: Removable, chrome plated brass strainer, 1 ¼” O.D. trap connection with 1 ¼” tailpiece.
- 3) Trap: Adjustable “P” chrome plated brass trap with 1 ½” 17 gauge tubing, drain to wall, ground swivel joints, clean-out, wall flange. Trap is to be concealed within cabinet.
- 4) Supply: 3/8” I.P.S. connection with 3/8” chrome plated angle valve with loose key stop and 3/8” copper flexible tube riser.

END OF SECTION 22 40 00

SECTION 23 05 00

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.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Coordination
 - 2. Interpretation of Plans
 - 3. Coordination Drawings.
 - 4. Cost Breakdown
 - 5. Substitutions and Prior Approval Requests
 - 6. Record Documents
 - 7. Maintenance Manuals
 - 8. Fire Safety Precautions
 - 9. Personal Safety Requirements
 - 10. Testing, Adjusting and Balancing
 - 11. Equipment Rebates
 - 12. Renovation Projects
 - 13. Temporary Heat/Equipment Operation
 - 14. Piping materials and installation instructions common to most piping systems.
 - 15. HVAC demolition.
 - 16. Equipment installation requirements common to equipment sections.
 - 17. Painting and finishing.
 - 18. Concrete bases.
 - 19. Supports and anchorages.

1.03 GENERAL

- A. This Section includes mechanical items common to all of this division specification sections.
- B. Provide services, skilled and common labor, and all apparatus and materials required for the complete installation as shown and within the intent of the contract documents, field conditions, and code requirements.
- C. The intention of these Contract Documents is to call for finished work, fully tested and ready for operation. Any components or labor not mentioned in the Contract Documents but required for functioning systems shall be provided. Should there appear to be any discrepancies or questions of intent, the Contractor shall refer the matter to the Architect/Engineer for decision before start of any related work.
- D. The drawings show the general arrangement of systems and equipment but do not show all required fittings and offsets that may be necessary to connect pipes and ductwork to equipment, and to coordinate with other trades. Provide all necessary fittings, offsets and runs based on field measurements and at no additional cost. Coordinate with other trades for space available and relative location of equipment and accessories. Pipe and duct location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.
- E. This contractor will be responsible to carry out the commissioning requirements specified. Refer to Division 1 for additional requirements.

1.04 DESCRIPTION

- A. These Division 23 specifications define the statutory, administrative, procedural, and technical requirements of the mechanical and controls modifications, replacements, and/or upgrades products and services to be provided on this Subcontract.
- B. Provide HVAC work as indicated on the Drawings and specified in Division 23 including:
 - 1. Prepare coordination drawings, shop drawings, submittals, as-built drawings, and operating and maintenance instructions.
 - 2. Determine items and quantities required.
 - 3. Provide complete, continuous, operational, and functioning systems.
 - 4. Fully coordinate with work of other Sections, including field verification of elevations, dimensions, clearance, and access.
 - 5. Repair of all damage done to premises as a result of this installation and removal of debris left by those engaged in this installation.
 - 6. Rigging, hoisting, transportation, and associated work necessary for placement of equipment in the final location shown.
 - 7. Disassembly and re-assembly of equipment furnished under this Section, should this be required in order to move equipment into final location shown on the Drawings.
 - 8. Labor, materials, tools, appliances and equipment that are required to furnish and install the complete installation for this section of the work including that which is reasonably inferred.
 - 9. Cooperation with other crafts in putting the installation in place at a time when space required is accessible.
 - 10. Temporary scaffolding necessary for performance of the work in this Division.
 - 11. Cutting and core drilling required for work of Division 23, including locating of rebar or coordination of locating rebar with the General Contractor.
 - 12. Pipe sleeves for all holes in walls, floors, and ceilings, and cutting of floor slabs and slabs on grade.
 - 13. Waterproofing where necessary for installation under this Division.
 - 14. Cooperation with and assistance to the Facilities Monitoring and Control System Contractor as required to provide a complete and functional HVAC system.
 - 15. Counterflashing of roof penetrations for work of Division 23.
 - 16. Sizes, and locations for installation of any curbs and pads for work of Division 23.
 - 17. Temporary and permanent stands and supports for equipment requiring them including vibration isolation.
 - 18. Temporary protection of existing installation.
 - 19. Stenciling and equipment identification.
 - 20. Firestopping of penetrations of ducts, piping, and conduits through walls, floors, and ceiling assemblies.
 - 21. Temporary utilities as required to install work on Division 23 including lighting, water, gas, electricity, etc.
 - 22. Fees, permits, inspections, taxes, and approach from agencies that have jurisdiction over installation of Division 23.
 - 23. Air and water balancing.
 - 24. Participation in and coordination with the Commissioning process.
 - 25. Warranty.

1.05 DEFINITIONS

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

- E. Concealed, Exterior Installations: Concealed from view and protected from weather conditions and physical contact by building occupants but subject to outdoor ambient temperatures. Examples include installations within unheated shelters.

1.06 WARRANTY

- A. Provide guarantee and maintain the stability of workmanship and materials used and keep same in good operating condition for a period of minimum or one year after final completion of the work (unless specified otherwise) as evidenced by the issuance of the final certificate by the Architect.
- B. Correct any deficiencies/defects of any kind immediately and; at the Contractors expense due to faulty workmanship or materials that arise during the above mentioned period of time. Corrections shall be done to the satisfaction of the Engineer/Architect. Such reconstruction and/or repairs shall include damages to the finishes or the building resulting from the original defect.

1.07 COORDINATION

- A. Coordinate mechanical work with that of other trades in order to:
 - 1. Avoid interferences between general construction, mechanical, electrical, structural and other specialty trades.
 - 2. Maintain clearances and advise other trades of clearance requirements for operation, repair, removal and testing of mechanical equipment.
 - 3. Indicate aisle-ways and access-ways required on coordinated shop drawings for roof equipment area, mechanical equipment rooms, data and telecomm rooms, corridors, ceiling spaces, shafts, corridors, ceiling space, laboratories, etc.
- B. Understanding of Work:
 - 1. Study, examine, and compare of the contract documents, including drawings and specifications. The Subcontractor shall have a full understanding of how the work in this part is scheduled, phased, and installed with work of other trades.
 - 2. Include in this installation piping, ductwork, devices, and equipment that are necessary for complete and operating systems as specified and as required.
 - 3. Connect piping and ductwork from fixtures, outlets, and devices full size to the nearest suitable main or riser.
 - 4. Certain installations may be presented as typical, and full details are not repeated for each case. Subcontractor shall provide complete installation as if full details apply to each and every case, and make adjustments to typical details to suit each specific installation as part of the basic work.
 - 5. Installation of work presented on the diagrams are applicable to the plans, and work depicted on the plans are applicable to the diagrams.
 - 6. If there is a discrepancy in the drawings or specifications, the contractor shall figure the work based on the most stringent requirements to complete the installation and obtain clarification from the Architect before installation.
- C. Sequence, coordinate, and integrate the various elements of mechanical systems, materials, and equipment. Comply with the following requirements:
 - 1. Coordinate mechanical systems, equipment, and materials installation with other building components.
 - 2. Verify dimensions by field measurements.
 - 3. Arrange for chases, slots, and openings in other building components during progress of construction, to allow for mechanical installations.
 - 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 mechanical 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. Work shall be above ceilings or ceiling line.

7. Coordinate installation and connection of mechanical 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.
8. 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. Coordinate with individual system requirements.
9. Install systems, materials, and equipment level and plumb, parallel and perpendicular to other building systems and components, where installed exposed in finished spaces.
10. Install mechanical equipment to facilitate servicing, maintenance, and repair or replacement of equipment components. As much as is practical, connect equipment for ease of disconnecting, with minimum of interference with other installations. Extend grease fittings to an accessible location.
11. Install systems, materials, and equipment giving right-of-way priority to systems required to be installed at a specified slope.
12. Coordinate with the locations of electrical panels and avoid installing piping and ductwork over them. Electrical panels are purposely located and have priority for location. The contractor is responsible for required piping and ductwork offsets to insure that the panels are located as designed and for other conditions.
13. Perform system modification recommended by Test and Balance Agency after recommendations are accepted by the Engineer

1.08 INTERPRETATION OF PLANS

- A. In general, the Drawings are to scale. However, to determine exact locations of walls and partitions, the Contractor shall consult the architectural and/or structural Drawings which are dimensioned. Drawings shall not take precedence over field measurements.
- B. Drawings are diagrammatic only. They are intended to indicate size and/or capacity where stipulated, approximate location and/or direction, and approximate general arrangement of one phase of work to another, but not the exact detail of construction. All work shall be constructed from field measurements taken at the site. This shall include all rises, drops, elbows, offsets, etc as necessary to avoid structural members or equipment and materials installed by other trades. The contractor shall coordinate the ductwork and piping layout before construction. No additional costs will be allowed for piping and ductwork fabrications without field verification of available space. If it is found, before installation, that a more convenient, suitable or workable arrangement of any or all phases of construction would result by altering the arrangement indicated on the Drawings, the architect/engineer may require the contractor to change the arrangement of his work without additional cost to the owner.
- C. The drawings and specifications are intended to supplement each other. Any items shown on the drawings and not mentioned in the specifications, or vice versa, shall be executed the same as if mentioned and shown.
- D. The greatest quantity or more expensive work shall govern where there is a conflict noted anywhere on the drawings and/or specifications.

1.09 COORDINATION DRAWINGS

- A. Review contract documents and prepare coordination model drawings as an informational supplemental submittal in accordance with Division 1, 21, 22, and 23 requirements. Provide drawings of all areas of the project. Architectural models of the building will be made available upon request. Detailed mechanical models will not be made available. Facilitate coordination meetings and revise drawings as required to resolve work conflicts.
- B. The Division 23 contractor shall coordinate the preparation of drawings by other trades including all new and existing conditions, steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems. The Division 23 contractor shall create composite Model drawings showing the work of all other trades. The Division 23 contractor shall facilitate coordination meetings as scheduled and coordinated by the General Contractor or Construction Manager to review potential conflicts and propose specific solutions. Any proposed revisions to the Contract Documents shall be noted on the coordination drawings for review by the Architect and Engineer.

- C. All contractors (including steel, precast concrete, fire protection, lighting, plumbing, piping, and building sound systems) are required to attend a minimum of (3) three coordination meetings on site to resolve any coordination issues prior to start of construction.
- D. If the coordination drawings are not complete and/or coordinated prior to the work being started no extra cost shall be incurred by the owner due to coordination issue and it shall be the responsibility of the contractors to make the necessary modifications to the system to meet the requirements. All modifications shall be approved by the engineer/architect but at the cost to the contractor.
- E. The composite model drawings of all trades shall detail all structural building elements, mechanical equipment, and work of other trades. Indicate locations where space is limited for installation, access for service, and where sequencing and coordination of installations are of importance to the efficient flow of work. The composite drawings shall include at a minimum the following. Where required for clarity multiple composite drawings may have to be submitted for each area.
 - 1. Clearances for maintaining ceiling heights.
 - 2. Clearances for installation of material and equipment for all trades.
 - 3. Clearances for installing and maintaining insulation.
 - 4. Clearances for servicing and maintaining equipment, including tube removal, filter removal, and space for equipment disassembly required for periodic maintenance.
 - 5. Equipment connections and support details.
 - 6. Penetrations thru block walls and Pre-cast walls.
 - 7. Exterior wall and foundation penetrations.
 - 8. Fire-rated wall and floor penetrations.
 - 9. Sizes and locations of required concrete pads and bases.
 - 10. Valve stem movement.
 - 11. Dimensional locations of pipe sleeves passing through floor/roof slabs.
 - 12. Locations of wall and ceiling access panels where required for access to mechanical equipment.
 - 13. Reflected ceiling plans to integrate installations of light fixtures, grilles, registers, and diffusers, sprinklers, communication systems, and other ceiling mounted components.
 - 14. Both new and existing structural elements.

1.10 COST BREAKDOWN

- A. Submit a cost breakdown for each claim according to General Conditions of the Contract. Include project name, location, Architect/Engineer, Contractor and date.
 - 1. List the cost breakdown for labor and material separately and include a total.
 - 2. Breakout and detail the cost according to specification sections.

1.11 SUBSTITUTIONS AND PRIOR APPROVAL REQUESTS

- A. Equipment manufacturers where indicated on the drawings are the basis of design. The contractor accepts responsibility for all design implications when providing approved equipment other than the design basis.
- B. Electrical Characteristics for HVAC Equipment: Equipment of higher electrical characteristics than the basis of design may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified at the cost of the contractor. If minimum energy rating or efficiencies are specified, equipment shall comply with those requirements. Cost implications to other trades are the responsibility of the contractor.
- C. Dimensional and Wight Changes: Substituted equipment with dimensions or weight different than the basis of design may be furnished provided such proposed equipment is approved in writing. The contractor is responsible for verifying and coordinating proposed equipment such that it maintains the design intent for access and serviceability and reserves space for future equipment where required. Cost implications to other trades are the responsibility of the contractor.
- D. Bids shall be based on the exact materials specified, those listed scheduled on the drawings, or on materials which have been accepted as equivalent. The specified/scheduled products have been used in the design of the project and the preparation of the drawings and specifications as such establish minimum standards of function, dimension, appearance and quality necessary and requisite for this project, which substitutes must meet to be considered acceptable. The burden of proof of equality rests with the party making the request.
- E. Requests for substitution shall be in writing and shall be received by the Engineer not later than 10 days before bid opening date. Materials not specified or accepted as equivalent shall not be acceptable for installation.
- F. Each prior approval request for substitution shall include and meet the following requirements:
 - 1. The name and model of the material or equipment for which an equivalent is being proposed and a complete description of the proposed equivalent including drawings, cuts sheets, equipment performance capacity and test data, equipment weights, electrical and any other information necessary for a complete evaluation.
 - 2. A written comparison listing any deviations from the scheduled equipment and/or the specification requirements must also be provided prior to any proposed substitution will be evaluated.
 - 3. A written statement setting forth any changes in other materials, equipment, electrical, structural and/or other Work in which incorporation of the equivalent may be required shall be included.
 - 4. Material and/or equipment requests which do not meet the above requirements will not be evaluated or approved.
 - 5. The burden of proof of the merit of the proposed equivalent is upon the proposer. Any and all extra costs associated with the equipment change and affecting architectural, structural, mechanical, plumbing or electrical work shall be responsibility of the entity requesting the substitution.
 - 6. The Engineer's decision of approval or disapproval of a proposed equivalent is final.
- G. Final approval of all equipment shall be contingent on shop drawing acceptance, compliance with the specifications and performance criteria as scheduled and acceptable installation. General approval to bid a product does not relieve the Supplier or Contractor of meeting specific specification requirements.
- H. The Mechanical Contractor shall pay, provide, install and be responsible for extra materials required or any other trade due to this use of alternate accepted equipment which has installation requirements different than the specified equipment. The Mechanical Contractor shall pay other trades for any extra work they are involved in due to this substitution of equipment.
- I. If substitutions of controls or equipment require any changes in the architectural, structural, mechanical, plumbing or electrical work from that shown on the drawings, the extra cost of the equipment or architectural, structural,

mechanical, plumbing or electrical work shall be responsibility of the Contractor requesting the substitution. All substitutions shall be prior approved by the Architect or Engineer before purchase by the contractor.

- J. Where any redesign of electrical, mechanical or other work is required due to substitution, arrangement or equipment layout other than herein specified or shown:
1. Arrange for required redesign by Architect and Engineer.
 2. Pay all costs for such redesign.

1.12 SUBMITTALS

- A. Refer to individual product and equipment specification sections for detailed submittal requirements.
- B. The mechanical and electrical contractor shall have an onsite meeting prior to installation to review all shop drawings and verify all electrical requirements with the electrical contractor. The mechanical contractor shall be responsible for coordinating and setting up meeting and sharing of mechanical equipment electrical requirements with electrical contractor prior to when construction is set to begin and equipment is to be ordered.
- C. The electrical contractor shall sign off on all mechanical shop drawings for electrical requirements prior to ordering equipment.

1.13 RECORD DOCUMENTS

- A. Prepare record documents in accordance with the requirements in Division 1 Section "Project Record Documents." In addition to the requirements specified in Division 1, at a minimum the contractors shall:
1. Maintain an on-site set of drawings to record actual revisions to the work being performed on site. Revisions shall be shown on the documents legibly to reflect actual on-site changes to the documents.
 2. Revisions shall be show on the documents in a contrasting color (red).
 3. Revisions shall be updated to the on-site plan daily.
 4. Ensure all revisions and documentation is complete and accurate, enabling future reference by Owner.
- B. Refer to specific sections for additional record documentation.

1.14 MAINTENANCE MANUALS

- A. Prepare maintenance manuals in accordance with Division 1 Section "Operating, Maintenance, and Warranty Data". Submit copies for review by Architect/Engineer. In addition to the requirements specified in Division 1, include the following information:
1. Descriptive summary of function, normal system 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. Warranty information for all mechanical items shall be included in one tabbed section.

1.15 FIRE SAFETY PRECAUTIONS

- A. The Contractors shall exercise extreme care to maintain and exercise adequate fire safety precautions throughout the work. This shall include providing sufficient fire fighting devices, watchmen, standby helpers or other precautions during construction, in use of temporary heat, welding, brazing, sweating, testing or other phases of work.
- B. At all times, access shall be maintained for fire department trucks to the building.
- C. All welding brazing, cutting and sweating operations performed in vicinity of or accessible to combustible materials shall be adequately protected to make certain that sparks or hot slag does not reach the combustible material and start a fire.
- D. All glass, glazed materials and other finish, in the vicinity of welding, brazing and cutting, shall be masked by the Contractor performing the welding work.
- E. When necessary to do cutting, welding, brazing, sweating and similar work in vicinity of wood, in shafts, or vicinity of any combustible material (and the combustible material cannot be removed), the materials shall be adequately protected with fire resistant blankets or similar approved coverings. In addition, a helper shall be stationed nearby with proper fire extinguishers (provided by the Contractor performing the work) to guard against sparks and fire.
- F. Whenever combustible materials have been exposed to sparks, molten metal, hot slag or splatter, a person shall be kept at the place of work to make sure the smoldering fires have not been started. Whenever cutting or welding operations are carried on in a vertical pipe shaft, a person to act as a fireguard shall be employed to examine all floors below the point of cutting or welding. This fireguard shall be kept on duty after completion of work to guard against fires and shall examine each level after this time, prior to leaving. There shall be no exceptions to this requirement and failure to comply will be construed as negligence.

1.16 PERSONAL SAFETY REQUIREMENTS

- A. The Contractor shall be responsible for initiating, maintaining and supervising all safety precautions required in connection with his work, including regulations of the Occupational Safety and Health Administration (OSHA) and other governing agencies.

1.17 TESTING, ADJUSTING AND BALANCING

- A. All mechanical systems will be balanced by an independent test and balance agency hired by the mechanical contractor. The scope of the testing and balancing work includes functional performance testing of all mechanical systems. Deficiency reports will be distributed directly to the contractor on an ongoing basis. Exceptions taken to specific direction issued by the testing agency shall be brought to the attention of the engineer by the installing contractor.
- B. The Contractor shall be certain that all systems are ready for proper operation prior to balancing and adjusting with clean filter and other system elements, e.g., coils. Temperature control calibration, electrical interface, etc., shall also be complete prior to balancing and adjusting. All equipment shall be freshly oiled. The Contractor shall instruct his employees and subcontractors to leave all balancing devices in a wide open position and free all operating arms and adjustments so that they can be easily operated. The contractor shall write a letter to the testing agency indicating that each of the areas defined by the construction schedule is complete and ready for balancing.
- C. The Contractor shall provide and coordinate the services of qualified, responsible subcontractors, suppliers and personnel as required to correct, repair, and/or replace any and all deficient items or conditions found during the course of this project, including the testing, adjusting, and balancing period.
- D. In order that all systems may be properly tested, balanced, and adjusted as required herein by these Specifications, the Contractor shall operate the systems at his expense for the length of time necessary to properly verify their completion and readiness for TAB.

- E. Project Contract completion schedules shall allow for sufficient time to permit the completion of TAB services prior to Owner occupancy. The Contractor shall allow adequate time for the testing and balancing activities of the Owner provided services, during the construction period, and prior to Substantial Completion as defined in the Uniform General Conditions of this Construction Document.
- F. The Drawings and Specifications indicate valves, dampers, and miscellaneous adjustment devices for the purpose of adjustment to obtain optimum operating conditions, and it will be the responsibility of the Contractor to install these devices in a manner that will leave them accessible and readily adjustable. Should any such device not be readily accessible, the Contractor shall provide access as requested by the TAB Firm. Also, any malfunction encountered by TAB personnel and reported to the Contractor shall be corrected by the Contractor immediately so that the balancing work can proceed with the minimum of delays.
- G. Complete operational readiness of the HVAC systems also requires that the following be accomplished:
1. Distribution Systems:
 - a. Verify installation for conformity to design. All supply, return, and exhaust ducts shall be terminated and tested as required by the Specification.
 - b. Dampers shall be properly located and functional. Dampers shall have tight closure and open fully with smooth and free operation.
 - c. Supply, return, exhaust, and transfer grilles, registers, diffusers, and terminal devices shall be installed and secured in a full open position.
 - d. Air handling systems, units, and associated apparatus shall be sealed to eliminate uncontrolled bypass or leakage of air. Final clean filters shall be in place, coils shall be clean with fins straightened, bearings properly greased, and the system shall be completely operational. The Contractor shall verify that all systems are operating within the design pressure limits of the piping and ductwork.
 - e. Under normal operating conditions, check condensate drains for proper connections and functioning. Cooling coil drain pans have a positive slope to drain. Cooling coil condensate drain trap maintains an air seal.
 - f. Check for proper sealing of air-handling unit components.
 - g. Fans shall be operating and verified for freedom from vibration, proper fan rotation and belt tension; heater elements in motor starters to be of proper size and rating, as per the starter manufacturer; record motor amperage and voltage on each phase at start-up, and verify they do not exceed nameplate ratings.
 - h. Thermal overload protection is in place for fans and other equipment. Bearings shall be greased. Belts shall be aligned and tight
 - i. Terminal units shall be installed and functional (i.e. controls functioning).
- H. Water Circulating Systems:
- a. Verify installation for conformity to design. Hydronic systems are pressure tested, flushed, filled, and properly vented. Service and balance valves are fully open. Examine HVAC system and equipment installations to verify that indicated balancing devices are properly installed, and that their locations are accessible and appropriate for effective balancing and for efficient system and equipment operation
 - b. All valves shall be set to their full open position. After the system is flushed and checked for proper operation, all strainers shall be removed and cleaned. The Contractor shall repeat the operation until circulating water is clean and then the start-up strainers shall be discarded. Bearings shall be greased.
 - c. Record pump motor amperage on each phase and voltage after reaching rated speed. Readings shall not exceed nameplate rating. Verify that the electrical heater elements are of the proper size and rating as per the starter manufacturer.
 - d. In preparation of TAB, water circulating systems shall be full and free of air, expansion tanks shall be set for proper water level, and all air vents shall be installed at high points of systems and operating freely. Chemicals shall be added to closed systems to treat piping and inhibit corrosion. The system static pressure shall be adequate to completely fill the system without operating the pumps.
 - e. Check and set operating parameters of the heat transfer and control devices to the design requirements.
 - f. Proper balancing devices shall be in place and located correctly. These devices include but are not limited to flow meters, pressure taps, thermometer wells, balancing valves, etc. Heat transfer coils shall be checked for correct piping connections.

I. Automation Controls

- a. The BAS shall verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.
- b. The BAS Contractor shall verify that all controlling instruments are calibrated and set for design operating conditions with the exception of components that require input from the TAB Agency, but a default shall be set. The Control Contractor shall cooperate with the TAB Agency and provide all software and interfaces to communicate with the system.
- c. The BAS Contractor shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Agency that the BAS is operational. The BAS Contractor shall provide technical support (technicians and necessary computers) to the TAB Agency for a complete check of these systems.
- d. Prior to occupancy, each ventilation system shall be tested to ensure that OA dampers operate properly in accordance with system design.
- e. Fire Alarm: Division 26 shall thoroughly check all detection devices, sequences, inter-locks, etc. before notifying the TAB Agency that the system is operational. Division 26 shall certify that the systems are totally operational to the Contract or prior to the TAB beginning.
 - 1) The BAS contractor and Fire Alarm contractor shall coordinate all fire and smoke dampers/sensors operation with the shutdown sequence with all air handling equipment.
 - 2) The Fire Alarm contractor shall be responsible for preparing final documentation of system integration:
 - 3) The contractors shall review the drawings and specifications. The contractors shall establish an initial sequence of operation and matrix for all integration of system, including fire alarm sequences, HVAC fan and equipment shutdown, fan operation, damper operation, door closings, door unlocking, exhaust/makeup air systems, etc.
 - 4) Review initial sequence of operation and matrix with mechanical and electrical engineer and owner to verify proposed system operation.
 - 5) Provide final sequence and matrix based on actual install conditions.

1.18 EQUIPMENT REBATES

- A. The contractor shall be responsible for applying for and leading the rebate application process for all eligible equipment / systems within the project on behalf of the owner.
- B. The contractor shall provide all receipts, invoicing, counts, site data, etc as required to procure equipment rebates
- C. The contractor shall forward the filled out application and all necessary rebate “back-up” requirements to the owner at the completion of the project.

1.19 RENOVATION PROJECTS

- A. Project Conditions: Partial Owner Occupancy: The Owner may occupy completed areas of the building before Substantial Completion. Cooperate with the Owner to minimize conflicts with the Owner's operations.
- B. The Contractor shall study all drawings and specifications, visit the site, and get acquainted with the existing conditions and the requirements of the plans and specifications. No claim will be recognized for extra compensation due to the failure of the Contractor to be familiarized with the conditions and extent of the proposed work. The Contractor shall execute all alterations, additions, removals, relocations or new work, etc., as indicated or required to provide a complete installation in accordance with the intent of the drawing and specifications.
- C. Use of Site: Limit use of premises to work in areas indicated. Do not disturb portions of site beyond areas in which the Work is indicated.
- D. Driveways and Entrances: Keep driveways and entrances serving premises clear and available to Owner, Owner's employees, and emergency vehicles at all times. Do not use these areas for parking or storage of materials.

Schedule deliveries to minimize use of driveways and entrances. Schedule deliveries to minimize space and time requirements for storage of materials and equipment on-site.

- E. Follow the recommended procedures of the SMACNA IAQ Guidelines for Occupied Buildings under Construction.
 - 1. Dust partitions and depressurization of the work are performed under Division 1.
 - 2. The return side of an HVAC system is, by definition, under negative pressure and thus capable of drawing in nearby construction dust and odor. When possible, the entire system shall be shut down during heavy construction or demolition. The system shall be isolated from the surrounding environment as much as possible (e.g., all tiles in place for a ceiling plenum, duct and air handler leaks repaired) to prevent induction of pollutants.
 - 3. Return system openings in (and immediately adjacent to) the construction area shall be sealed with plastic.
 - 4. When the system must remain operational during construction, temporary filters shall be added to return grilles. All filters must receive frequent periodic maintenance and be replaced at end of project.
 - 5. When the general system must remain operational, the heaviest work areas shall be dampered off or otherwise blocked if temporary imbalance of the return air system does not create a greater problem.
 - 6. The mechanical room shall not be used to store construction or waste materials.
 - 7. Diffusers, VAV boxes, and ducts may be adequately protected in most cases where the above measures are implemented. When the system is off for the duration of construction, diffusers shall also be sealed in plastic for further protection. Ducts, diffusers, and window units shall be inspected upon completion of the work for the amount of deposited particulate present and cleaned where needed. If significant dust deposits are observed in the system during construction, some particulate discharge can be expected during start-up. When such a discharge is only minor, delaying re-occupancy long enough to clean up the dust may be sufficient. In more severe cases, installing temporary coarse filters on diffusers or cleaning the ducts may be necessary. The condition of the main filters shall be checked whenever visible particulates are discharged from the system.
- F. Continuity of Services: The building will be in use during construction operations. Maintain existing systems in operation within all rooms of building at all times. Schedules for various phases of contract work shall be coordinated with all other trades and with Owner. Provide, as part of contract, temporary plumbing and mechanical and electrical connections and relocations as required to accomplish the above.
- G. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services. Notify Owner at least two days in advance of proposed utility interruptions. Identify extent and duration of utility interruptions. Indicate method of providing temporary utilities. Do not proceed with utility interruptions without Owner's written permission.
- H. Cutting And Patching
 - 1. Refer to Division 1 Section "Execution" for cutting and patching requirements.

1.20 TEMPORARY HEAT/EQUIPMENT OPERATION

- A. Provide temporary gas meter and connections to equipment provided by the General Contractor as required for temporary heat.
- B. Warranties:
 - 1. The Contractor shall provide extended warranties for all equipment and mechanical system components operated prior to the date of substantial completion. The Contractor shall obtain in writing from the manufacturer extended warranties for all equipment such that the Owner's warranty starts at the date of substantial completion in accordance with the General Division 1 requirements. Any additional costs shall be the burden of the Contractor.
- C. Temporary Air Handling Equipment Operation:

1. Manually operate air-handling systems to provide suitable environment for installation of interior finishes. Provide factory start-up of all variable speed drives. Perform commissioning operations prior to starting units and operate the systems in accordance with the following procedures for manually operating the air handling systems. The Contractor shall obtain in writing from the manufacturer extended warranties for all affected equipment. Any additional costs shall be the burden of the Contractor:
 - a. The air handling systems shall not be operated at outside air temperature below 40.0 degrees. Open outdoor air dampers, close return air dampers, open all air terminals to full open, install filters, ensure condensate drain is functioning and electrical protection devices are installed. Start fan, monitor indoor and outdoor conditions, and operate heating and cooling systems to control space conditions; shut down systems completely and close outdoor air dampers at end of each workday. Return/exhaust fans shall not run during temporary operation.

D. Temporary Condensing Unit Operations:

1. The condensing units may be used for maintaining a suitable environment for the installation of interior finishes. The condensing unit installation must be complete in accordance with all manufacturer guidelines. Provide start-up services by an authorized factory representative. The contractor shall obtain in writing from the manufacturer extended warranties for all affected equipment. Any additional costs shall be the burden of the contractor.

E. Temporary Boiler Operation:

1. The boiler and building hot water system shall not be used for temporary heat in the building. The boiler may be started prior to substantial completion only with written approval from the Owner. The boiler circulation loop, circulation pump, and controls must be installed.
2. The contractor must submit to the Engineer a phasing plan for bringing areas of the building and systems on line. The phasing plan must include time allotment to complete cleaning and flushing procedures as outlined in specification Section 15510. Prior to starting each phase, the contractor must document that all cleaning and flushing procedures have been completed. The contractor shall provide any additional piping, pumps, fittings, and power required such that any additional areas of piping added to the system are flushed and cleaned prior to circulating water from previously cleaned areas.
3. Provide start-up services for the boiler and all pump variable speed drives by an authorized factory representative. The contractor shall obtain in writing from the manufacturer, extended warranties for all affected equipment. Any additional cost shall be the burden of the contractor. The temperature control system shall be operational to trend the boiler circulation loop to ensure the boiler has been shock protected for the entire duration of the temporary service.

PART 2: PRODUCTS

2.01 PIPE, TUBE, AND FITTINGS

- A. Refer to individual Division 23 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.

2.02 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.
- F. The following are industry abbreviations for plastic materials:
 - 1. CPVC: Chlorinated polyvinyl chloride plastic.
 - 2. PE: Polyethylene plastic.
 - 3. 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.

2.03 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 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.

2.04 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.

2.05 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.

2.06 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.
- B. Plastic-to-Metal Transition Fittings: One-piece fitting with manufacturer's Schedule 80 equivalent dimensions; one end with threaded brass insert, and one solvent-cement-joint end.
- 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.
- D. Plastic-to-Metal Transition Unions: MSS SP-107, four-part union. Include brass end, solvent-cement-joint end, rubber O-ring, and union nut.
- E. Flexible Transition Couplings for Underground Nonpressure Drainage Piping: ASTM C 1173 with elastomeric sleeve, ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.07 DIELECTRIC FITTINGS

- A. Description: Combination fitting of copper alloy and ferrous materials with threaded, solder-joint, plain, or weld-neck end connections that match piping system materials.
- B. Insulating Material: Suitable for system fluid, pressure, and temperature.
- C. Dielectric Unions: Factory-fabricated, union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Flanges: Factory-fabricated, companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- 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.

- F. Dielectric Couplings: Galvanized-steel coupling with inert and noncorrosive, thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples: Electroplated steel nipple with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F.

2.08 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve.
 - 1. Sealing Elements: EPDM 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. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Stainless steel of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.09 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.

2.010 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. Provide with polished chrome plated finish.

2.011 GROUT

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

2.012 VIBRATION ISOLATION

- A. All equipment shall be provided with adequate vibration isolation to prevent vibration and noise transmission to the building structure.
- B. No rigid connections between equipment and building structure shall be made that degrades the noise and vibration isolation system herein specified. Electrical conduit connections to isolated equipment shall be looped to allow free motion of isolated equipment.

- C. Spring isolation shall be provided for all moving equipment as per plans and specifications. If no floor mounted spring isolation is required, equipment shall mount on neoprene elastomer in-shear vibration isolation pads and then anchored to the structure.

PART 3: EXECUTION

3.01 HVAC DEMOLITION

- A. Refer to Division 01 Section "Cutting and Patching" and Division 02 Section "Selective Structure Demolition" for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove HVAC systems, equipment, and components indicated to be removed.
 - 1. Piping to Be Removed: Remove portion of piping indicated to be removed and cap or plug remaining piping with same or compatible piping material.
 - 2. Piping to Be Abandoned in Place: Drain piping and cap or plug piping with same or compatible piping material.
 - 3. Ducts to Be Removed: Remove portion of ducts indicated to be removed and plug remaining ducts with same or compatible ductwork material.
 - 4. Ducts to Be Abandoned in Place: Cap or plug ducts with same or compatible ductwork material.
 - 5. Equipment to Be Removed: Disconnect and cap services and remove equipment.
 - 6. Equipment to Be Removed and Reinstalled: Disconnect and cap services and remove, clean, and store equipment; when appropriate, reinstall, reconnect, and make equipment operational.
 - 7. Equipment to Be Removed and Salvaged: Disconnect and cap services and remove equipment and deliver to Owner.
- C. If pipe, insulation, or equipment to remain is damaged in appearance or is unserviceable, remove damaged or unserviceable portions and replace with new products of equal capacity and quality.

3.02 PIPING SYSTEMS - COMMON REQUIREMENTS

- A. Install piping according to the following requirements and Division 23 Sections specifying piping systems.
- B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- C. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- E. 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:
- M. Sleeves are not required for core-drilled holes.
- N. 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 Sheet Sleeves: For pipes NPS 6 and larger, penetrating gypsum-board partitions.
 - b. 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.
 - 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.
- O. 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.
- P. 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.

- Q. 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.
- R. Verify final equipment locations for roughing-in.
- S. Refer to equipment specifications in other Sections of these Specifications for roughing-in requirements.

3.03 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and Division 23 Sections specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- C. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- D. Soldered Joints: Apply ASTM B 813, water-flushable flux, unless otherwise indicated, to tube end. Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook," using lead-free solder alloy complying with ASTM B 32.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.04 PIPING CONNECTIONS

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

3.05 ACCESS DOORS/PANELS IN GENERAL CONSTRUCTION

- A. Size: 16" x 16" minimum where valves and similar related items are within easy reach of operator, and at least 24" x 24" when passage through opening is required to reach devices requiring maintenance and manual operation.

- B. Construction: Hinged flush type steel frame panel, 14 gauge minimum for door and 16 gauge minimum for frame, and with anchor straps.
 - 1. Border: Only narrow border exposed.
 - 2. Hinges: Concealed type.
 - 3. Locking device: Flush cam type and screwdriver operated.
 - 4. Metal surfaces: Prime coat with rust-inhibitive paint.
- C. Manufacturer: Milcor type by L. M. Walsh Company.
 - 1. Gypsum Board Surfaces: Style DW with concealed spring hinges.
 - 2. Masonry Surfaces: Style M, with masonry anchors.
 - 3. Acoustical Tile Ceilings: Style AT with recessed pan to receive acoustical tile material.

3.06 EQUIPMENT INSTALLATION - COMMON REQUIREMENTS

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

3.07 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.

3.08 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 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."

3.09 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 HVAC materials and equipment.
- C. Field Welding: Comply with AWS D1.1.

3.010 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

3.11 GROUTING

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

END OF SECTION 23 05 00

SECTION 23 05 13

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.

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. Comply with IEEE 841 for severe-duty motors.

2.02 MOTOR CHARACTERISTICS

- A. Duty: Continuous duty at ambient temperature of 40 deg C 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. Efficiency: Energy efficient, as defined in NEMA MG 1.

- C. Service Factor: 1.15.
- D. Multispeed Motors: Separate winding for each speed.
- E. Rotor: Random-wound, squirrel cage.
- F. Bearings: Regreasable, shielded, antifriction ball bearings suitable for radial and thrust loading. Sleeve type bearings permitted for fractional hp (less than ½ hp) light duty applications.
- G. Temperature Rise: Match insulation rating.
- H. Insulation: Class F.
- I. 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.
- J. 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 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. Efficiency: Motor efficiency shall meet or exceed efficiency requirements for as listed below. Motors shall be tested in accordance with IEEE Standard 112, test method B. Motor efficiencies are based upon the NEMA MG1-1987, Table 12-6B (as referenced in the State Energy Code) plus 2.5%.

MINIMUM MOTOR EFFICIENCY TABLE

Number of Poles Motor Horsepower	Open Motor Premium Efficiency				Closed Motor Premium Efficiency			
	3600	1800	1200	900	3600	1800	1200	900
1	-	85.0	79.5	74.5	-	83.0	78.0	74.5
1.5	82.5	85.0	85.0	78.0	81.0	84.0	85.0	78.0
2	85.0	85.0	86.5	88.0	84.0	85.0	85.0	85.0
3	85.0	89.0	88.0	89.0	85.0	86.5	86.5	84.0
5	88.0	89.0	89.0	90.0	88.0	88.0	88.0	86.5
7.5	88.0	91.0	91.0	91.0	90.0	90.0	90.0	90.0
10	90.0	91.0	92.7	92.0	90.0	90.0	90.0	90.0
15	92.0	92.7	92.0	92.0	91.0	92.7	92.0	92.0
20	92.7	93.5	92.7	92.7	91.0	92.7	92.0	92.0
25	93.5	94.2	93.5	92.7	92.0	93.5	92.7	92.0
30	93.5	94.2	94.2	93.5	92.0	93.5	93.5	92.7
40	94.2	94.9	94.2	92.7	92.7	94.2	94.2	92.7
50	94.2	94.9	94.2	94.2	92.7	94.9	94.2	93.5
60	95.5	95.5	94.9	94.9	94.2	95.5	94.2	94.2
75	95.5	96.1	95.5	96.1	94.9	95.5	95.5	95.5
100	95.5	96.1	96.1	96.1	95.5	96.1	95.5	95.5
125	95.5	96.1	96.1	96.1	95.5	96.1	95.5	96.1
150	96.1	96.6	96.1	96.1	95.5	96.6	96.6	96.1
200	96.1	96.6	96.6	96.1	96.6	97.0	96.6	96.6

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: Prelubricated, 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.

PART 3: EXECUTION, GENERAL

3.01 INSTALLATION, GENERAL

- A. Install motor and equipment associated with the mechanical installation, including items furnished by others.
- B. Provide electrical requirements for equipment installation, connection, and control. Refer to Division 16 for exceptions.
- C. Provide power factor correction capacitors on motors as required to correct power factor of the motor to 90 percent or better on all motors 1 horsepower and larger. Turn capacitors over to the Electrical Contractor for installation. The power factors of motors shall be measured at rated loads. Do not provide power factor correction for motors installed with variable frequency drives.

END OF SECTION 23 05 13

SECTION 23 05 19

METERS AND GAGES FOR HVAC 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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. Section Includes:
 - 1. Thermometers.
 - 2. Gages.
 - 3. Test plugs.
- B. Related Sections:
 - 1. Division 23 Section "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. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of product indicated; include performance curves.
- C. Shop Drawings: Schedule for thermometers and gages indicating manufacturer's number, scale range, and location for each.

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. Trerice, H. O. Co.
 - 3. Weiss Instruments, Inc.
 - 4. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Die-cast aluminum or brass, 7 inches long.

- C. Tube: Red or blue reading, organic-liquid filled, with magnifying lens.
- D. Tube Background: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- E. Window: Glass.
- F. Connector: Adjustable type, 180 degrees in vertical plane, 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 Div.
 - 2. KOBOLD Instruments, Inc.
 - 3. Marsh Bellofram.
 - 4. Trerice, H. O. Co.
 - 5. Weiss Instruments, Inc.
 - 6. Weksler Instruments Operating Unit; Dresser Industries; Instrument Div.
- B. Case: Liquid-filled type, drawn steel or cast aluminum diameter.
- C. Element: Bourdon tube or other type of pressure element.
- D. Movement: Mechanical, connecting element and pointer.
- E. Dial: Satin-faced, nonreflective aluminum with permanently etched scale markings.
- F. Pointer: Red metal.
- G. Window: Glass.
- H. Ring: Brass in unfinished areas including mechanical rooms. Stainless steel in finished areas.
- I. Connector: Adjustable type, 180 degrees in vertical plane, 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 THERMOWELLS

- A. Manufacturers: Same as manufacturer of thermometer being used.
- B. Description: Pressure-tight, socket-type metal fitting made for insertion into piping and of type, diameter, and length required to hold thermometer.

2.04 PRESSURE GAGES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft Commercial Instrument Operations; Dresser Industries; Instrument Div.
 - 2. Marsh Bellofram.
 - 3. Palmer - Wahl Instruments Inc.
 - 4. Trerice, H. O. Co.

5. Weiss Instruments, Inc.
6. Winters Instruments.

B. Direct-Mounting, Dial-Type Pressure Gages: Indicating-dial type complying with ASME B40.100.

1. Case: Dry type, drawn steel or cast aluminum. Provide 2" diameter for fuel oil systems. 4" diameter for all other systems.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, 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, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass.
8. Ring: Brass in unfinished areas including mechanical rooms. Stainless steel in finished areas.
9. Accuracy: Grade B, plus or minus 2 percent of middle half.
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 Gages: ASME B40.100, indicating-dial type.

1. Case: Dry type, drawn steel or cast aluminum. Provide 2" diameter for fuel oil systems. 4" diameter for all other systems for panel mounting.
2. Pressure-Element Assembly: Bourdon tube, unless otherwise indicated.
3. Pressure Connection: Brass, NPS 1/4, 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, nonreflective aluminum with permanently etched scale markings.
6. Pointer: Red metal.
7. Window: Glass.
8. Ring: Brass in unfinished areas including mechanical rooms. Stainless steel in finished areas.
9. Accuracy: Grade B, plus or minus 2 percent of middle half.
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-Gage Fittings:

1. Valves: NPS 1/4 brass or stainless-steel needle type.
2. Syphons: NPS 1/4 coil of brass tubing with threaded ends.
3. Snubbers: ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant, porous-metal disc of material suitable for system fluid and working pressure.

2.05 TEST PLUGS

- A. 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.
- B. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.
- C. Core Inserts: One or two self-sealing rubber valves.
1. Insert material for air, water, oil, or gas service at 20 to 200 deg F shall be CR.
 2. Insert material for air or water service at minus 30 to plus 275 deg F shall be EPDM.

PART 3: EXECUTION

3.01 THERMOMETER APPLICATIONS

- A. Install liquid-in-glass thermometers in the following locations:
 - 1. Inlet and outlet of each hydronic zone.
 - 2. Inlet and outlet of each hydronic boiler and chiller.
 - 3. Inlet and outlet of each hydronic coil in air-handling units and built-up central systems.
 - 4. Inlet and outlet of each hydronic heat exchanger.
- B. Install dry, vapor-actuated dial thermometers at suction and discharge of each pump.
- C. Provide the following temperature ranges for thermometers:
 - 1. Heating Hot Water: 30 to 240 deg F, with 2-degree scale divisions
 - 2. Condenser Water: 0 to 160 deg F., with 2-degree scale divisions
 - 3. Chilled Water: 0 to 100 deg F, with 2-degree scale divisions
 - 4. Steam and Condensate: 30 to 300 deg F, with 5-degree scale divisions

3.02 GAGE APPLICATIONS

- A. Install dry-case-type pressure gages for discharge of each pressure-reducing valve.
- B. Install dry-case-type pressure gages at chilled and condenser-water inlets and outlets of chillers.
- C. Install dry-case-type pressure gages 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 and in vertical position in piping tees where thermometers are indicated.
- D. Duct Thermometer Support Flanges: Install in wall of duct where duct thermometers are indicated. Attach to duct with screws.
- E. Install direct-mounting pressure gages in piping tees with pressure gage located on pipe at most readable position.
- F. Install remote-mounting pressure gages on panel.
- G. Install needle-valve and snubber fitting in piping for each pressure gage for fluids.
- H. Install test plugs in tees in piping.
- I. Insulate all gauges and thermometer stems fully from the socket trap of the pipe main to the instrument body per the piping insulation type schedules.

3.04 ADJUSTING

- A. Calibrate meters according to manufacturer's written instructions, after installation.
- B. Adjust faces of meters and gages to proper angle for best visibility.

END OF SECTION 23 05 19

SECTION 23 05 23

GENERAL-DUTY VALVES FOR HVAC 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 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 SUMMARY

- A. Section Includes:

1. Bronze ball valves.
2. Iron ball valves.
3. Iron, single-flange butterfly valves.
4. Bronze lift check valves.
5. Bronze swing check valves.
6. Iron swing check valves.
7. Iron swing check valves with closure control.
8. Bronze gate valves.
9. Bronze globe valves.
10. Iron globe valves.
11. Lubricated plug valves.

- B. Related Sections:

1. Division 23 HVAC piping Sections for specialty valves applicable to those Sections only.
2. Division 23 Section "Identification for HVAC Piping and Equipment" for valve tags and schedules.

1.04 DEFINITIONS

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

1.05 SUBMITTALS

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

1.06 QUALITY ASSURANCE

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

1.07 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 handwheels or stems as lifting or rigging points.

PART 2: PRODUCTS

2.01 GENERAL REQUIREMENTS FOR VALVES

- A. Refer to valve schedule articles for applications of valves.
- B. Valve Pressure and Temperature Ratings: Not less than indicated and as required for system pressures and temperatures.
- C. Valve Sizes: Same as upstream piping unless otherwise indicated.
- D. Valve Actuator Types:
 - 1. Gear Actuator: For quarter-turn valves NPS 8 and larger.
 - 2. Handwheel: For valves other than quarter-turn types.
 - 3. Handlever: For quarter-turn valves NPS 6 and smaller except plug valves.
 - 4. Wrench: For plug valves with square heads. Furnish Owner with 1 wrench for every 5 plug valves, for each size square plug-valve head.
- E. Valves in Insulated Piping: With 2-inch stem extensions and the following features:
 - 1. Gate Valves: With rising stem.

2. Ball Valves: With extended operating handle of non-thermal-conductive material, and protective sleeve that allows operation of valve without breaking the vapor seal or disturbing insulation.
3. Butterfly Valves: With extended neck.

F. Valve-End Connections:

1. Flanged: With flanges according to ASME B16.1 for iron valves.
2. Grooved: With grooves according to AWWA C606.
3. Solder Joint: With sockets according to ASME B16.18.
4. Threaded: With threads according to ASME B1.20.1.

G. Valve Bypass and Drain Connections: MSS SP-45.

2.02 BRONZE BALL VALVES

A. Two-Piece, Full-Port, Bronze Ball Valves with Stainless-Steel Trim:

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

2.03 IRON, SINGLE-FLANGE BUTTERFLY VALVES

A. 300 CWP, Ductile Iron, Grooved-End Butterfly Valves with EPDM Seat and Electroless Nickel Plated Ductile Iron Disk:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic (Vic-300 MasterSeal)
 - b. Milwaukee Valve Company.
 - c. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:

- a. CWP Rating: 300 psi
- b. Body: Ductile iron conforming to ASTM A-536
- c. Body Design: Suitable for bidirectional and dead-end service at full rated pressure.
- d. Coating: Black alkyd enamel
- e. Ends: Grooved
- f. Seat: EPDM, pressure responsive.
- g. Stem: 416 stainless steel conforming to ASTM A-582
- h. Disc: Ductile iron conforming to ASTM A-536, grade 65-45-12, with electroless nickel coating conforming to ASTM B-733
- i. Disc Design: Disc shall be offset from the stem centerline to allow full 360 degree seating.

2.04 BRONZE GROOVED-END CHECK VALVES:

- A. Grooved-End Check Valves
 - 1. Manufacturers:
 - a. Victaulic (Series 716)
 - b. Milwaukee Valve Company.
 - c. NIBCO INC.
 - 2. Description:
 - a. CWP Rating: 300 psi
 - b. Body Material: ASTM A-536 ductile iron.
 - c. Ends: Grooved.
 - d. Spring and Shaft: Stainless steel.
 - e. Disc: Stainless steel or elastomer coated ductile iron.
 - f. Suitable for vertical or horizontal installation.

2.05 BRONZE GATE VALVES

- A. Class 150, NRS Bronze Gate Valves:
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Kitz Corporation.
 - b. Milwaukee Valve Company.
 - c. Powell Valves.
 - d. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
 - 2. Description:
 - a. Standard: MSS SP-80, Type 1.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.

- f. Disc: Solid wedge; bronze.
- g. Packing: Asbestos free.
- h. Handwheel: Malleable iron.

2.06 IRON GATE VALVES

A. Class 125, NRS, Iron Gate Valves:

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

2.07 BRONZE GLOBE VALVES

A. Class 150, Bronze Globe Valves with Nonmetallic Disc:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.
 - b. Hammond Valve.
 - c. Milwaukee Valve Company.
 - d. NIBCO INC.
 - e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.
2. Description:
 - a. Standard: MSS SP-80, Type 2.
 - b. CWP Rating: 300 psig.
 - c. Body Material: ASTM B 62, bronze with integral seat and union-ring bonnet.
 - d. Ends: Threaded.
 - e. Stem: Bronze.
 - f. Disc: PTFE or TFE.
 - g. Packing: Asbestos free.
 - h. Handwheel: Malleable iron.

2.08 IRON SWING CHECK VALVES

A. Class 125, Iron Swing Check Valves with Metal Seats:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Crane Co.
 - b. Hammond Valve.

- c. Milwaukee Valve Company.
- d. NIBCO INC.
- e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Standard: MSS SP-71, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Design: Clear or full waterway.
- e. Body Material: ASTM A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Bronze.
- h. Gasket: Asbestos free.

2.9 IRON SWING CHECK VALVES WITH CLOSURE CONTROL

A. Class 125, Iron Swing Check Valves with Lever and Weight-Closure Control:

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

- a. Crane Co.
- b. Hammond Valve.
- c. Milwaukee Valve Company.
- d. NIBCO INC.
- e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Standard: MSS SP-71, Type I.
- b. NPS 2-1/2 to NPS 12, CWP Rating: 200 psig.
- c. NPS 14 to NPS 24, CWP Rating: 150 psig.
- d. Body Design: Clear or full waterway.
- e. Body Material: ASTM A 126, gray iron with bolted bonnet.
- f. Ends: Flanged.
- g. Trim: Bronze.
- h. Gasket: Asbestos free.
- i. Closure Control: Factory-installed, exterior lever and weight.

2.10 IRON GLOBE VALVES

A. Class 125, Iron Globe Valves:

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

- a. Crane Co.
- b. Hammond Valve.
- c. Milwaukee Valve Company.
- d. NIBCO INC.
- e. Watts Regulator Co.; a division of Watts Water Technologies, Inc.

2. Description:

- a. Standard: MSS SP-85, Type I.
- b. CWP Rating: 200 psig.
- c. Body Material: ASTM A 126, gray iron with bolted bonnet.
- d. Ends: Flanged.

- e. Trim: Bronze.
- f. Packing and Gasket: Asbestos free.

PART 3: EXECUTION

3.01 EXAMINATION

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

3.02 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Provide isolation shutoff valves at all supply and return branch hydronic lines routing from the main header piping whether specifically shown on drawings or not. Locate all valves in an accessible location and mark on ceiling tile.
- C. Provide Isolation shutoff valves at all supply and return hydronic lines serving each floor, wing, area of the building for shutting down of system and service. Provide valves whether specifically shown on drawings or not. Locate all valves in an accessible location and mark on ceiling tile.
- D. Locate valves for easy access and provide separate support where necessary.
- E. Install valves in horizontal piping with stem at or above center of pipe.
- F. Install valves in position to allow full stem movement.
- G. Install chainwheels on operators for ball and butterfly valves NPS 4 and larger and more than 96 inches above floor. Extend chains to 60 inches above finished floor.
- H. Install check valves for proper direction of flow and as follows:
 - 1. Swing Check Valves: In horizontal position with hinge pin level.
 - 2. Lift Check Valves: With stem upright and plumb.

3.03 ADJUSTING

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

3.04 GENERAL REQUIREMENTS FOR VALVE APPLICATIONS

- A. If valve applications are not indicated, use the following:
 - 1. Shutoff Service: Ball or butterfly valves.

2. Butterfly Valve Dead-End Service: Single-flange (lug) type.
 3. Throttling Service except Steam: Globe or ball valves.
 4. Throttling Service, Steam: Globe valves.
 5. Pump-Discharge Check Valves:
 - a. NPS 2 and Smaller: Bronze swing check valves with bronze disc.
 - b. NPS 2-1/2 and Larger: Iron swing check valves with lever and weight or with spring or iron, center-guided, metal-seat check valves.
- B. If valves with specified SWP classes or CWP ratings are not available, the same types of valves with higher SWP classes or CWP ratings may be substituted.
- C. Select valves, except wafer types, with the following end connections:
1. For Copper Tubing, NPS 2 and Smaller: Threaded ends except where solder-joint valve-end option is indicated in valve schedules below.
 2. For Copper Tubing, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 3. For Copper Tubing, NPS 5 and Larger: Flanged ends.
 4. For Steel Piping, NPS 2 and Smaller: Threaded ends.
 5. For Steel Piping, NPS 2-1/2 to NPS 4: Flanged ends except where threaded valve-end option is indicated in valve schedules below.
 6. For Steel Piping, NPS 5 and Larger: Flanged ends.

3.05 HEATING-WATER VALVE SCHEDULE

- A. Pipe NPS 2 and Smaller:
1. Bronze Valves: May be provided with solder-joint ends instead of threaded ends.
 2. Ball Valves: Two piece, full port, bronze with stainless-steel trim.
 3. Bronze Swing Check Valves: Class 150, bronze disc.
 4. Bronze Gate Valves: Class 150, NRS.
 5. Bronze Globe Valves: Class 150, bronze disc.
- B. Pipe NPS 2-1/2 and Larger:
1. Iron Valves, NPS 2-1/2 to NPS 4: May be provided with threaded ends instead of flanged ends.
 2. Iron Ball Valves, NPS 2-1/2 to NPS 10: Class 150.
 3. Iron, Single-Flange Butterfly Valves, NPS 2-1/2 to NPS 12: 200 CWP, EPDM seat, aluminum-bronze disc.
 4. Iron, Single-Flange Butterfly Valves, NPS 14 to NPS 24: 150 CWP, EPDM seat, aluminum-bronze disc.
 5. Iron Swing Check Valves: Class 125, metal seats.
 6. Iron Swing Check Valves with Closure Control, NPS 2-1/2 to NPS 12: Class 125, lever and weight.
 7. Iron Globe Valves, NPS 2-1/2 to NPS 12: [Class 125] [Class 250].

END OF SECTION 23 05 23

SECTION 23 05 29

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 1 Specification Sections, apply to this Section.

1.02 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 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 05 Section "Metal Fabrications" for structural-steel shapes and plates for trapeze hangers for pipe and equipment supports.
 - 2. Division 21 Section "Water-Based Fire-Suppression Systems" for pipe hangers for fire-suppression piping.
 - 3. Division 23 Section "Expansion Fittings and Loops for HVAC Piping" for pipe guides and anchors.
 - 4. Division 23 Section "Ductwork" for duct hangers and supports.

1.04 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."

1.05 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.

1.06 SUBMITTALS

- A. Product Data: For the following:

1. Steel pipe hangers and supports.
 2. Fiberglass pipe hangers.
 3. Thermal-hanger shield inserts.
 4. Powder-actuated fastener systems.
- B. Shop Drawings: Show fabrication and installation details and include calculations for the following:
1. Trapeze pipe hangers. Include Product Data for components.
 2. Metal framing systems. Include Product Data for components.
 3. Fiberglass strut systems. Include Product Data for components.
 4. Pipe stands. Include Product Data for components.
 5. Equipment supports.
- C. Welding certificates.

1.07 EXTRA MATERIALS

- A. Provide material and installation costs for (10) additional 4" clevis hangers with insulation saddles and all associated rods, clips, bolts, supports, and building attachments for 4" insulated piping. Actual routing, installation and sizes are to be field verified at location required and ordered only after approval from the Engineer.

1.08 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. Galvanized, Metallic Coatings: Pregalvanized or hot dipped.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.
- D. Padded Hangers: Hanger with fiberglass or other pipe insulation pad or cushion for support of bearing surface of piping.

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. Coatings: Manufacturer's standard finish, unless bare metal surfaces are indicated.
- C. Nonmetallic Coatings: Plastic coating, jacket, or liner.

2.04 THERMAL-HANGER SHIELD INSERTS

- A. Description: 100-psig- minimum, compressive-strength insulation insert encased in sheet metal shield.
- B. Insulation-Insert Material for Cold Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass with vapor barrier.
- C. Insulation-Insert Material for Hot Piping: Water-repellent treated, ASTM C 533, Type I calcium silicate or ASTM C 552, Type II cellular glass.
- D. For Trapeze or Clamped Systems: Insert and shield shall cover entire circumference of pipe.
- E. For Clevis or Band Hangers: Insert and shield shall cover lower 180 degrees of pipe.
- F. Insert Length: Extend 2 inches beyond sheet metal shield for piping operating below ambient air temperature.

2.05 INSULATION SHIELD

- A. Description: 16 gauge galvanized sheet metal formed to fit contour of pipe insulation.
- B. Shield Length: Minimum 12”.

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.
- 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.

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.
- C. Low-Type, Single-Pipe Stand: One-piece plastic base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 - 1. Base: Stainless steel.
 - 2. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 - 3. 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. Bases: One or more plastic.
 2. Vertical Members: Two or more protective-coated-steel channels.
 3. Horizontal Member: Protective-coated-steel channel.
 4. 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 EQUIPMENT SUPPORTS

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

2.09 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, nonshrink and nonmetallic grout; suitable for interior and exterior applications.
1. Properties: Nonstaining, 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. 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 noninsulated or insulated stationary pipes, NPS 1/2 to NPS 30.
 2. Yoke-Type Pipe Clamps (MSS Type 2): For suspension of 120 to 450 deg F pipes, NPS 4 to NPS 16, 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, 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, if little or no

insulation is required.

5. Pipe Hangers (MSS Type 5): For suspension of pipes, NPS 1/2 to NPS 4, to allow off-center closure for hanger installation before pipe erection.
 6. Adjustable, Swivel Split- or Solid-Ring Hangers (MSS Type 6): For suspension of noninsulated stationary pipes, NPS 3/4 to NPS 8.
 7. Adjustable, Steel Band Hangers (MSS Type 7): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 8. Adjustable Band Hangers (MSS Type 9): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 8.
 9. Adjustable, Swivel-Ring Band Hangers (MSS Type 10): For suspension of noninsulated stationary pipes, NPS 1/2 to NPS 2.
 10. Split Pipe-Ring with or without Turnbuckle-Adjustment Hangers (MSS Type 11): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 8.
 11. Extension Hinged or 2-Bolt Split Pipe Clamps (MSS Type 12): For suspension of noninsulated stationary pipes, NPS 3/8 to NPS 3.
 12. U-Bolts (MSS Type 24): For support of heavy pipes, NPS 1/2 to NPS 30.
 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, 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, with steel pipe base stanchion support and cast-iron floor flange and with U-bolt to retain pipe.
- 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.
 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.
 3. Insulate all Vertical piping clamps connections.
- 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 deg 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 deg 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-joint construction to attach to top flange of structural shape.
 3. Side-Beam or Channel Clamps (MSS Type 20): For attaching to bottom flange of beams, channels, or angles.
 4. Center-Beam Clamps (MSS Type 21): For attaching to center of bottom flange of beams.
 5. Welded Beam Attachments (MSS Type 22): For attaching to bottom of beams if loads are considerable and rod sizes are large.
 6. C-Clamps (MSS Type 23): For structural shapes.
 7. Top-Beam Clamps (MSS Type 25): For top of beams if hanger rod is required tangent to flange edge.
 8. Side-Beam Clamps (MSS Type 27): For bottom of steel I-beams.
 9. Steel-Beam Clamps with Eye Nuts (MSS Type 28): For attaching to bottom of steel I-beams for heavy loads.
 10. Linked-Steel Clamps with Eye Nuts (MSS Type 29): For attaching to bottom of steel I-beams for heavy loads, with link extensions.
 11. Malleable Beam Clamps with Extension Pieces (MSS Type 30): For attaching to structural steel.
 12. Welded-Steel Brackets: For support of pipes from below, or for suspending from above by using clip and rod. Use one of the following for indicated loads:
 - a. Light (MSS Type 31): 750 lb.
 - 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. Comply with MSS SP-69 for trapeze pipe hanger selections and applications that are not specified in piping system Sections.
- L. Comply with MFMA-102 for metal framing system selections and applications that are not specified in piping system Sections.

- M. 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.
- 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. Fiberglass Pipe Hanger Installation: Comply with applicable portions of MSS SP-69 and MSS SP-89. Install hangers and attachments as required to properly support piping from building structure.
- D. Metal Framing System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled metal framing systems.
- E. Fiberglass Strut System Installation: Arrange for grouping of parallel runs of piping and support together on field-assembled fiberglass struts.
- F. Thermal-Hanger Shield Installation: Install in pipe hanger or shield for insulated piping.
- G. 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.
- H. 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.
- I. Install hangers and supports complete with necessary inserts, bolts, rods, nuts, washers, and other accessories.
- J. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- K. 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.
- L. Install lateral bracing with pipe hangers and supports to prevent swaying.
- M. 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 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.

- N. Load Distribution: Install hangers and supports so piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- O. Pipe Slopes: Install hangers and supports to provide indicated pipe slopes and so maximum pipe deflections allowed by ASME B31.1 (for power piping) and ASME B31.9 (for building services piping) are not exceeded.
- P. Insulated Piping: Comply with the following:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above or below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - b. Do not exceed pipe stress limits according to ASME B31.1 for power piping and 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 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 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: 12 inches long and 0.048 inch thick.
 - b. NPS 4: 12 inches long and 0.06 inch thick.
 - c. NPS 5 and NPS 6: 18 inches long and 0.06 inch thick.
 - d. NPS 8 to NPS 14: 24 inches long and 0.075 inch thick.
 - e. NPS 16 to NPS 24: 24 inches long and 0.105 inch thick.
 - 5. Pipes NPS 8 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 23 05 29

SECTION 23 05 53

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.

1.02 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 SUMMARY

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

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of product indicated.
- C. Samples: For color, letter style, and graphic representation required for each identification material and device.
- D. Equipment Label Schedule: Include a listing of all equipment to be labeled with the proposed content for each label.
- E. Valve numbering scheme.
- F. Valve Schedules: For each piping system to include in maintenance manuals.

1.05 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 or Stainless steel 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 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 deg F.
 5. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
 6. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
 7. Fasteners: Stainless-steel rivets or self-tapping screws.
 8. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- C. Label Content: Include equipment's Drawing designation or unique equipment number.
- D. Equipment Label Schedule: For each item of equipment to be labeled, on 8-1/2-by-11-inch 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 deg F.
- E. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.

- F. Minimum Letter Size: 1/4 inch for name of units if viewing distance is less than 24 inches, 1/2 inch for viewing distances up to 72 inches, and proportionately larger lettering for greater viewing distances. Include secondary lettering two-thirds to three-fourths the size of principal lettering.
- G. Fasteners: Stainless-steel rivets or self-tapping screws.
- H. 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. Pretensioned Pipe Labels: Precoiled, semirigid 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.
 - 3. Color: Provide background and lettering color in accordance with Part 3 applications.

2.04 DUCT LABELS

- A. Maximum Temperature: Able to withstand temperatures up to 160 deg F.
- B. Minimum Label Size: Length and width vary for required label content, but not less than 2-1/2 by 3/4 inch.
- C. 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.
- D. Adhesive: Contact-type permanent adhesive, compatible with label and with substrate.
- E. Duct Label Contents: Include identification of duct service using same designations or abbreviations as used on Drawings, duct size, and an arrow indicating flow direction.
 - 1. Flow-Direction Arrows: Integral with duct system service lettering to accommodate both directions, or as separate unit on each duct label to indicate flow direction to cover full circumference or perimeter of ductwork.
 - 2. Lettering Size: At least 1-1/2 inches high.
 - 3. Color: Provide background and lettering color in accordance with Part 3 applications.

2.05 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 or Stainless steel 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 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.

2.06 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 surfaces 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.
- C. Provide equipment labels for each piece of equipment identified on drawing schedules.

3.03 PIPE LABEL INSTALLATION

- A. 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. At each side of penetrations through all 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 30 feet along each run. Reduce intervals to 15 feet in areas of congested piping and equipment.

7. On piping above removable acoustical ceilings. Omit intermediately spaced labels.
8. Where major devices, valves, dampers, etc are above ceiling, provide equipment identification on ceiling grid to assist in locating device. Include direction arrow to identify specific tile.

B. Pipe Label Color Schedule:

1. Heating Water Piping:
 - a. Background Color: Red.
 - b. Letter Color: White.
2. Refrigerant Piping:
 - a. Background Color: Black.
 - b. Letter Color: White.

3.04 DUCT LABEL INSTALLATION

A. Install self-adhesive duct labels with permanent adhesive on air ducts in the following color codes:

1. Supply, Return, and Mixed air:
 - a. Background Color: Green
 - b. Letter Color: White
2. Exhaust and Relief Air:
 - a. Background Color: Red
 - b. Letter Color: White
3. Outside Air:
 - a. Background Color: Blue
 - b. Letter Color: White

B. Locate labels near points where ducts enter into concealed spaces and at maximum intervals of 20 feet in each space where ducts are exposed or concealed by removable ceiling system.

3.05 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 HVAC terminal devices and similar roughing-in connections of end-use fixtures and units. List tagged valves in a valve schedule.

B. Valve-Tag Application Schedule: Tag valves according to size, shape, and color scheme and with captions similar to those indicated in the following subparagraphs:

1. Valve-Tag Size and Shape:
 - a. Refrigerant: 1-1/2 inches, round.
 - b. Hot Water: 1-1/2 inches, round.
 - c. Gas: 1-1/2 inches, round.
2. Valve-Tag Color:
 - a. Refrigerant: Natural.
 - b. Hot Water: Natural.
 - c. Gas: Natural.

3. Letter Color:
 - a. Refrigerant: Black.
 - b. Hot Water: Black.
 - c. Gas: Black.

3.06 WARNING-TAG INSTALLATION

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

END OF SECTION 23 05 53

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1: GENERAL

1.01 QUALIFICATIONS

- A. The Balancing Contractor shall be a certified member of the Associated Air Balance Council or the National Environmental Balancing Bureau and shall issue, upon receipt of contract, an A.A.B.C. "National Project Certification Performance Guarantee".
- B. The Balancing Contractor shall have a minimum of five (5) years corporate existence along with balancing personnel assigned to this project that each have a minimum of five (5) years experience of successful balancing Mechanical Building Systems in facilities similar to this project.

1.02 SCOPE

- A. The mechanical system balancing shall include all labor, materials, skills, instruments and equipment necessary to perform a complete and proper heating, ventilating and air conditioning system balance adjustment as intended by the Contract Documents, including the following:
 - 1. Complete ventilating, air conditioning and exhaust systems, balancing the airflow to and from all openings, adjusting dampers, fan speeds and making adjustments necessary to provide fully balanced systems performing as intended by the Contract Documents.
 - a. The setting and adjusting of all dampers, deflecting vanes, discharge vanes, and accessories to achieve proper air distribution and patterns in all parts of the air supply, return, relief and exhaust systems.
 - b. Adjusting of all belt-drive fan speeds to attain design or optimum total CFM deliveries.
 - c. The balancing contractor shall be responsible for providing and installation to replace and install all fan and motor sheaves and belts as required to achieve the required airflow and static from each piece of equipment (new and existing). The TAB contractor shall be responsible for testing and preliminarily balancing of the equipment and system after changes have been made prior to final testing and balancing.
 - 2. Piped/pumped systems of all hydronic water, condenser water, and other systems, balancing the flow to/from each device and making such test and adjustments necessary to meet the required volume and performance intended by the Contract Documents.
 - 3. Domestic Piped/pumped systems of all domestic hot water recirculating systems, balancing the flow to/from each circulation balancing valve and circ pump making such test and adjustments necessary to meet the required volume and performance intended by the Contract Documents.
 - 4. The testing and balancing contractor shall perform a complete balancing of the entire existing and new building ventilation, air conditioning, exhaust, and hydronic systems to meet the new design requirements as well as the existing conditions to remain. Original documents referencing the existing building ventilation and hydronic equipment to be rebalanced shall be provided by the owner to the contractor for information on the balancing of the existing equipment..
 - 5. The testing and balancing contractor shall be familiar with phasing of construction and shall responsible for providing preliminary testing and balancing of the system after each phase in completed and shall provide a final complete test and balance after all phases are complete.

6. The testing and balancing contractor shall provide a pre-balance prior ceiling being installed in areas where access is limited due to inaccessible ceiling.
 7. The TAB contractor shall coordinate with the mechanical contractor to verify exact locations of balancing valves, dampers, etc. prior to completion to allow for work to be performed.
- B. The Mechanical Contractor shall provide the balancing agency with a copy of the project specifications, the latest approved mechanical drawings, fan submittals, pump curves, coil data, control diagrams and any other necessary information required to perform the balancing and adjusting with information listing all changes, revisions, additions, etc. that pertain to the balancing and adjusting of the mechanical systems.
 - C. The Mechanical Contractor shall instruct his employees and subcontractors to leave all devices in a wide-open position and to free all operating arms and adjustments so they can be easily operated.
 - D. The Mechanical Contractor shall be certain that all systems are in proper operation; and prior to the balancing and adjusting, will install clean filters in all air systems, clean all water strainers and maintain same during the balancing and adjusting operations.
 - E. The Balancing Contractor shall enlist the aid of the installing contractor, subcontractors or equipment suppliers and whenever such aid is required, it shall be provided at no additional cost to the Balancing Contractor or to the Owner.
 - F. All balancing procedures and instrumentation shall be in accordance with the requirements and recommendations of A.A.B.C. "National Standards for Field Measurements and Instrumentation Total System Balance".
 - G. Instruments used for balancing systems must have been calibrated within a period of six (6) months prior to balancing this project.
 - H. The Balancing Contractor shall cooperate with the Engineer and the Contractor installing the work to effect a smooth coordination of the balancing work with the job schedule.

1.03 REFERENCES

- A. National Environmental Balancing Bureau (NEBB) "Procedural Standards".
- B. Associated Air Balance Council (AABC) Manual MN-1.
- C. American Society of Heating, Refrigeration, and Air Conditioning Engineers (ASHRAE) Handbook "HVAC Systems and Applications".
- D. Sheet Metal Contractors National Association (SMACNA) Publications.

1.04 SUBMITTALS

- A. The Balancing Contractor shall submit three (3) certified copies of the balancing reports to the Architect/Engineer for evaluation of the system operation. The balancing report shall adhere to the A.A.B.C. general outlines, however, modifications shall be made, adding or deleting specific items as may be required to suit individual system needs.
- B. The balancing work shall include a report and review of the required work with the Engineer before beginning field balance work. Provide two (2) inspections of the system during construction. Submit a report of the findings in writing to the Engineer.
- C. All reports shall be signed by a supervisor who is certified by the National Environmental Balancing Bureau (NEBB) or the Associated Air Balance Council (AABC).
- D. Balancing reports shall include identification and types of balancing instruments used and date of most recent calibration.

PART 2: PRODUCTS AND EXECUTION

2.01 BALANCING AIR SYSTEMS

- A. Air quantity in all main ducts shall be measured by pilot tube traverse. Where necessary for proper balancing, similar measurements shall be made in branch ducts. Openings in ducts for pilot tube insertion shall be sealed with plugs. Outlet and inlet air quantities shall be determined by anemometer in accordance with outlet and inlet manufacturer's recommendation.
- B. Dampers shall be permanently marked after air balance is complete so that they can be restored to their correct position if disturbed at any time.
- C. Adjusting of individual outlets shall be performed under procedures recommended by the manufacturers of the outlets or as otherwise approved by the Engineer.
- D. These adjustments shall be made with all fans in operation, the filters in place, and all room doors and other openings in the normal operating position.
- E. The total airflow CFM of all outlets, as recorded in the balance report and within acceptable limits, shall agree with the measured airflow CFM at the fan or in the main and/or branch ducts.
- F. Patch holes in insulation, ductwork and housing, which have been cut or drilled for test purposes, in manner recommended by original installer.
- G. Mark equipment settings, including damper control positions, fan speed control levers, and similar controls and devices, to show final settings at completion of balancing work. Provide markings with paint or other suitable permanent identification materials.
- H. Balance the air deliveries from each unit in accordance with recommendations of the diffuser, register, or grille manufacturer; setting fan speeds, dampers, controls and/or other volume control devices in such a manner as to produce the air volumes shown on the drawings. Record the following items:
 - 1. Room number or name.
 - 2. Grille, register or diffuser type and size.
 - 3. Specified CFM.
 - 4. Actual CFM
 - 5. Volume of air handled by each supply, return and exhaust fan.
 - 6. Static pressure at inlet and outlet of each fan, coil, and filter.
 - 7. Speed of all fans and motors.
 - 8. Rated fans and motors.
 - 9. Actual fan motor amperage.
 - 10. Outside air and exhaust air quantities for fans and air handing units.
- I. Balance vehicle areas to have a slight negative pressure relationship to offices areas, but slight positive pressure to outdoors.

2.02 BALANCING HYDRONIC SYSTEMS

- A. The Balancing Contractor shall prepare the hydronic system for balancing in the following manner:
 - 1. Open all valves to full open position. Close coil bypass stop valves. Set mixing valve to full coil flow.
 - 2. Installing Contractor to remove and clean all strainers.
 - 3. Examine water in system and determine if water has been treated and cleaned.
 - 4. Check pump rotation.
 - 5. Check expansion tanks to determine they are not air bound and the system is completely full of water.
 - 6. Check all air vents at high points of water systems and determine all are installed and operating freely.
 - 7. Set all temperature controls so all coils are calling for full cooling. This should close all automatic bypass valves at coil and chiller. Follow same procedure when balancing hot water coils, set on full call for heating.
 - 8. Check operation of automatic bypass valve.
 - 9. Check and set operating temperatures of boilers and chillers to design requirements.
 - 10. Balancing of air systems shall be complete before actual balancing of hydronic systems begins.
 - 11. The Balancing Contractor shall then proceed with balancing of the hydronic systems.
- B. For each pump measure and record the following data:
 - 1. Specified GPM, pressure difference, RPM, horsepower, electrical characteristics.
 - 2. Actual pressure difference.
 - 3. Actual RPM.
 - 4. Motor nameplate amps, volts and horsepower.
 - 5. Actual measured motor volts and amps.
- C. Plot the actual system pump curve using actual measured values of GPM, pressure difference and RPM.
- D. When a standby pump backs up more than one system, separate readings shall be taken for each standby pump operation for each system.
- E. Flowmeter Station: When flow measuring devices are used, record GPM at each.
- F. Hydronic Coil: Record GPM at each.
- G. Each pump and flow measuring device shall be identified. Flow-measuring device may be identified by referencing the coil or coil bank it controls.

2.03 CONTROL SYSTEMS

- A. The control systems shall be tested under operating conditions with the actual operations verified and temperature readings taken around each control point to verify the correct control function or operation. All damper functions

shall be similarly verified. These results shall also be recorded onto certificates and submitted to the Architect/Engineer.

- B. The Balancing Contractor shall at all times during the balancing and adjusting operations note any deficiencies, malfunctions or omissions that are discovered. These problems shall be reported to the proper parties for correction and to the Engineer.
- C. The Control Systems Contractor shall be responsible for the proper setting of the motors to stroke dampers, valves, etc., as set by the Balancing Contractor.

2.04 PREPARATION

- A. Review the contract documents and shop drawings and identify to the Mechanical Systems Installers where balancing devices are required and not indicated.
- B. Examine installed work and conditions under which testing and balancing is to be done to ensure that work has been completed, cleaned and is operable. Do not proceed with balancing work until unsatisfactory conditions have been corrected in manner acceptable to the Balancer.

2.05 REPORTS

- A. Prepare a report of test results, including instrumentation calibration reports, in format recommended by applicable standards. Include in the report all information obtained in balancing on the mechanical systems as specified herein.
- B. Prepare a report of recommendations for correcting unsatisfactory mechanical performances when a system cannot be successfully balanced, including, where necessary, modifications which exceed requirements of the contract documents for mechanical work.

2.06 RETEST SYSTEM

- A. Retest, adjust and rebalance systems subsequent to significant system modifications, and resubmit test results.

END OF SECTION 23 05 93

SECTION 23 07 00

HVAC 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 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 SUMMARY

- A. Section Includes:

1. Insulation Materials:
 - a. Flexible elastomeric.
 - b. Mineral fiber.
 - c. Polyolefin.
2. Fire-rated insulation systems.
3. Insulating cements.
4. Adhesives.
5. Mastics.
6. Lagging adhesives.
7. Sealants.
8. Factory-applied jackets.
9. Field-applied fabric-reinforcing mesh.
10. Field-applied cloths.
11. Field-applied jackets.
12. Tapes.
13. Securements.
14. Corner angles.

- B. Related Sections:

1. Division 21 Section "Fire-Suppression Systems Insulation."
2. Division 22 Section "Plumbing Insulation."
3. Division 23 Section "Ductwork" for duct liners.

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of product indicated. Include thermal conductivity, thickness, and jackets (both factory and field applied, if any).
- C. Shop Drawings:
 1. Detail application of protective shields, saddles, and inserts at hangers for each type of insulation and hanger.

2. Detail attachment and covering of heat tracing inside insulation.
 3. Detail insulation application at pipe expansion joints for each type of insulation.
 4. Detail insulation application at elbows, fittings, flanges, valves, and specialties for each type of insulation.
 5. Detail removable insulation at piping specialties, equipment connections, and access panels.
 6. Detail application of field-applied jackets.
 7. Detail application at linkages of control devices.
 8. Detail field application for each equipment type.
- D. Qualification Data: For qualified Installer.

1.05 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. Work shall be done per "Commercial and Industrial Insulation Standards;" published by the Midwest Insulation Contractors Association, by firms with at least five (5) years corporate experience.
- C. Material shall be delivered to job site in original unbroken factory sealed packaging, labeled with manufacturer's density and thickness, and fire and smoke ratings. Materials shall be protected from weather and kept clean and dry
- D. 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.

1.06 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.

1.07 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Coordinate clearance requirements with piping Installer for piping insulation application, duct Installer for duct insulation application, and equipment Installer for equipment insulation application. Before preparing piping and ductwork 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.

1.08 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. Flexible Elastomeric (FE): Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials and Type II for sheet materials; thermal conductivity (avg) of 0.27 Btu/hr-ft²-°F or lower at mean temperature of 75°F; 3.0 lbs./ft³ density (ASTM D/622); 0.08 perm-in permeability (ASTM E96); 0.2% water absorption (ASTM C209). Provide field applied jacket on all exposed indoor and exterior piping.
- G. Mineral-Fiber Blanket Insulation (MF): Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 553, Type II and ASTM C 1290, Type I; thermal conductivity (avg) of 0.27 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article. Refer to Part 3 below for insulation density.
- H. Mineral-Fiber Board Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type 1, 3.0 lb./cu. ft. density for up to 450°F. Service shall meet or exceed ASTM C 680 thermal conductivity test of .23 BTU-in/hr-ft² - °F at 75°F mean temperature. Provide with factory applied FSK jacket.
- I. Rigid Fiberglass Ductwork Insulation: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C612, Type 1, 3.0 lb./cu. ft. density for up to 450°F. Service shall meet or exceed ASTM C 680 thermal conductivity test of .23 BTU-in/hr-ft² - °F at 75°F mean temperature. Provide with factory applied FSK jacket.
- J. Mineral-Fiber, Preformed Pipe Insulation (MF): Type I, 850 deg F Materials: Mineral or glass fibers bonded with a thermosetting resin. Comply with ASTM C 547, Type I, Grade A, with factory-applied ASJ-SSL; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- K. Mineral-Fiber, Pipe and Tank Insulation (MF): Mineral or glass fibers bonded with a thermosetting resin. Semirigid 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 3.5 lb/cu. ft. or more. Thermal conductivity (k-value) at 100 deg F is 0.29 Btu x in./h x sq. ft. x deg F or less. Factory-applied jacket requirements are specified in "Factory-Applied Jackets" Article.
- L. Polyolefin (P): Unicellular, polyethylene thermal plastic insulation. Comply with ASTM C 534 or ASTM C 1427, Type I, Grade 1 for tubular materials and Type II, Grade 1 for sheet materials; thermal conductivity (avg) of 0.25 Btu/hr-ft²-°F or lower at mean temperature of 75°F; 1.5 lbs./ft³ density (ASTM D1622); 0.0 perm-in permeability (ASTM E96); 0.0% water absorption (ASTM C209).

2.02 FIRE-RATED INSULATION SYSTEMS

- A. Fire-Rated Board: Structural-grade, press-molded, xonolite calcium silicate, fireproofing board suitable for operating temperatures up to 1700 deg F. Comply with ASTM C 656, Type II, Grade 6. tested and certified to provide a 1-hour fire rating by a NRTL acceptable to authority having jurisdiction.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Johns Manville; Super Firetemp M.
- B. Fire-Rated Blanket: High-temperature, flexible, blanket insulation with FSK jacket that is tested and certified to provide a 1-hour fire rating by a NRTL acceptable to authority having jurisdiction.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. CertainTeed Corp.; FlameChek.
 - b. Johns Manville; Firetemp Wrap.
 - c. Nelson Firestop Products; Nelson FSB Flameshield Blanket.
 - d. Thermal Ceramics; FireMaster Duct Wrap.
 - e. 3M; Fire Barrier Wrap Products.
- C. Grease Duct Fire-Rated Blanket: High-temperature, flexible, blanket insulation suitable for operating temperatures up to 2000 deg F. Comply with ASTM E 2336 and NFPA 96. Tested and certified to provide a 2-hour fire rating by a NRTL acceptable to authority having jurisdiction.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Thermal Ceramics; FireMaster FastWrap XL Duct Wrap

2.03 INSULATING CEMENTS

- A. Mineral-Fiber, Hydraulic-Setting Insulating and Finishing Cement: Comply with ASTM C 449/C 449M.

2.04 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 and Polyolefin Adhesive: Comply with MIL-A-24179A, Type II, Class I.
- C. Mineral-Fiber Adhesive: Comply with MIL-A-3316C, Class 2, Grade A.
- D. ASJ Adhesive, and FSK and PVDC Jacket Adhesive: Comply with MIL-A-3316C, Class 2, Grade A for bonding insulation jacket lap seams and joints.
- E. PVC Jacket Adhesive: Compatible with PVC jacket.

2.05 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. Water-Vapor Permeance: ASTM E 96, Procedure B, 0.013 perm at 43-mil dry film thickness.
 - 2. Service Temperature Range: Minus 20 to plus 180 deg F.
 - 3. Solids Content: ASTM D 1644, 59 percent by volume and 71 percent by weight.

4. Color: White.
- C. Breather Mastic: Water based; suitable for indoor and outdoor use on above ambient services.
1. Water-Vapor Permeance: ASTM F 1249, 3 perms at 0.0625-inch dry film thickness.
 2. Service Temperature Range: Minus 20 to plus 200 deg F.
 3. Solids Content: 63 percent by volume and 73 percent by weight.
 4. Color: White.

2.06 LAGGING ADHESIVES

- A. Description: Comply with MIL-A-3316C Class I, Grade A and shall be compatible with insulation materials, jackets, and substrates.
1. Fire-resistant, water-based lagging adhesive and coating for use indoors to adhere fire-resistant lagging cloths over duct, equipment, and pipe insulation.
 2. Service Temperature Range: Minus 50 to plus 180 deg F.
 3. Color: White.

2.07 SEALANTS

- A. FSK and Metal Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 4. Color: Aluminum.
- B. ASJ Flashing Sealants, and Vinyl, PVDC, and PVC Jacket Flashing Sealants:
1. Materials shall be compatible with insulation materials, jackets, and substrates.
 2. Fire- and water-resistant, flexible, elastomeric sealant.
 3. Service Temperature Range: Minus 40 to plus 250 deg F.
 4. Color: White.

2.08 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, for applications where the systems operate below ambient temperature at least part of the time or where a vapor barrier is required.

2. ASJ-SSL: ASJ with self-sealing, pressure-sensitive, acrylic-based adhesive covered by a removable protective strip; complying with ASTM C 1136, Type I, for applications where the systems operate below ambient temperature at least part of the time or where a vapor barrier is required.
3. FSK Jacket: Aluminum-foil, fiberglass-reinforced scrim with kraft-paper backing; complying with ASTM C 1136, Type II. Vapor retarder shall be rated for 150°F service, ASTM E 96 vapor permeance rated at 0.02 perms., for applications where systems operate above ambient temperatures or where a vapor retarder is not required.

2.09 FIELD-APPLIED JACKETS

- A. Field-applied jackets shall comply with ASTM C 921, as follows:
 1. Shall comply with ASTM C921, Type I, for applications where the systems operate below ambient temperature at least part of the time or where a vapor barrier is required.
 2. Shall comply with ASTM C921, Type II, for applications where systems operate above ambient temperatures or where a vapor retarder is not required.
- B. PVC Jacket: High-impact-resistant, UV-resistant PVC complying with ASTM D 1784, Class 16354-C; thickness as scheduled; roll stock ready for shop or field cutting and forming. Thickness is indicated in field-applied jacket schedules.
 1. Adhesive: As recommended by jacket material manufacturer.
 2. Color: White.
 3. Factory-fabricated fitting covers to match jacket if available; otherwise, field fabricate.
 - a. Shapes: 45- and 90-degree, short- and long-radius elbows, tees, valves, flanges, unions, reducers, end caps, soil-pipe hubs, traps, mechanical joints, and P-trap and supply covers for lavatories.
 4. Factory-fabricated tank heads and tank side panels.
 5. Provide paintable PVC jacket on all exposed piping not concealed with a ceiling or chase.
- C. Fitting Covers:
 1. PVC Jacket: One or two piece pre-molded high impact PVC fitting covers with fiberglass inserts and accessories. Covers shall be UV resistant and comply with ASTM 1784-92. Covers shall be sized to comply with insulation applications detailed in Part 3.0.
 - a. Below ambient systems: provide continuous vapor barrier in accordance with manufacturer recommendations.
 - b. Fiberglass Inserts: Thermal conductivity (ASTM C177), thermal conductivity average of 0.26 Btu/hr-ft²-°F or lower at a mean temperature of 75 °F.
- D. Metal Jacket:
 1. Aluminum Jacket: Comply with ASTM B 209, Alloy 3003, 3005, 3105 or 5005, Temper H-14.
 - a. Factory cut and rolled to size.
 - 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.

2.10 TAPES

- A. ASJ Tape: White vapor-retarder tape matching factory-applied jacket with acrylic adhesive, complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 11.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. ASJ Tape Disks and Squares: Precut disks or squares of ASJ tape.
- B. FSK Tape: Foil-face, vapor-retarder tape matching factory-applied jacket with acrylic adhesive; complying with ASTM C 1136.
 1. Width: 3 inches.
 2. Thickness: 6.5 mils.
 3. Adhesion: 90 ounces force/inch in width.
 4. Elongation: 2 percent.
 5. Tensile Strength: 40 lbf/inch in width.
 6. FSK Tape Disks and Squares: Precut disks or squares of FSK tape.
- C. PVC Tape: Paintable white vapor-retarder tape matching field-applied PVC jacket with acrylic adhesive. Suitable for indoor and outdoor applications.
 1. Width: 2 inches.
 2. Thickness: 6 mils.
 3. Adhesion: 64 ounces force/inch in width.
 4. Elongation: 500 percent.
 5. Tensile Strength: 18 lbf/inch in width.
- D. Aluminum-Foil Tape: Vapor-retarder tape with acrylic adhesive.
 1. Width: 2 inches.

2. Thickness: 3.7 mils.
3. Adhesion: 100 ounces force/inch in width.
4. Elongation: 5 percent.
5. Tensile Strength: 34 lbf/inch in width.

2.11 SECUREMENTS

A. Bands:

1. Stainless Steel: ASTM A 167 or ASTM A 240/A 240M, Type 304; 0.015 inch wide with wing seal.
2. Aluminum: ASTM B 209, Alloy 3003, 3005, 3105, or 5005; Temper H-14, 0.020 inch wide with wing seal.

B. Insulation Pins and Hangers:

1. 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.
2. 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.
3. Metal, Adhesively Attached, Perforated-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Perforated, galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive: Recommended by hanger manufacturer. Product with demonstrated capability to bond insulation hanger securely to substrates indicated without damaging insulation, hangers, and substrates.
4. Self-Sticking-Base Insulation Hangers: Baseplate welded to projecting spindle that is capable of holding insulation, of thickness indicated, securely in position indicated when self-locking washer is in place. Comply with the following requirements:
 - a. Baseplate: Galvanized carbon-steel sheet, 0.030 inch thick by 2 inches square.
 - b. Spindle: Copper- or zinc-coated, low carbon steel, fully annealed, 0.106-inch- diameter shank, length to suit depth of insulation indicated.
 - c. Adhesive-backed base with a peel-off protective cover.
5. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick, galvanized-steel sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.
6. Nonmetal Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick nylon sheet, with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 inches in diameter.

- C. Staples: Outward-clinching insulation staples, nominal 3/4-inch- wide, stainless steel or Monel.
- D. Wire: 0.062-inch soft-annealed, stainless steel.

2.12 CORNER ANGLES

- A. Aluminum Corner Angles: 0.040 inch thick, minimum 1 by 1 inch, aluminum according to ASTM B 209, Alloy 3003, 3005, 3105 or 5005; Temper H-14.

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. Coordinate insulation installation with the trade installing heat tracing. Comply with requirements for heat tracing that apply to insulation.
- C. Mix insulating cements with clean potable water; if insulating cements are to be in contact with stainless-steel surfaces, use demineralized water.

3.03 PIPING INSULATION APPLICATION

- A. Indoor Piping System Insulation: Insulate with insulation types and thicknesses as listed in the table below. If more than one pipe material is listed for a piping system, selection from materials listed is the contractor's option.

TABLE NO. 23 07 00: MINIMUM PIPE INSULATION

Piping System Types	Fluid Temp Range, °F	Type of ⁽¹⁾ Insulation	Insulation Thickness in Inches for Pipe Sizes				
			3/4" and Smaller	1" to 1 1/4"	1 1/2" to 3"	4" to 6"	8" and Larger
<u>Conditioned Spaces</u>							
Hot Water (7)	105-200	MF	1 1/2"	1 1/2"	2"	2"	2"
Low Pressure Steam (7)	201-250	MF	2 1/2"	2 1/2"	2 1/2"	3"	3"
High Pressure Steam (7)	251-350	MF	3"	4"	4 1/2"	4 1/2"	4 1/2"
Steam Condensate (7)	Any	MF	1 1/2"	1 1/2"	2"	2"	2"
Chilled Water ⁽²⁾⁽³⁾	Greater than or equal to 40	FE	1/2"	1/2"	1"	1"	1"
Chilled Water ⁽²⁾⁽³⁾	Less than 40	FE	1/2"	1"	1"	1"	1 1/2"
Condenser water ⁽⁵⁾	Any	FE	-	-	1"	1"	1"
Make-Up Water	Any	MF, FE	1/2"	1/2"	1"	-	-
Condensate Drains	Any	FE, P	1/2"	1"	1"	-	-
Refrigerant (Suction)	40-55	FE, P	1/2"	1/2"	1"	1"	-
Refrigerant (Hot Gas) ⁽⁴⁾	Up to 140	MF	1"	1"	1 1/2"	-	-
<u>Unconditioned Spaces⁽⁶⁾</u>							
Chilled Water ⁽²⁾⁽³⁾	Greater than or equal to 40	FE	1"	1"	1 1/2"	1 1/2"	1 1/2"
Chilled Water ⁽²⁾⁽³⁾	Less than 40	FE	1"	1 1/2"	1 1/2"	1 1/2"	2"
Refrigerant (Suction)	40-55	FE, P	1"	1"	1 1/2"	1 1/2"	-

¹ Insulation material abbreviations:

- a. Mineral fiber (MF) – with factory applied jacket per part 2.0 requirements.
- b. Flexible Elastomeric (FE)
- c. Polyolefin (P)

² Provide flexible elastomeric cellular insulation at valves and fittings with paintable PVC jacket on all exposed paintable. Refer to drawings for installation details.

³ Provide two layers of insulation for thickness 1 1/2" and greater. Longitudinal seams shall be offset to ensure a continuous vapor barrier.

⁴ Insulation not required outside of the building.

⁵ Insulate piping indicated within 10 feet at the exterior envelope.

⁶ Unconditioned spaces shall include all systems indicated located in mechanical rooms, tunnels, boiler rooms, out door storage rooms, and outside the building envelope.

⁷ For hot water, steam and steam condensate piping only, piping smaller than 1 1/2" and located in partitions within conditioned spaces, reduction of these thicknesses by 1" shall be permitted, but not to thicknesses below 1".

- B. Refer to Division 23 Section 23 05 29 "Hangers and Supports for HVAC Piping and Equipment" for insulation insert and insulation shield requirements.
- C. Outdoor Piping System Insulation: Increase insulation thicknesses indicated for indoor applications by 1/2". All outdoor insulation shall be flexible elastomeric or polyolefin. Provide with weather barrier aluminum jacket.
- D. Insulation Omitted: Omit insulation for the following:
 - 1. Hot low pressure piping within radiation enclosures or unit cabinets.
 - 2. Cold piping within unit cabinets provided piping is located over drain pan.

3.04 DUCT INSULATION SCHEDULE, GENERAL

- A. Plenums and Ducts Requiring Insulation:

- 1. Indoor, concealed supply, outdoor, and combustion air.

2. Indoor, exposed supply (unless otherwise noted), outdoor air, and combustion air.
3. Indoor, concealed return and exhaust located in nonconditioned space. This includes ducted returns above a non-plenum ceiling. Return ducts in a return air plenum do not require insulation.
4. Indoor, exposed return located in nonconditioned space.
5. Indoor, concealed exhaust and relief between isolation damper and penetration of building exterior.
6. Indoor, exposed exhaust and relief between isolation damper and penetration of building exterior.
7. Outdoor, concealed supply, return, outdoor air and exhaust.
8. Outdoor, exposed supply, return, outdoor air and exhaust.
9. All existing exposed ductwork which is to be enclosed within a wall, soffit, ceiling, etc. shall be fully insulated per insulation requirements.

B. Items Not Insulated:

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

3.05 INDOOR DUCT AND PLENUM INSULATION SCHEDULE

A. Concealed, supply-air duct and plenum insulation:

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.

B. Concealed, return-air duct and plenum insulation; non-conditioned areas including ducted returns in a non-plenum ceiling (insulation not required in return air ceiling plenums or in chases or shafts within the conditioned building perimeter):

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.

C. Concealed, outdoor and combustion air duct and plenum insulation:

1. Mineral-Fiber Blanket: 2 inches thick and 1.0-lb/cu. ft nominal density.

D. Concealed, exhaust-air and relief-air duct and plenum insulation (within 10 feet of exterior wall or roof):

1. Mineral-Fiber Blanket: 1-1/2 inches thick and 1.0-lb/cu. ft nominal density.

E. Exposed, supply-air duct and plenum insulation (insulation not required on exposed ductwork within a conditioned space, i.e. Gym):

1. Mineral-Fiber Board: 2 inches thick and 3.0-lb/cu. ft nominal density.

F. Exposed, supply, return-air duct and plenum insulation, non-conditioned areas:

1. Mineral-Fiber Board: 2 inches thick and 3.0-lb/cu. ft nominal density.

G. Exposed, outdoor and combustion air duct and plenum insulation:

1. Mineral-Fiberboard: 2 inches thick and 3.0-lb/cu.ft. nominal density.
2. Mineral-Fiberblanket: 2 inches thick and 1.5 lb/cu.ft nominal density. For round ducts only.

H. Exposed, exhaust-air and relief-air duct and plenum insulation:

1. Mineral-Fiber Board: 2 inches thick and 3.0-lb/cu. ft nominal density.

- I. Flexible Elastomeric Duct Liner: (Preformed, cellular, closed-cell):
 - 1. Closed cell foam, 0.25 BTU/in/Sq.ft. at 75degF
 - a. Provide at all transfer ducts shown on the drawings.
 - b. Provide at all supply and return ductwork a minimum distance of 15 feet from the air handling, rooftop units, vertical unit ventilators, fan coil units, heat pumps, etc.
 - c. All ductwork installed with sound insulating closed cell liner as specified shall also be externally wrapped with duct insulation per the insulation schedules.

3.06 OUTDOOR DUCT AND PLENUM INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a duct system, selection from materials listed is Contractor's option.
- B. Concealed, supply-air and return duct and plenum insulation:
 - 1. Mineral-Fiber Board: 2 inches thick and 3.0-lb/cu. ft nominal density.
- C. Exposed, supply-air duct and return and plenum insulation:
 - 1. Flexible Elastomeric: 2.5 inches (meeting R-8 insulation value). Provide with aluminum metal jacket of the same gauges as the duct.
 - 2. Provide ice and water shield on outer layer of insulation and between aluminum metal jacket, refer to architectural specifications for exact requirements of shield material.

3.07 EQUIPMENT INSULATION SCHEDULE

- A. Insulation materials and thicknesses are identified below. If more than one material is listed for a type of equipment, selection from materials listed is Contractor's option.
- B. Insulate indoor and outdoor equipment in paragraphs below that is not factory insulated.
- C. Heating-hot-water pump insulation shall be:
 - 1. Flexible Elastomeric: 1 inch thick.
- D. Heating-hot-water expansion/compression tank insulation shall be:
 - 1. Flexible Elastomeric: 1 inch thick.
- E. Heating-hot-water air-separator insulation shall be:
 - 1. Flexible Elastomeric: 1 inch thick.

3.08 GENERAL INSTALLATION REQUIREMENTS

- A. Install insulation materials, accessories, and finishes with smooth, straight, and even surfaces; free of voids throughout the length of equipment, ducts and fittings, and all piping including fittings, drains, valves, control valve bodies, expansion joints and specialties. All piping including piping, fitting and specialties between valves and coil shall be insulated.
- B. Install insulation materials, forms, vapor barriers or retarders, jackets, and thicknesses required for each item of equipment, duct system, 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. For all insulation, seal. Exposed fiberglass including cut pre-formed pipe sections with manufacturer's approved mastic.
- 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 duct and 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. Testing agency labels and stamps.
 - 3. Nameplates and data plates.
 - 4. Manholes.
 - 5. Handholes.
 - 6. Cleanouts.

3.09 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. 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 Section "Firestopping" for firestopping and fire-resistive joint sealers.
- F. 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. Pipe: Install insulation continuously through floor penetrations.
3. Seal penetrations through fire-rated assemblies. Comply with requirements in Division 07 Section "Firestopping."

3.10 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 prestressed 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 prestressed 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. Flexible Elastomeric Thermal Insulation Installation for Tanks and Vessels: Install insulation over entire surface of tanks and vessels.
1. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
 2. Seal longitudinal seams and end joints.

3.11 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. Fiberglass inserts with PVC fitting covers are acceptable. 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.
 - a. Fiberglass inserts with a thickness and density equal to the adjacent pipe insulation with a pre-formed PVC fitting cover may be used in lieu of preformed or mitered fitting covers.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Fiberglass inserts with PVC fitting covers are acceptable. 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. Fiberglass inserts with PVC fitting covers are acceptable. 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. Fiberglass inserts with PVC fitting covers are acceptable. 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. Stencil or label the outside insulation jacket of each union with the word "UNION." Match size and color of pipe labels.
- C. Insulate instrument connections for thermometers, pressure gages, pressure temperature taps, test connections, flow meters, sensors, switches, and transmitters on insulated pipes, 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.
- 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.
- E. Provide paintable PVC jacket on all exposed piping not with ceiling or chase spaces. All exterior piping shall be jacket with an aluminum jacket.
- F. Provide 16 gauge galvanized sheet metal insulation shields at all hanger locations. Shields shall be a minimum of 12" in length and formed to fit pipe contour.

3.12 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.

3.13 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.
- E. 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 100 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 overcompress 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 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 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.
- F. 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 100 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 deg F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to 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.

3.14 POLYOLEFIN INSULATION INSTALLATION

A. Insulation Installation on Straight Pipes and Tubes:

1. Seal split-tube 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 polyolefin 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 polyolefin 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 cut sections of polyolefin pipe and sheet insulation to valve body.
 2. 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.

3.15 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.
- B. Provide paintable PVC jacket on all exposed piping not with ceiling or chase spaces. All exterior piping shall be jacket with an aluminum jacket.
- C. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications, install with longitudinal seams along top and bottom of tanks and vessels. Seal with manufacturer's recommended adhesive.
1. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.

- D. Where metal jackets are indicated, install with 2-inch overlap at longitudinal seams and end joints. Overlap longitudinal seams arranged to shed water. Seal end joints with weatherproof sealant recommended by insulation manufacturer. Secure jacket with stainless-steel bands 12 inches o.c. and at end joints.

3.16 FIRE-RATED INSULATION SYSTEM INSTALLATION

- A. Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating.
- B. Insulate duct access panels and doors to achieve same fire rating as duct.
- C. Install firestopping at penetrations through fire-rated assemblies. Fire-stop systems are specified in Division 07 Section "Firestopping."

3.17 OUTDOOR, FIELD-APPLIED JACKET SCHEDULE

- A. Install jacket over insulation material. For insulation with factory-applied jacket, install the field-applied jacket over the factory-applied jacket.
- B. If more than one material is listed, selection from materials listed is Contractor's option.
- C. Outdoor Ducts and Plenums:
 - 1. Aluminum, Smooth of the same gauge as the enclosed duct.
- D. Outdoor Piping:
 - 1. Aluminum, Smooth with Z-Shaped Locking Seam, 0.032 inch thick.

END OF SECTION 23 07 00

SECTION 23 09 00

BUILDING AUTOMATION SYSTEM

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 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 SUMMARY

- A. Provide a complete Building Automation System as described here in and within the BAS Sequence of Operations Section 23 09 93. The system shall include all programming, material and installation as described in order to control all new mechanical equipment as well as all existing equipment described in these specification sections and shown on the design documents. The Temperature Control Contactor shall remove all existing pneumatic control currently serving existing equipment and field install all new required DDC controllers and monitoring points in order to provide and complete DDC system.
- B. The TCC shall also visit the site prior to bidding and field verify the extent of existing equipment to be retrofitted as to maintain a new complete seamless building automation and frontend control. The TCC include all necessary work in their bid to install, program, control and monitor existing equipment to remain as to maintain at a minimum their same existing control functions prior to retrofit unless specifically called out for under these specifications. The TCC shall provide all required taps, wells, sensors, actuators, etc into the existing piping and ventilation system as required to provide a complete system as specified.
- C. The TCC shall make all necessary modification to the controls and graphics of all equipment which is to be added to, rebalanced, modified and/or is serves new areas. The TTC shall update the graphics to show all changes including updating areas served.
- D. Existing equipment to be retrofitted to new DDC controls shall maintain at a minimum their same existing control functions prior to retrofit unless specifically called out for under these specifications.
- E. Integration shall be seamless and complete; including but not limited to: all necessary hardware, system server, software, and new system graphic pages for all points and systems in these buildings, no exceptions.
 - 1. All field level controllers and operator software for the new addition and existing building will be of the same manufacturer at the completion of the project
 - 2. Interfacing/integrating to the existing building's field level controllers is not acceptable
- F. General Description: Furnish a fully integrated Building Automation System utilizing intelligent distributed control modules for equipment monitoring and control. EMCS is hereby defined to include, but not limited to, central computer workstation, input/output (I/O) devices, I/O interfaces, modems, housings, interconnect cabling, valves, sensors, thermostats, dampers, controllers, actuators, and control modules and other panels associated with equipment and required to provide system control functions as indicated on drawings and schedules, and by requirements of this section.
 - 1. The system shall be modular in nature and shall permit expansion of both capacity and function through the addition of sensors, actuators, modular control units, application specific controllers and operator devices.

2. All control system hardware and virtual software points required to accomplish the intent of the control sequences shall be programmed conforming to ANSI/ASHRAE standard 135-2001 BACnet protocol. It is the intent that the system be programmed with BACnet interoperable objects such that it can be interfaced with other equipment at a future date.
- G. Provide assistance and technical support as required to the Testing and Balancing and Functional Performance Contractor to accomplish all testing work required. Upon completion of the self performed tests required in article 3.03 "Quality Control", notify the testing agent in writing that the system is ready for testing. The notification shall include a copy of all self performed checklists. Refer to specification section 01 45 43 for testing agent's testing requirements.
 - H. Access to the system, either locally in the building or off site shall be accomplished through standard web browser software via the internet and local area network.
 - I. Coordinate with the Owner's representative and associated building technologies groups for the installation of a rack mounted web based server. Conform to the Building Technology requirements.
 - J. Provide all variable frequency motor controllers in accordance with all requirements of specification section 23 09 50 "Variable-Frequency Motor Controllers." Provide all variable-frequency controllers as indicated on the drawings and as required to accomplish all control functions required in the sequence of operations. Turn drives over to the Electrical Contractor for installation.
 - K. Program systems to accomplish all control functions in accordance with the requirements of Specification Section 23 09 93 "BAS Sequence of Operations."
 - L. Provide (1) new computer control terminal with monitor and printer located in the building engineer's office for BAS control.
 - M. Refer to architectural and mechanical specification sections for additional "testing and balancing" and "commissioning" requirements.
 - N. The BAS contractor shall provide a detailed coordination drawings showing location and elevation of all thermostats and coordinate exact location with architect prior installation.

1.04 ELECTRICAL WORK

- A. Provide the following electrical work as work of this section, complying with all Division 26 specification requirements:
 1. Power supply wiring from power source to power connections on controls and/or control modules. Provide all 24 VAC transformers as required for all control operations. Coordinate with the electrical contractor for the locations and quantities of available spare breakers. Review the Electrical Drawings prior to bid to determine power source locations and voltage. The Building Automation System Contractor is required to provide all transformer installations as required for the available power voltage.
 2. Where any additional sources of 120-volt electrical power is required, the TCC shall sub-contract all work as required.
 3. Control wiring between field-installed controls, indicating devices, thermostats and sensors unit control panels.
 4. Raceways, and Electrical Boxes and Fittings: Provide raceways, and electrical boxes and fittings complying with Division 26 specifications.
 5. Conduit and junction boxes for all control devices (temperature sensor, thermostats, wall switches, etc.) shall be provided by the Building Automation System Contractor. Route conduit from control device junction boxes in wall up to ceiling/plenum spaces. All wiring in outdoors and in mechanical rooms, electrical rooms and similar spaces shall be completely in conduit.

6. The Temperature Control Contractor shall provide relays as required for starters of all 120/1-volt equipment not furnished with factory starters, or if starters are not furnished by the Electrical Contractor. Control relays shall be provided in NEMA 1 enclosure.
7. All conduit in spaces other than mechanical rooms, boiler rooms, and electrical rooms that is not routed above the ceiling shall be concealed in walls. It is the responsibility of the Building Automation System Contractor to coordinate conduit required to be installed in poured concrete walls prior to construction.

1.05 QUALITY ASSURANCE

- A. Contractors shall have a minimum ten years of experience installing and programming control systems. Contractors shall also be factory authorized representative for the control product installed. Submit proof of years of experience and factory authorization upon request.
- B. NEC Compliance: Comply with applicable requirements of NEC pertaining to installation of energy management and control systems, including, but not limited to, remote-control, signaling and power-limited circuits.
- C. UL Compliance: Provide energy management and control system components and ancillary equipment which are listed and labeled in accordance with UL 864 and UL 916.
- D. NEMA Compliance: Comply with NEMA'S Pub No. 250, and Stds ICS 1, 2, 3 and 6 pertaining to enclosures and controls for energy management and control systems.
- E. FCC Compliance: Comply with Subpart J of Part 15, Federal Communications Commission Rules, pertaining to Class A radiation and computing devices and low power communication equipment operating in commercial type environment. Comply with Part 68, Federal Communication Commission Rules, pertaining to labeling of telephone equipment, including data sets and modems, indicating FCC registration and numbering.
- F. EIA Compliance: Comply with Electronic Industries Association's Std RS-232 pertaining to interfacing requirements for connecting data terminals and communication equipment.
- G. IEEE Compliance: Comply with IEEE Std 488, "Standard Digital Interface for Programmable Instrumentation", for interfacing instrumentation into system.
- H. ANSI Compliance: Comply with ANSI X3.4, "Code for Information Interchange", requirements for interfacing computer data processing with communication terminal equipment.
- I. NFPA Compliance: Comply with NFPA 90A "Standard for the Installation of Air Conditioning and Ventilating Systems" where applicable to electronic controls and control sequences.
- J. Fire Alarm and Smoke Control System UL Compliance: Provide all energy management and control system components and ancillary equipment which are listed and labeled in accordance with UL 864.

1.06 RELATED WORK

- A. Refer to other Division 23 sections for the installation of instrument wells, valve bodies, sensors, flow switches, smoke detectors, and dampers. Coordinate equipment delivery schedules and installation requirements.
- B. BAS contractor will furnish the following:
 1. Flow meters: furnish to mechanical installer and coordinate per manufacturers requirements.
 2. AFMS shall be provided by, installed and wired by the temperature control contractor
 3. Flow switches: furnish to mechanical installer and coordinate per manufacturer's requirements.
 4. Refrigerant pressure and temperature sensor wells: furnish to mechanical installer and coordinate per

- manufacturer's requirements.
5. Hydronic pressure and temperature sensor wells: furnish to mechanical installer and coordinate per manufacturer's requirements.
 6. Control valves: furnish to mechanical installer and coordinate per manufacturer's requirements.
 7. Automatic control dampers actuators: furnish to mechanical installer and coordinate per manufacturer's requirements.
- C. BAS contractor must meet with installer furnishing the following equipment to coordinate details of the control interface boards between these products and the BAS networks. The owner or his representative shall be present at this meeting. Each installer shall provide the owner and all other Installers with details of the proposed interface including PICS for BACnet equipment, hardware, and software identifiers for the interface points, network identifiers, wiring requirements, communication speeds, and required network accessories. The purpose of the meeting shall be to insure there are not unresolved issues regarding the integration of these products in the BAS network.

1.07 SUBMITTALS

- A. Product Data: Submit manufacturer's technical product data for each control device furnished, dampers, valves, sensors, thermostats, etc. Indicate dimensions, capacities, performance characteristics, electrical characteristics, finishes of materials, and including installation instructions and start-up instructions. Indicate system power connections to electrical power feeders.
- B. Shop Drawings
8. Provide system architecture lay out showing field panels, terminal (VAV) box controllers, central computer terminal, tie-in to existing systems, power panels (see system layout for system requirements).
 9. Provide panel numbering sequence and (VAV) box controller submittal showing specific units controlled by each piece of DDC hardware.
 10. Provide point address, set points, alarm limits, wire types, conduit knock out diagrams and wiring diagrams for all points of interface.
 11. Provide power panel layouts showing number and type of transformers and termination strips. Panels must meet UL listing requirements.
 12. Provide technical cut sheets for DDC hardware and sensors.
 13. Submit drawings for each system automatically controlled, containing the following information:
 - a. Schematic flow diagram of system showing fans, pumps, coils, dampers, valves, sensors and control devices. List all equipment associated with each system, no general references will be accepted. Include damper and valve failure positions.
 - b. Label each control device with setting or adjustable range of control.
 - c. Indicate factory and field wiring.
 - d. Indicate each control panel required, with internal and external piping and wiring clearly indicated. Provide detail of panel face, including controls, instruments, and labeling. Include verbal description of sequence of operation.
- C. User Interface Graphics: Submit for review all user interface graphics prior to substantial completion of the project. The Owner reserves the right to modify system graphics prior to final payment.
- D. Wiring Diagrams: Submit power, signal and control wiring diagrams, breaker location and identification,

transformer locations, and communication link locations indicating panel-to-panel connections, for energy management and control systems. Clearly differentiate between portions of wiring that are manufacturer- installed and portions that are field-installed.

- E. Maintenance Data: Submit maintenance instructions and spare parts lists. Include product data and shop drawings in maintenance manual in accordance with requirements of Division 1. Include copy of shop drawings in each maintenance manual in accordance with requirements of Division 1.
- F. Samples: Submit samples of each type of thermostat/temperature sensor, in accordance with requirements of Division 1.
- G. Agreement to Maintain: Prior to time of final acceptance, installer shall submit 4 copies of agreement for continued service and maintenance of energy management and control systems, for Owner's possible acceptance. Offer terms and conditions for furnishing parts and providing continued testing and servicing, including replacement of materials and equipment, and software maintenance for one-year period commencing after the warranty period required by the terms of this contract. the Owner's representative shall retain the option for annual renewal of the offered service agreement.

1.08 DELIVERY, STORAGE AND HANDLING

- A. Provide factory shipping cartons for each piece of equipment, and control device. Maintain cartons through shipping, storage and handling as required to prevent equipment damage, and to eliminate dirt and moisture from equipment. Store equipment and materials inside and protected from weather.

1.09 WARRANTY

- A. Provide a warranty and maintain the stability of work and materials and keep same in perfect repair and condition for a minimum of two (2) years. The warranty shall be for one (1) year in addition to the one year required by the terms in the front end of these contract documents.
- B. Correct defects of any kind immediately and at Contractor's expense, due to faulty work or materials appearing during the above mentioned period and made to the entire satisfaction of the Owner and Architect/Engineer. Such reconstruction and repairs shall include damage to the finish or the building resulting from the original defect or repairs thereto.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering energy management and control systems which may be incorporated in the work include the following: The building automation system shall be an extension of the existing Tridium Niagara control system.

2.02 BUILDING AUTOMATION SYSTEM – HARDWARE

- A. General: Provide energy management and control systems with adequate capacity and performance rating to process the number of system points indicated. Comply with manufacturer's standard design, materials, and components; construct in accordance with published product information, as required for complete installation, and as herein specified.
 - 1. The intent of this specification is to provide a peer-to-peer networked, standalone, distributed control system with the capability to integrate both the ANSI/ASHRAE Standard 135-2001 BACnet communication protocols an open, interoperable system.

2. The supplied computer software shall employ object-oriented technology (OOT) for representation of all data and control devices within the system. In addition, adherence to industry standards including ANSI/ASHRAE™ Standard 135-2001, BACnet to assure interoperability between all system components is required. For each BACnet device, the device must provide a PICS document showing the installed device's compliance level. Minimum compliance is Level 3; with the ability to support data read and write functionality. Physical connection of BACnet devices shall be via Ethernet.
 3. All components and controllers supplied under this contract shall be true "peer-to-peer" communicating devices. Components or controllers requiring "polling" by a host to pass data shall not be acceptable.
 4. The supplied system must incorporate the ability to access all data using standard Web browsers without requiring proprietary operator interface and configuration programs. An Open Data Base Connectivity (ODBC) or Structured Query Language (SQL) compliant server database is required for all system database parameter storage. This data shall reside on a supplier-installed server for all database access. Systems requiring proprietary database and user interface programs shall not be acceptable.
 5. A hierarchical topology is required to assure reasonable system response times and to manage the flow and sharing of data without unduly burdening the customer's internal Intranet network. Systems employing a "flat" single tiered architecture shall not be acceptable.
 - a. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 5 seconds for network connected user interfaces.
 - b. Maximum acceptable response time from any alarm occurrence (at the point of origin) to the point of annunciation shall not exceed 60 seconds for remote or dial-up connected user interfaces.
 6. Control modules shall be capable of proper operation in an ambient environment of 32°F to 120°F and 10% to 90% relative humidity--non-condensing.
- B. Central Computer Workstation: Provide central computer workstation consisting of, but not limited to, components which have the following construction features. Select equipment whose assembled console configuration is suitable for desktop installation. Construct the components required for interface with the building network. Locate central computer workstation in building maintenance office. Coordinate exact location with the Owner's representative.
1. Computer: PC/AT , employing Intel I-series technology operating at a minimum 2.5 GHz with a 500 gigabyte hard disk, 6 GB random access memory (RAM) (expandable), DVD/CD RWD, 1GB video card. Operating system shall be the most current Microsoft OS. The computer shall have a battery powered uninterruptible power supply. The real time clock shall provide the following information: time-of-day, month, year, and day of week. Provide a minimum of two USB ports for connection to peripherals in addition to a parallel and serial port.
 2. Colorgraphics Monitor and Controller: Provide high resolution, Color DVI LCD monitor to display real time graphic data, execute operator commands, and report system activity. Display unit shall consist of at least a 19" (diagonal measurement) color flat screen monitor. The unit shall be configured for a minimum 1024 x 768 Pixel resolution. Provide high-speed video graphics card with 1MB ram.
 3. Mouse: The primary operator interface device shall consist of a 2-button optical mouse.
 4. Keyboard: The enhanced keyboard with 101-key layout shall contain a full ASCII complement and shall include a dedicated numeric keypad with separate ENTER key for rapid entry of data.
 5. Printers: Provide one color laser printer for data information, and alarm reports.
- C. Control Networks
1. Local Area Network (LAN):

- a. Provide a microprocessor-based communications data path which shall act as a "peer-to-peer" network allowing all control modules to communicate with equal authority.
- b. The LAN shall be responsible for routing global information from the various control module networks.
- c. LAN shall support a minimum of 16 workstations connected simultaneously.
- d. The Local Area Network (LAN) shall be 100/1000 Ethernet network supporting BACnet, Java, XML, HTTP, and CORBA IIOP for maximum flexibility for integration of building data with enterprise information systems and providing support for multiple Network Area Controllers (NACs), user workstations and, if specified, a local host computer system.
- e. Local area network minimum physical and media access requirements:
 - 1) Ethernet; IEEE standard 802.3
 - 2) Cable; 10 Base-T, UTP-8 wire, category 6
 - 3) Minimum throughput; 100 Mbps, with ability to increase to 1.0 GBps
- f. The system shall be capable of providing access to the LAN from a remote location, via the Internet. Coordinate with the Owner's technology representative to determine the level of access desired. The Owner will provide a connection to the Internet to enable this access via high speed cable modem, asynchronous digital subscriber line (ADSL) modem, ISDN line, T1 Line or via the customer's Intranet to a corporate server providing access to an Internet Service Provider (ISP).

2. Application Specific Controller (ASC) Network

- a. ASC Controllers shall be used for direct digital control of selected single zone equipment. They shall be microprocessor based. In the event of loss of communication with the network, the controller shall function in a stand-alone mode, with all control sequences and schedules performed. Provide user-defined default algorithms (values) for global points affecting the operation of the ASC, such as outside lights levels, outside temperatures, status of heating system, etc.

D. Network Area Controller (NAC)

1. Provide one or more Network Area Controllers (NAC) as required to interface between the LAN and the field control devices, and provide global supervisory control functions over the control devices connected to the NAC. NAC controllers shall present data in accordance with BACnet ANSI/ASHRAE Standard 135/2001. It shall be capable of executing application control programs to provide:
 - a. Calendar functions
 - b. Scheduling
 - c. Trending
 - d. Alarm monitoring and routing
 - e. Time synchronization
 - f. Integration BACnet controller data.
2. The Network Area Controller must provide the following hardware features as a minimum:
 - a. One Ethernet Port -10 / 100 Mbps
 - b. One RS-232 port
 - c. Battery Backup
 - d. Flash memory for long term data backup (If battery backup or flash memory is not supplied, the controller must contain a hard disk with at least 1 gigabyte storage capacity)
 - e. The NAC must be capable of operation over a temperature range of 0 to 55°C
 - f. The NAC must be capable of withstanding storage temperatures of between 0 and 70°C

- g. The NAC must be capable of operation over a humidity range of 5 to 95% RH, non-condensing
3. The NAC shall provide multiple user access to the system. A database resident on the NAC shall provide a data access mechanism to read and write data stored within it.
 4. The NAC shall support standard Web browser access via the Intranet/Internet. It shall support a minimum of 16 simultaneous users.
 5. The NAC shall provide alarm recognition, storage; routing, management, and analysis to supplement distributed capabilities of equipment or application specific controllers.
 6. The NAC shall be able to route any alarm condition to any defined user location whether connected to a local network or remote via dial-up, telephone connection, or wide-area network. Provide at a minimum eight alarm classes for the purpose of routing types.
 7. Alarm data recorded for each alarm shall include the time and date, location, equipment, acknowledge time and date, number of occurrences since last acknowledgement.
 8. The NAC shall have the ability to collect data for any property of any object and store this data for future use.
 9. All log data shall be stored in a relational database in the NAC and the data shall be accessed from a server (if the system is so configured) or a standard Web Browser.
 10. Provide and maintain an Audit Log that tracks all activities performed on the NAC. Provide the ability to specify a buffer size for the log and the ability to archive log based on time or when the log has reached it's user-defined buffer size. Provide the ability to archive the log locally (to the NAC), to another NAC on the network, or to a server.
 11. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on a user-defined time interval.
 12. Each (NAC) shall be capable of stand-alone direct digital operation utilizing its own processor, non-volatile memory, input/output, A to D conversion, clock/calendar and voltage transient protection. All volatile memory shall have a battery backup.
 13. All point data, algorithms and application software within an (NAC) network shall be modifiable from the Central workstation. It shall not be necessary to enter parameters at the (NAC) for control and programs to operate.
 14. Each (NAC) shall execute application programs, calculations, and commands via a microcomputer resident in the (NAC). The database and all application programs for each (NAC) shall be stored in read/write non-volatile memory within the (NAC) and shall be able to upload/download to or from the Central Site.
 15. Each (NAC) shall be connected to a (LAN) communicating to/from other Control modules. Each (NAC) shall include self-test diagnostics which allow the (NAC) to automatically relay any malfunctions of alarm conditions that exceed desired parameters as determined by programming input to the network.
 16. Each (NAC) shall contain both software and hardware to perform full DDC/PID control loops.
- E. Database Backup and Storage
1. The NAC shall have the ability to automatically backup its database. The database shall be backed up based on an user-defined time interval.
 2. Copies of the current database and, at the most recently saved database shall be stored in the NAC. The age of the most recently saved database is dependent on the user-defined database save interval.

3. The NAC database shall be stored, at a minimum, in XML format to allow for user viewing and editing, if desired. Other formats are acceptable as well, as long as XML format is supported.

F. Web Server

1. The server shall support all Network Area Controllers (NAC) connected to the customer's network whether local or remote. Web server shall be rack mounted at a location coordinated with the Owner's representative and associated building technologies groups. Conform to all the Owner's representative networking requirements.
2. Local connections shall be via an Ethernet LAN. Remote connections can be via ISDN, ADSL, T1 or dial-up connection.
3. It shall be possible to provide access to all Network Area Controllers via a single connection to the server. In this configuration, each Network Area Controller can be accessed from the Graphical User Interface (GUI) or from a standard Web browser (WBI) by connecting to the server.
4. The server shall provide the following functions, at a minimum:
 - a. Global Data Access: The server shall provide complete access to distributed data defined anywhere in the system.
 - b. Distributed Control: The server shall provide the ability to execute global control strategies based on control and data objects in any NAC in the network, local or remote.
 - c. The server shall include a master clock service for its subsystems and provide time synchronization for all Network Area Controllers (NAC).
 - d. The server shall accept time synchronization messages from trusted precision Atomic Clock Internet sites and update its master clock based on this data.
 - e. The server shall provide scheduling for all Network Area Controllers and their underlying field control devices.
 - f. The server shall provide demand limiting that operates across all Network Area Controllers. The server must be capable of multiple demand programs for sites with multiple meters and or multiple sources of energy. Each demand program shall be capable of supporting separate demand shed lists for effective demand control.
 - g. The server shall implement the BACnet Command Prioritization scheme (16 levels) for safe and effective contention resolution of all commands issued to Network Area Controllers. Systems not employing this prioritization shall not be accepted.
 - h. Each Network Area Controller supported by the server shall have the ability to archive its log data, alarm data and database to the server, automatically. Archiving options shall be user-defined including archive time and archive frequency.
 - i. The server shall provide central alarm management for all Network Area Controllers supported by the server. Alarm management shall include:
 - 1.) Routing of alarms to display, printer, email and pagers
 - 2.) View and acknowledge of alarms
 - 3.) Query alarm logs based on user-defined parameters
 - j. The server shall provide central management of log data for all Network Area Controllers supported by

the server. Log data shall include process logs, runtime and event counter logs, audit logs and error logs. Log data management shall include:

- 1.) Viewing and printing log data
- 2.) Exporting log data to other software applications
- 3.) Query log data based on user-defined parameters

G. Application Specific Control Modules (ASC)

1. Provide one of the following ASC's:
 - a. ASC Modules shall be microprocessor based Interoperable Controllers that shall communicate in BACnet ANSI/ASHRAE Standard 135-2001 open protocol. ASC's shall be capable of providing the direct digital control of single zone Terminal HVAC Units, Unit Ventilators, Fan Coils, Heat Pumps, Variable Air Volume (VAV) Terminals and other applications as shown on the drawings. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier must provide a PICS document showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-2001. Minimum compliance is Level 3.
2. The ASC's shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
3. The ASC Sensor shall connect directly to the ASC and shall not utilize any of the I/O points of the controller. The ASC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The ASC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the ASC controller is connected. The ASC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
4. All ASC's shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the ASC shall be stored in non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
5. All control applications shall be field-selectable such that a single controller may be used in conjunction with any of the above types of terminal units.
6. Each ASC shall communicate with equal authority on a "peer-to-peer" basis.
7. Each ASC shall execute application programs, calculations, and commands via a microcomputer resident in the ASC. The database and all application programs for each ASC shall be stored in read/writable non-volatile memory. All volatile memory shall have a battery backup.
8. Each ASC shall contain both software and hardware to perform full DDC/PID control loops. ASC shall be able to provide analog output, in addition to normal binary type output.
9. Control modules shall include all point inputs and outputs necessary to perform the specified control sequences. As a minimum, 50% of the point outputs shall be of the Universal type. Analog outputs shall be industry standard signals (e.g. 24V floating control) allowing for interface to a variety of modulating actuators.
10. The control modules shall be powered from a 24 VAC source and shall function normally under an operating range of 18 to 28 VAC(-25% to +17%), allowing for power source fluctuations and voltage drops. Provide each module with a suitable cover or enclosure to protect the intelligence board assembly.
11. Each ASC shall have LED indication for visual status of communication, power, and all outputs.

12. Each controller shall include provisions for manual and automatic calibration of associated transducers in order to maintain stability and control drift over time.
13. The module shall interface to a variety of matching electronic room temperature sensors of the RTD or thermistor type with the following characteristics:
 - a. Independent setpoint modes for heating, cooling, and Night Setback.
 - b. Tamperproof locking cover.
 - c. Allow installation up to 100 ft from controller.
14. Controller points and set points shall be accessible from the central workstation and from a plug in jack at the base of each controller's sensor.
15. Contractor shall field verify operation of all controllers to insure correct field wiring, test actuator stroke, and correlate with controller submittal.
16. Contractor shall provide a POT and instructions to the balancer to read and adjust system perimeters for the balancing report.

H. Interoperable BACnet Controller (IBC)

1. Controls shall be microprocessor based Interoperable Controllers that shall communicate in either the BACnet ANSI/ASHRAE Standard 135-2001 open protocol. IBCs shall be provided for each Variable Air Volume (VAV) Terminals and other applications as shown on the drawings. The application control program shall be resident within the same enclosure as the input/output circuitry, which translates the sensor signals. The system supplier shall provide a PICS document upon request from the Engineer showing the installed systems compliance level to the ANSI/ASHRAE Standard 135-2001. Minimum compliance is Level 3.
 2. The IBCs shall communicate with the NAC via an Ethernet connection at a baud rate of not less than 10 Mbps.
 3. The IBC Sensor shall connect directly to the IBC and shall not utilize any of the I/O points of the controller. The IBC Sensor shall provide a two-wire connection to the controller that is polarity and wire type insensitive. The IBC Sensor shall provide a communications jack for connection to the BACnet communication trunk to which the IBC controller is connected. The IBC Sensor, the connected controller, and all other devices on the BACnet bus shall be accessible by the POT.
 4. All IBCs shall be fully application programmable and shall at all times maintain their BACnet Level 3 compliance. Controllers offering application selection only (non-programmable), require a 10% spare point capacity to be provided for all applications. All control sequences within or programmed into the IBC shall be stored in a non-volatile memory, which is not dependent upon the presence of a battery, to be retained.
 5. Provide documentation for each device upon request from the Engineer, with the following information at a minimum:
 - a. BACnet Device; MAC address, name, type and instance number
 - b. BACnet Objects; name, type and instance number
- I. Fault-Tolerance: Select components to operate over a wide range of supply voltage and frequency, with static, transient and short-circuit protection on all inputs and outputs. Protect communication lines against incorrect wiring, static transients and induced magnetic interference. Provide AC coupled devices for connection to communication network to limit device time-outs.

2.03 GRAPHICAL USER INTERFACE SOFTWARE

- A. Operating System:

1. The GUI shall run on Microsoft Windows 7.0, Service Pack 4 or later.
- B. The GUI shall employ browser-like functionality for ease of navigation. It shall include a tree view (similar to Windows Explorer) for quick viewing of, and access to, the hierarchical structure of the database. In addition, menu-pull downs, and toolbars shall employ buttons, commands and navigation to permit the operator to perform tasks with a minimum knowledge of the HVAC Control System and basic computing skills. These shall include, but are not limited to, forward/backward buttons, home button, and a context sensitive locator line (similar to a URL line), that displays the location and the selected object identification.
- C. Real-Time Displays. The GUI, shall at a minimum, support the following graphical features and functions:
 1. Graphic screens shall be developed using any drawing package capable of generating a GIF, BMP, or JPG file format. Use of proprietary graphic file formats shall not be acceptable. In addition to, or in lieu of a graphic background, the GUI shall support the use of scanned pictures.
 2. Graphic screens shall have the capability to contain objects for text, real-time values, animation, color spectrum objects, logs, graphs, HTML or XML document links, schedule objects, hyperlinks to other URL's, and links to other graphic screens.
 3. Graphics shall support layering and each graphic object shall be configurable for assignment to one a layer. A minimum of six layers shall be supported.
 4. Modifying common application objects, such as schedules, calendars, and set points shall be accomplished in a graphical manner.
 - a. Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - b. Holidays shall be set by using a graphical calendar, without requiring any keyboard entry from the operator.
 5. Commands to starts and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 6. Adjustments to analog objects, such as set points, shall be done by right-clicking the selected object and using a graphical slider to adjust the value. No entry of text shall be required.
- D. System Configuration. At a minimum, the GUI shall permit the operator to perform the following tasks, with proper password access:
 1. Create, delete or modify control strategies.
 2. Add/delete objects to the system.
 3. Tune control loops through the adjustment of control loop parameters.
 4. Enable or disable control strategies.
 5. Generate hard copy records or control strategies on a printer.
 6. Select points to be alarmable and define the alarm state.
 7. Select points to be trended over a period of time and initiate the recording of values automatically.
- E. On-Line Help. Provide a context sensitive, on-line help system to assist the operator in operation and editing of the system. On-line help shall be available for all applications and shall provide the relevant data for that particular screen. Additional help information shall be available through the use of hypertext. All system documentation and help files shall be in HTML format.
- F. Security. Each operator shall be required to log on to that system with a user name and password in order to view, edit, add, or delete data. System security shall be selectable for each operator. The system administrator shall have the ability to set passwords and security levels for all other operators. Each operator password shall be able to

restrict the operators' access for viewing and/or changing each system application, full screen editor, and object. Each operator shall automatically be logged off of the system if no keyboard or mouse activity is detected. This auto log-off time shall be set per operator password. All system security data shall be stored in an encrypted format.

- G. System Diagnostics. The systems shall automatically monitor the operation of all workstations, printer, modems, network connections, building management panels, and controllers. The failure of any device shall be annunciated to the operator.
- H. Alarm Console:
 - 1. The system will be provided with a dedicated alarm window or console. This window will notify the operator of an alarm condition, and allow the operator to view details of the alarm and acknowledge the alarm. The use of the Alarm Console can be enabled or disabled by the system administrator.
 - 2. When the Alarm Console is enable, a separate alarm notification window will supercede all other windows on the desktop and shall not be capable of being minimized or closed by the operator. This window will notify the operator of new alarms and un-acknowledged alarms. Alarm notification windows or banners that can be minimized or closed by the operator shall not be acceptable.
- J. Provide complete and entire building BAS Floor Plan and Navigation Graphics. Provide graphics for using floor plans of the building and "owner's room numbers" at a minimum. Coordinate with the Architect/Engineer (A/E). Size graphics to allow the operator to read room numbers and descriptions. Incorporate the capability to navigate section to section as required to view entire floor and to navigate floor to floor, individual rooms, and specification equipment.
 - 1. Floor plan graphics shall show heating and cooling zones throughout the buildings in a range of colors, which provide a visual display of temperature relative to their respective setpoints.
 - 2. The colors shall be updated dynamically as a zone's actual temperature to setpoint changes. These full screen plans shall be accessible by rolling over the floor on the building elevation rendering. This will provide the viewer a quick and accurate overview of which zones are at setpoint, near setpoint, or need attention.
 - 3. The viewer may then click on any zone to be brought to the terminal unit that is related to that zone. Rolling over any zone will bring up the zone description and temperature in a pop-up flag. Flags are used to keep the zone information legible regardless of how small the zone is depicted on the plan
 - 4. All floor plans shall be vector based to allow for zooming in and out of floor plans without pixelization.
 - 5. If zone lighting controls are tied into the BAS, then produce the same floor viewing and control for lights.
 - 6. If a Web-based graphical interface is specified, then the floor plan graphics shall be accessible through the Web Browser Interfaces.

2.04 WEB BROWSER CLIENTS

- A. The system shall be capable of supporting an unlimited number of clients using a standard Web browser such as Internet Explorer™ or Netscape Navigator™. Systems requiring additional software (to enable a standard Web browser) to be resident on the client machine, or manufacture-specific browsers shall not be acceptable.
- B. The Web browser software shall run on any operating system and system configuration that is supported by the Web browser. Systems that require specific machine requirements in terms of processor speed, memory, etc., in order to allow the Web browser to function with the EMCS, shall not be acceptable.
- C. The Web browser shall provide the same view of the system, in terms of graphics, schedules, calendars, logs, etc., and provide the same interface methodology as is provided by the Graphical User Interface. Systems that require different views or that require different means of interacting with objects such as schedules, or logs, shall not be permitted.
- D. The Web browser client shall support at a minimum, the following functions:
 - 1. User log-in identification and password shall be required. If an unauthorized user attempts access, a black web

page shall be displayed. Security using Java authentication and encryption techniques to prevent unauthorized access shall be implemented.

2. Graphical screens developed for the GUI shall be the same screens used for the Web browser client. Any animated graphical objects supported by the GUI shall be supported by the Web browser interface.
3. 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.
4. Storage of the graphical screens shall be in the Network Area Controller (NAC), without requiring any graphics to be stored on the client machine. Systems that require graphics storage on each client are not acceptable.
5. Real-time values displayed on a Web page shall update automatically without requiring a manual “refresh” of the Web page.
6. Users shall have administrator-defined access privileges. Depending on the access privileges assigned, the user shall be able to perform the following:
 - a. Modify common application objects, such as schedules, calendars, and set points in a graphical manner.
 - 1) Schedule times will be adjusted using a graphical slider, without requiring any keyboard entry from the operator.
 - 2) Holidays shall be set using a graphical calendar, without requiring any keyboard entry from the operator.
 - b. Commands to start and stop binary objects shall be done by right-clicking the selected object and selecting the appropriate command from the pop-up menu. No entry of text shall be required.
 - c. View logs and charts.
 - d. View and acknowledge alarms.
 - e. Setup and execute SQL queries on log and archive information.
7. The system shall provide the capability to specify a user’s (as determined by the log-on user identification) home page. Provide the ability to limit a specific user to just their defined home page. From the home page, links to other views, or pages in the system shall be possible, if allowed by the system administrator.
8. Graphic screens on the Web Browser client shall support hypertext links to other locations on the Internet or on Intranet sites, by specifying the Uniform Resource Locator (URL) for the desired line.

2.05 SYSTEM PROGRAMMING

- A. The Graphical User Interface software (GUI) shall provide the ability to perform system programming and graphic display engineering as part of a complete software package. Access to the programming functions and features of the GUI shall be through password access as assigned by the system administrator.
- B. A library of control, application, and graphic objects shall be provided to enable the creation of all applications and user interface screens. Applications are to be created by selecting the desired control objects from the library, dragging or pasting them on the screen, and linking them together using a built in graphical connection tool. Completed applications may be stored in the library for future use. Graphical User Interface screens shall be created in the same fashion. Data for the user displays is obtained by graphically linking the user display objects to the application objects to provide "real-time" data updates. Any real-time data value or object property may be connected to display its current value on a user display. Systems requiring separate software tools or processes to create applications and user interface displays shall not be acceptable.

C. Programming Methods

1. Provide the capability to copy objects from the supplied libraries, or from a user-defined library to the user's application. Objects shall be linked by a graphical linking scheme by dragging a link from one object to another. Object links will support one-to-one, many-to-one, or one-to-many relationships. Linked objects shall maintain their connections to other objects regardless of where they are positioned on the page and shall show link identification for links to objects on other pages for easy identification. Links will vary in color depending on the type of link; i.e., internal, external, hardware, etc.
2. Configuration of each object will be done through the object's property sheet using fill-in the blank fields, list boxes, and selection buttons. Use of custom programming, scripting language, or a manufacturer-specific procedural language for configuration will not be accepted.
3. The software shall provide the ability to view the logic in a monitor mode. When on-line, the monitor mode shall provide the ability to view the logic in real time for easy diagnosis of the logic execution. When off-line (debug), the monitor mode shall allow the user to set values to inputs and monitor the logic for diagnosing execution before it is applied to the system.
4. All programming shall be done in real-time. Systems requiring the uploading, editing, and downloading of database objects shall not be allowed.
5. The system shall support object duplication within a customer's database. An application, once configured, can be copied and pasted for easy re-use and duplication. All links, other than to the hardware, shall be maintained during duplication.

2.06 OBJECT LIBRARIES

- A. A standard library of objects shall be included for development and setup of application logic, user interface displays, system services, and communication networks.
- B. The objects in this library shall be capable of being copied and pasted into the user's database and shall be organized according to their function. In addition, the user shall have the capability to group objects created in their application and store the new instances of these objects in a user-defined library.
- C. In addition to the standard libraries specified here, the supplier of the system shall maintain an on-line accessible (over the Internet) library, available to all registered users to provide new or updated objects and applications as they are developed.
- D. All control objects shall conform to the control objects specified in the BACnet specification.
- E. The library shall include applications or objects for the following functions, at a minimum:
 1. Scheduling Object. The schedule must conform to the schedule object as defined in the BACnet specification, providing 7-day plus holiday & temporary scheduling features and a minimum of 10 on/off events per day. Data entry to be by graphical sliders to speed creation and selection of on/off events.
 2. Calendar Object. The calendar must conform to the calendar object as defined in the BACnet specification, providing 12-month calendar features to allow for holiday or special event data entry. Data entry to be by graphical "point-and-click" selection. This object must be "linkable" to any or all scheduling objects for effective event control.
 3. Duty Cycling Object. Provide a universal duty cycle object to allow repetitive on/off time control of equipment as an energy conserving measure. Any number of these objects may be created to control equipment at varying intervals

4. Temperature Override Object. Provide a temperature override object that is capable of overriding equipment turned off by other energy saving programs (scheduling, duty cycling etc.) to maintain occupant comfort or for equipment freeze protection.
 5. Start-Stop Time Optimization Object. Provide a start-stop time optimization object to provide the capability of starting equipment just early enough to bring space conditions to desired conditions by the scheduled occupancy time. Also, allow equipment to be stopped before the scheduled un-occupancy time just far enough ahead to take advantage of the building's "flywheel" effect for energy savings. Provide automatic tuning of all start /stop time object properties based on the previous day's performance.
 6. Demand Limiting Object. Provide a comprehensive demand-limiting object that is capable of controlling demand for any selected energy utility (electric, oil, and gas). The object shall provide the capability of monitoring a demand value and predicting (by use of a sliding window prediction algorithm) the demand at the end of the user defined interval period (1-60 minutes). This object shall also accommodate a utility meter time sync pulse for fixed interval demand control. Upon a prediction that will exceed the user defined demand limit (supply a minimum of 6 per day), the demand limiting object shall issue shed commands to either turn off user specified loads or modify equipment set points to effect the desired energy reduction. If the list of sheddable equipment is not enough to reduce the demand to below the set point, a message shall be displayed on the users screen (as an alarm) instructing the user to take manual actions to maintain the desired demand. The shed lists are specified by the user and shall be selectable to be shed in either a fixed or rotating order to control which equipment is shed the most often. Upon suitable reductions in demand, the demand-limiting object shall restore the equipment that was shed in the reverse order in which it was shed. Each sheddable object shall have a minimum and maximum shed time property to effect both equipment protection and occupant comfort.
- F. The library shall include control objects for the following functions. All control objects shall conform to the objects as specified in the BACnet specification.
1. Analog Input Object -Minimum requirement is to comply with the BACnet standard for data sharing. Allow high, low and failure limits to be assigned for alarming. Also, provide a time delay filter property to prevent nuisance alarms caused by temporary excursions above or below the user defined alarm limits.
 2. Analog Output Object -Minimum requirement is to comply with the BACnet standard for data sharing.
 3. Binary Input Object -Minimum requirement is to comply with the BACnet standard for data sharing. The user must be able to specify either input condition for alarming. This object must also include the capability to record equipment run-time by counting the amount of time the hardware input is in an "on" condition. The user must be able to specify either input condition as the "on" condition.
 4. Binary Output Object -Minimum requirement is to comply with the BACnet standard for data sharing. Properties to enable minimum on and off times for equipment protection as well as interstart delay must be provided. The BACnet Command Prioritization priority scheme shall be incorporated to allow multiple control applications to execute commands on this object with the highest priority command being invoked. Provide sixteen levels of priority as a minimum. Systems not employing the BACnet method of contention resolution shall not be acceptable.
 5. Pill Control Loop Object -Minimum requirement is to comply with the BACnet standard for data sharing. Each individual property must be adjustable as well as to be disabled to allow proportional control only, or proportional with integral control, as well as proportional, integral and derivative control.
 6. Comparison Object -Allow a minimum of two analog objects to be compared to select either the highest, lowest, or equality between the two linked inputs. Also, allow limits to be applied to the output value for alarm generation.
 7. Math Object -Allow a minimum of four analog objects to be tested for the minimum or maximum, or the sum, difference, or average of linked objects. Also, allow limits to be applied to the output value for alarm generation.

8. Custom Programming Objects -Provide a blank object template for the creation of new custom objects to meet specific user application requirements. This object must provide a simple BASIC- like programming language that is used to define object behavior. Provide a library of functions including math and logic functions, string manipulation, and e-mail as a minimum. Also, provide a comprehensive on-line debug tool to allow complete testing of the new object. Allow new objects to be stored in the library for re-use.
 9. Interlock Object -Provide an interlock object that provides a means of coordination of objects within a piece of equipment such as an Air Handler or other similar types of equipment. An example is to link the return fan to the supply fan such that when the supply fan is started, the return fan object is also started automatically without the user having to issue separate commands or to link each object to a schedule object. In addition, the control loops, damper objects, and alarm monitoring (such as return air, supply air, and mixed air temperature objects) will be inhibited from alarming during a user-defined period after startup to allow for stabilization. When the air handler is stopped, the interlocked return fan is also stopped, the outside air damper is closed, and other related objects within the air handler unit are inhibited from alarming thereby eliminating nuisance alarms during the off period.
 10. Temperature Override Object -Provide an object whose purpose is to provide the capability of overriding a binary output to an "On" state in the event a user specified high or low limit value is exceeded. This object is to be linked to the desired binary output object as well as to an analog object for temperature monitoring, to cause the override to be enabled. This object will execute a Start command at the Temperature Override level of start/stop command priority unless changed by the user.
 11. Composite Object -Provide a container object that allows a collection of objects representing an application to be encapsulated to protect the application from tampering, or to more easily represent large applications. This object must have the ability to allow the user to select the appropriate parameters of the "contained" application that are represented on the graphical shell of this container.
- G. The object library shall include objects to support the integration of devices connected to the Network Area Controller (NAC). At a minimum, provide the following as part of the standard library included with the programming software:
1. For BACnet devices, provide the following objects at a minimum:
 - a. BACnet AI.
 - b. BACnet AO
 - c. BACnet BI
 - d. BACnet BO
 - e. BACnet Device
 2. For each BACnet object, provide the ability to assign the object a BACnet device and object instance number.

2.07 MATERIALS AND EQUIPMENT

- A. General Description: Furnish direct digital electronic control products in sizes and capacities indicated, including valves, dampers, thermostats, clocks, sensors, controllers, and other components required for complete installation. Except as otherwise indicated, provide manufacturer's standard control system components as indicated by published product information, designed and constructed as recommended by manufacturer. Provide direct digital electronic control systems with the following functional and construction features, as indicated.
- B. Control Valves: Provide factory-fabricated electronic control valves of type, body material and pressure class indicated. Where type or body material is not indicated, provide selection as determined by manufacturer for installation requirements and pressure class, based on maximum pressure and temperature rating of piping system. Except as otherwise indicated, provide valves which mate and match material of connecting piping. Equip control valves with control valve motors, and with proper shutoff ratings for each individual application.

1. Water Service Valves: Globe screwed, equal percentage characteristics with rangeability of 50 to 1, and maximum full flow pressure drop of 5 psig. Motorized ball valves will be acceptable. Motorized butterfly valves will not be acceptable.
 2. Single-Seated Valves: Cage type trim, providing seating and guiding surfaces for plug on "top and bottom" guided plugs.
 3. Double-Seated Valves: Balanced plug-type, with cage type trim providing seating and guiding surfaces for plugs on "top and bottom" guided plugs.
 4. Valve Trim and Stems: Polished stainless steel.
 5. Packing: ½"-3/4" double O-ring; 1" and above spring-loaded Teflon, self-adjusting.
 6. Terminal Unit Control Valves: Provide control valves for control of terminal units including, but not necessarily limited to, convectors, finned tube radiation, and HW coils that are of integral motor type. Provide modulating type valves, electrically actuated by line voltage of 24 Volt.
- C. Dampers: Provide automatic control dampers as indicated, with damper frames not less than formed 13-ga. galvanized steel. Provide mounting holes for enclosed duct mounting. Provide damper blades not less than formed 16-ga. galvanized steel, with maximum blade width of 8". Equip dampers with motors, with proper rating for each application.
1. Secure blades to 1/2" diameter zinc-plated axles using zinc-plated hardware. Seal off against spring stainless steel blade bearings. Provide blade bearings of nylon and provide thrust bearings at each end of every blade. Construct blade linkage hardware of zinc-plated steel and brass. Submit leakage and flow characteristic, plus size schedule for controlled dampers.
 2. Operating Temperature Range: From -20 to 200°F.
 3. For standard applications as indicated, provide parallel or opposed blade design (as selected by manufacturer's sizing techniques) with optional closed-cell neoprene edging.
 4. Outside air dampers shall be parallel or opposed blade design (as selected by manufacturer's sizing techniques) with inflatable seal blade edging, or replaceable rubber seals, rated for leakage at less than 10 cfm/sq. ft. of damper area, at differential pressure of 4" w.g. when damper is being held by torque of 50 inch-pounds.
- D. Electric Actuators: Size each motor to operate dampers or valves with sufficient reserve power to provide smooth modulating action or 2-position action as specified. Provide multiple operators to match torque requirements.
1. Electronic actuators shall be direct coupled with a manual override feature and spring return.
 2. The actuator shall be direct-coupled over the damper shaft, enabling it to mount directly to the damper assembly without the need for connecting linkage. The fastening clamp assembly shall be a toothed "V" bolt design with associated toothed cradle, creating a "cold-weld" attachment to the damper shaft for maximum strength and eliminating slippage. Spring return actuators shall have a "V" clamp assembly of sufficient size to be directed to a damper jackshaft up to 1.05 inches in diameter when the damper is constructed in this manner. Single bolt or setscrew type fasteners are not acceptable.
 3. The actuator shall have an electronic overload or digital rotation sensing circuitry to prevent damage to the actuator through the entire rotation of the actuator. Mechanical end switches or magnetic clutches used to deactivate the actuator at the end of rotation are not acceptable.
 4. For power-failure and/or safety applications, and internal mechanical spring return mechanism shall be built into the actuator housing. Non-mechanical forms of fail-safe operation are not acceptable. All spring return actuators shall be capable of both clockwise and counter-clockwise spring return operation by simply changing

the actuator mounting orientation. Spring-return actuators shall deliver full torque capacity ratings of the actuator when operating in the fail-safe mode.

5. Proportional (modulating) actuators shall accept a 0 to 10 VDC or 0 to 20 mA control input and provide a 2 to 10 VDC or 4 to 20 mA control operating range. Actuators utilizing Pulse Width Modulating or Tri-State control signals and providing full proportional control of the damper shall also be acceptable. All modulating actuators shall provide 2 to 10 VDC position feedback signal.
 6. All 24 VAC/VDC actuators shall operate on Class 2 wiring and shall not require more than 10 VA for AC power or more than 8 watts for DC applications. Actuators operating on 120 VAC shall not require more than 10 VA. Actuators operating on 230 VAC shall not require more than 11 VA.
 7. All non-spring return actuators shall have an external manual gear release to allow manual positioning of the damper when the actuator is not powered. Spring return actuators with more than 60 in-lb torque capacity shall have an external, manual crank for this purpose.
 8. All modulating actuators shall have an external, built-in switch to allow the reversing of the direction of rotation.
 9. All actuators shall be provided with a conduit fitting and pre-terminated three-foot (minimum) cable, with wires color and/or number coded. Where installation does not require conduit, external terminal strips may be used. At no time shall it be necessary to open the actuator housing to make electrical connections, change direction of rotation, provide damper position indication or manual overrides.
 10. All actuators shall be listed under UL Standard 873 and CSA Class 4813-02 certified as required to meet recognized industry standards and local safety and electrical codes.
 11. Actuators shall be designed to deliver a minimum of 60,000 full stroke cycles at the actuators rated torque. Actuators shall have a full manufacturers warranty of 2 years from the time of installation.
- E. Remote-Bulb Thermostats: Provide remote-bulb thermostats of on/off or modulating type, as required by sequence of operation. Provide liquid-filled units designed to compensate for changes in ambient temperature at instrument case. Provide capillary and bulb of copper unless otherwise indicated. Equip bulbs in water lines with separate wells of same material as bulb. Support bulbs installed in air ducts securely, to prevent damage and noise from vibrations. Provide averaging bulbs where shown or specified in operational sequence, consisting of copper tubing not less than 8'-0" in length with either single or multiple-unit elements. Extend tubing to cover full width of duct or unit, and support adequately.
1. Provide scale settings and differential settings where applicable, which are clearly visible and adjustable from front of instrument.
 2. Equip on-off remote-bulb thermostats with precision snap switches, and with electrical ratings as required by application.
 3. Provide modulating remote-bulb thermostats of potentiometer type constructed so that complete potentiometer coil and wiper assembly is removable for inspection or replacement without disturbing calibration of instrument.
- F. Low-Temperature Protection Thermostats: Provide low-temperature protection thermostats of manual-reset type, with sensing elements 8'-0" or 20'-0" in length. Provide thermostat designed to operate in response to coldest 1'-0" length of sensing element, regardless of temperature at other parts of element. Support element properly to cover entire cross sectional area at duct. Provide separate thermostats for each 25 sq. ft. of coil face area or fraction thereof.
- G. Electronic Temperature Sensors: Provide electronic temperature sensors of supersensitive resistance type (RTD) or thermister, which are vibration and corrosion-resistant, and of wall mounted, immersion, duct mounting, averaging

or bulb type as required for application.

- H. Wall Mounted Space Temperature Sensor: Provide electronic temperature sensors of supersensitive resistance type (RTD) or thermister which are vibration and corrosion resistant. The sensing element shall be adhered to a flat stainless steel plate and be vandal resistant.
 - I. Provide a clear plastic lockable cover for all thermostats mounted in public entry vestibules.
- J. Pressure Transducers and Transmitters: Provide electronic pressure transmitters of variable capacitance type with stainless steel diaphragm and sensor body, vibration and corrosion-resistant, and weather-resistant for outdoor installations. Suitable for measurement of static or differential pressure with conversion to proportional electrical output.
- K. Current Sensors: Provide analog type current sensors to provide actual current draw for each motor. The high/low alarm limits, setpoint, etc. shall be user defined and adjustable.
- L. Humidity Sensors: Sensors shall have an accuracy of $\pm 5\%$ over a range of 20% to 95% RH.
- M. Water Flow Switches: Provide water flow switches of stainless steel or bronze paddle types. Provide pressure-flow switches of bellows actuated mercury type or snap-acting type, with appropriate scale range and differential adjustment for service indicated.
- N. System Accuracy:
 - 1. The system shall maintain an end-to-end accuracy for one year from sensor to diagnostic display the following applications.
 - a. Space temperature in range of 50-85°F: within plus or minus 0.5°F.
 - b. Duct temperature in range of 40-140°F: within plus or minus 0.5°F.
 - c. Outside air (OA) temperature in range of minus 40-130°F: within plus or minus 1.0°F.
 - d. Water temperature in range of 30-100°F: plus or minus 0.5°F; in range of 100-300°F: within plus or minus 1.0°F.
 - e. Pressure: Within plus or minus 2.0 percent of range.
- O. Environmental Conditions: Furnish equipment designed to operate under ambient environmental conditions of 35-120°F dry bulb and 10 to 95 percent relative humidity. Furnish sensors and control elements designed to operate under the ambient environmental temperature, pressure, humidity, and vibration conditions specified or normally encountered for the installed location.
- P. Power Line Surge Protection: Protect equipment power supplies from power line surges.
- Q. Grounding Protection: Protect equipment from any ground fault by providing special grounding as required to prevent equipment failure under any kind of ground fault.
- R. Control Relays: Control relay contacts shall be rated for 150% of the loading application, with self-wiping, snap-acting Form C contracts, enclosed in dustproof enclosure. Relays shall have silver cadmium contacts with a minimum life span rating of one million operations. Relays shall be equipped with coil transient suppression devices. Provide control relays for all 120/1-volt motors not provided with a motor starter with auxiliary contacts.
- S. Control Panels: Provide control panels with suitable brackets for wall or floor mounting, for each supply fan and miscellaneous control systems. Locate panel adjacent to systems served.
 - 1. Provide steel cabinets as required to contain temperature controllers, relays, switches, and similar devices, except limit controllers and other devices excluded in sequence of operations. Fabricate panels of 14-ga. furniture-quality steel, or 6063-T5 extruded aluminum alloy, totally enclosed, with hinged doors and keyed lock, with manufacturer's standard shop-painted finish and color. Provide UL-listed cabinets for use with line

voltage devices.

2. Panel Mounted Equipment: Include temperature controllers, relays and automatic switches, except exclude low-temperature protection thermostats and other devices excluded in sequence of operation. Fasten devices with adjustments accessible through front of panels.
 3. Door-Mounted Equipment: Flush-mount (on hinged door) manual switches, including damper "minimum-off" positioning switches, "manual-automatic" switches, and dial thermometers.
- T. Fault-Tolerance: Select components to operate over a wide range of supply voltage and frequency, with static, transient and short-circuit protection on all inputs and outputs. Protect communication lines against incorrect wiring, static transients and induced magnetic interference. Provide AC coupled devices for connection to communication network to limit time-outs.
- U. Carbon Dioxide Sensor: Infrared sensors capable of measuring CO₂ over a range of 0-2000 ppm. Sensor accuracy shall be ±75 ppm, and repeatability shall be ±20 ppm, over an operating temperature range of 0°C to 50°C. Provide with 0-10VAC or 4-20mA analog output for connection to the Building Automation System. Provide with Duct inlet and outlet ports, filter tubing, and hardware. Provide with LCD display option.
- V. Carbon Monoxide Sensors: Provide space carbon monoxide (CO) sensor in the underground parking area to control the space ventilation rate based on CO concentration levels. CO system shall consist of a Brasch Model GDCP Universal Controller with Brasch Model BGS-CM-TRNS analog carbon monoxide sensor transmitters in the parking space, or prior approved equal. Sensors shall provide a 4 to 20 ma. signal to the system controller to monitor space CO levels, with CO levels from 1 to 400 PPM range and initiate opening of outside air dampers and operate exhaust fan when CO levels rise above an operator definable level. ACM, Acme, Toxalert and Vulcain are also approved manufacturers.
- W. Air Quality Sensor: Staefa Model FRA-Q1 or approved equal. The sensor shall be a heated semi-conductor. Sensor shall be self-cleaning and require no maintenance. Sensor installation and locations shall be suitable for sensing vehicle diesel fume exhaust.
- X. Air Flow Measuring Stations:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - a. Ebtron Gold Series
 2. AFMS shall be provided by, installed and wired by the temperature control contractor. Provide all necessary air flow measuring stations of the capacity and configuration as indicated on the drawings and/or within these specifications. Provide AFMS's as required to provide a complete system and provide the necessary control/measurement as indicated in the "sequence of controls" and "points list". At a minimum an AFMS shall be installed in the outside air, return air and supply air ductwork for all air handling and rooftop unit equipment.
 3. The AFMS shall be field measured and verified by an approved manufacturer representative to insure proper mounting locations and probe densities prior to product ordering and installation.
 4. The airflow/temperature measurement station (AFMS) shall be capable of monitoring airflow and temperature rates at each measurement location. The system shall be factory tested prior to shipment and shall not require calibration or adjustment over the life of the equipment, when installed in accordance to manufacturer's guidelines. Each sensor probe shall be provided with a UL plenum-rated connecting cable. Connecting cable shall be a minimum of 10 feet in length for each probe. No additional devices or transducers shall be required to interface with the host controls. Sensors shall be calibrated to NIST-traceable standards for both airflow and temperature. Each sensing point shall independently measure airflow and temperature prior to averaging. Installed accuracy shall be percent of reading and demonstrated at both maximum and minimum airflow rates for each measurement location.

5. The transmitter shall operate on 24 VAC. The transmitter shall have a minimum 16 character alphanumeric LCD display for airflow, temperature, and system diagnostics. Analog output signals shall be user selectable (0-10 VDC or 4-20 mA). When required on the plans, a serial RS-485 interface will be made available with network protocols as required by the DDC control equipment. All inputs and outputs shall be fused, protected, and internally isolated from the 24 VAC power supply. The transmitter shall have a non-drifting adjustment for output signal offset/gain. The transmitter display shall be capable of being configured in either I.P. or S.I. units. The transmitter shall accept a user-defined area to display volumetric flow rates in CFM or LPS.
6. The enclosure shall be aluminum alloy for indoor use and capable of operating over a temperature range of +30° F to +120° F [-1.1° C to 48.9° C]. The electronics shall be installed inside and protected from the weather. (specify NEMA4 for outdoor use).
7. Duct & Plenum Mounted Sensor Probes
 - a. Sensor probes shall be constructed of anodized aluminum alloy tube with stainless steel mounting brackets. Probes shall be constructed to provide insertion, internal, or standoff mounting, depending on the applications and field installation requirements.
8. Probe Performance Requirements
 - a. The sensor accuracy for airflow shall be at least ±2% of Reading over the sensor probe operating ranges. The installed total accuracy for airflow shall be better than ±3% of Reading over the sensor probe operating ranges when installed in accordance with manufacturers' guidelines. The sensor accuracy for temperature shall be better than ±0.15° F [±0.1° C] over the entire operating range. Each sensing point shall independently measure airflow and temperature prior to averaging.
9. Probe Sensor Density
 - a. The number of independent sensing points shall be distributed per duct face area, at a minimum quantity as indicated below.

Area (ft2)	Area (m2)	Sensors
<= 1	<= 0.093	2
>1 to <4	>0.093 to < 0.372	4
4 to <8	0.372 to < 0.743	6
8 to <12	0.743 to < 1.115	8
12 to <16	1.115 to < 1.486	12
>=16	>= 1.486	16

Probe Operating Ranges:

Airflow: 0 to 5,000 FPM [0 to 25.4 m/s]

Temperature: -20° F to +160° F [-28.9° C to 71.1° C]

Relative Humidity: 0 to 99% (non-condensing)

10. Fan Inlet Velocity Sensors
 - a. Sensors shall be totally constructed from non-corrosive materials, with stainless steel sensor bodies, stainless steel mounting brackets and with adjustable cadmium-plated mounting rods.
11. Fan Inlet Performance Requirements
 - a. The individual sensor accuracy for airflow shall be better than ±3% of Reading over the sensor probe operating ranges when installed in accordance with manufacturers' guidelines. The installed accuracy for temperature shall be better than ±0.15° F [±0.1° C] over the entire operating range.
12. Fan Inlet Sensor Operating Ranges:
 - a. Airflow: 0 to 10,000 FPM [0 to 50.8 m/s]
 - b. Temperature: -20° F to +160° F [-28.9° C to +71.1° C]
 - c. Relative Humidity: 0 to 99% (non-condensing)

PART 3: EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which control systems are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in a manner acceptable to the Installer.

3.02 INSTALLATION OF ENERGY MANAGEMENT AND CONTROL SYSTEMS

- A. Install energy management and control systems as indicated, in accordance with system manufacturer's written instructions, and with recognized industry practices, to ensure that energy management and control equipment complies with requirements. Comply with requirements of NEC, and applicable portions of NECA's "Standard of Installation" pertaining to general electrical installation practices. Mount controllers at convenient locations and heights.
- B. Coordinate with other electrical work, including power distribution and equipment, as necessary to interface installation of energy management and control equipment work with other work.
- C. Control Wiring: The term "control wiring" is defined to include providing EMCS manufacturer-approved wiring, conduit and miscellaneous materials as required for mounting and connecting control devices. Conceal wiring, except in mechanical rooms and areas where other conduit and piping are exposed. Provide plenum rated multi-conductor instrument harness (bundle) in place of single conductors where number of conductors can be run along common path. Fasten flexible conductors bridging cabinets and doors, neatly along hinge side, and protect against abrasion. Tie and support conductors neatly. Control wiring shall be plenum rated. Tees or wye taps in the communication network are not permitted.
- D. Number-code and color-code conductors, excluding those used for local individual room controls, appropriately for future identification and servicing of control system. Label ends of all conductors in control cabinets with 3M tape indicating control device.
- E. Install electrical terminations in UL approved, vented panel enclosures. Locate panels in spaces designated for use as electrical or mechanical equipment rooms. Panels shall be located to provide adequate access and clearance for servicing.
- F. All control transformers shall be located in mechanical rooms, janitor closets, or electrical rooms exposed to view. All transformers shall be clearly labeled with the systems it serves.
- G. Reset Limit Controls: Install manual-reset limit controls to be independent of power controllers.
- H. Unit-Mounted Equipment: Where control devices are indicated to be unit-mounted, ship relays, switches, etc. to unit manufacturer for mounting and wiring at factory.
- I. Grounding: Provide tight equipment grounding connections, sufficiently tight to assure permanent and effective ground, for energy management and control systems as indicated.
- J. The TCC contractor shall be responsible for wiring of any and all remote panels, summer/winter switches, medium user interfaces, etc associated with all specified equipment as to allow complete operation and control of all equipment. Verify exact requirements with installed manufacturers equipment.

3.03 PROJECT SCHEDULING

- A. Provide a detailed critical path schedule within 14 days of the Owner's acceptance of the General Contractor's or Construction Manager's master schedule. The critical path schedule shall incorporate the project phasing plans, and identify all equipment start-up dates. The equipment start-up dates shall be planned such that there is an adequate period of time to complete the quality control requirements and associate self-performed functional performance testing. Coordinate any specific requirements of other trades, such as power wiring, with the General Contractor or

construction manager such that the master schedule incorporates these requirements of other subcontractors. The schedule shall prove a methodology to complete all work prior to Substantial Completion.

B. The critical path schedule shall include at a minimum the following elements.

1. Start and end dates for work in each phase established on the master schedule.
2. Delivery of submittal documents.
3. Delivery of control components to other trades such as valves and dampers.
4. On-site installation of control wiring, controllers, and other control components.
5. Start-up dates for each piece of equipment.
6. Functional performance tests for each phase of construction and each piece of equipment.
7. Delivery of all Quality Control documents.
8. Start date for Owner's testing agent for each phase and each piece of equipment.
9. Substantial Completion date.

3.04 QUALITY CONTROL

A. Upon completion of installation of system hardware and software and after circuitry has been energized, demonstrate capability and compliance of system with requirements. All testing work shall be self performed and completed by the installer and appropriate subcontractors. Where possible, correct malfunctioning units at site, then re-test to demonstrate compliance; otherwise remove and replace with new units, and proceed with re-testing.

1. Functional Performance Tests: Completion and documentation of all functional performance tests are required as a condition of substantial completion. Provide written notification to the Owner and Engineer including a copy of all testing documents that the systems are ready for the Owner's independent testing agent to begin testing. The functional performance tests shall be in checklist form and include the initials of the assigned tester and the pass date of each item to be tested. The checklists shall include but not be limited to the following:
 - a. Visual inspection verifying the installation of all control components and wiring is complete.
 - b. Calibration of all analog sensing devices.
 - c. Conductance tests of all communication and network wiring.
 - d. Visual crosscheck of each control point by making a comparison between the command and field-controlled device.
 - e. Verification of loss of power and control failure modes for each control device.
 - f. Verification of alarm notifications on the system front end as required in the control sequences.
 - g. A checklist of deficiencies that require corrective work by other trades and an anticipated date for completion.
2. Owner's Testing: Once the functional performance test is submitted, the Owner's functional performance testing agent will re-verify performance of the system. For tests that fail, the controls contractor will be responsible to reimburse the Owner for the costs of the failed tests, or for any delays the tester endures due to the work being incomplete. The costs for re-testing will be paid for by the Contractor through deduct charge. Provide assistance and technical support as required to the Owner testing agent to accomplish all functional performance testing and system validation testing. Assistance shall include providing trend logs of any control points at the direction of the Owner's testing agent to troubleshoot system performance.
3. The BAS shall verify that all control components are installed in accordance with project requirements and are functional, including all electrical interlocks, damper sequences, air and water resets, fire and freeze stats, high and low temperature thermostats, safeties, etc.

4. The BAS Contractor shall verify that all controlling instruments are calibrated and set for design operating conditions with the exception of components that require input from the TAB Agency, but a default shall be set. The Control Contractor shall cooperate with the TAB Agency and provide all software and interfaces to communicate with the system.
5. The BAS Contractor shall thoroughly check all controls, sensors, operators, sequences, etc. before notifying the TAB Agency that the BAS is operational. The BAS Contractor shall provide technical support (technicians and necessary computers) to the TAB Agency for a complete check of these systems.
6. Prior to occupancy, each ventilation system shall be tested to ensure that OA dampers operate properly in accordance with system design.
7. Fire Alarm: Division 26 shall thoroughly check all detection devices, sequences, inter-locks, etc. before notifying the TAB Agency that the system is operational. Division 26 shall certify that the systems are totally operational to the Contract or prior to the TAB beginning.
 - a. The BAS contractor and Fire Alarm contractor shall coordinate all fire and smoke dampers/sensors operation with the shutdown sequence with all air handling equipment.
 - b. The Fire Alarm contractor shall be responsible for preparing final documentation of system integration:
 - c. The contractors shall review the drawings and specifications. The contractors shall establish an initial sequence of operation and matrix for all integration of system, including fire alarm sequences, HVAC fan and equipment shutdown, fan operation, damper operation, door closings, door unlocking, exhaust/makeup air systems, etc.
 - d. Review initial sequence of operation and matrix with mechanical and electrical engineer and owner to verify proposed system operation.
 - e. Provide final sequence and matrix based on actual install conditions.

3.05 GRAPHICAL USER INTERFACE

- A. Provide a sample of each graphic intended for the front end user interface for review and approval by the Engineer and Owner's representative prior to final installation. The graphic must illustrate the following for review.
 1. Intended procedure for navigating between graphics.
 2. Sensor and control signal information available.
 3. Mode of operation status, and safety information available.
 4. Operator override procedures.
 5. Room number and equipment designations.
- B. Update final graphics with Owner requested revisions to room name and number identification and equipment identifications. Allocate time for technicians to update graphics and associated engineering drawing and as-built submittals after final installation of system software. The work shall be scheduled to occur prior to substantial completion.

3.06 DEMONSTRATION AND TRAINING

- A. Provide demonstration and training for Owner's representative in accordance with this specification section.
- B. Building Operating Personnel Training: Train Owner's building personnel in procedures for starting-up, testing and operating energy management and control system equipment. In addition, train building personnel to maintain software, that they are capable of initiating changes to computer programs including addition and deletion of points.
- C. 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. All training shall be held during normal work hours of 8:00 a.m. to 4:30 p.m. weekdays as follows:
 1. Provide 40 hours of on-site training for owner's operating personnel. Training shall include:
 - a. Explanation of drawings, operations and maintenance manuals.
 - b. Walk-thru of the job to locate control components.

- c. Operator workstation and peripherals and operation/functions.
 - d. Operator control functions, including graphic generation and field panel programming
 - e. Operation of portable operator's terminal.
 - f. Explanation of adjustment, calibration and replacement procedures.
2. Provide additional 20 hours of training to be executed each quarter for a period of one year from final completion of the project.
 3. Technical support staff must be made available to discuss problems as they arise, at no additional cost to the Owner.
 4. Training hours shall be documented and signed off by the owner. During the onsite training hours the contractor shall also assist the owner in requested graphics programing, changes, modifications, additions, etc as determined by the owner.
 5. If additional such training is required by the Owner, it will be contracted at a later date. Provide description of available local and factory customer training.

3.07 ADJUSTING AND CLEANING

- A. Start-Up: Start-up, test, and adjust direct digital electronic control systems in presence of manufacturer's authorized representative. Demonstrate compliance with requirements. Replace damaged or malfunctioning controls and equipment.
- B. Cleaning: Clean factory-finished surfaces. Repair any marred or scratched surfaces with manufacturer's touch-up paint.
- C. Final Adjustment: After completion of installation, adjust controllers, sensors and similar equipment provided as work of this section.
 1. Final adjustment shall be performed by specially trained personnel in direct employ of manufacturer of primary temperature control system.

3.08 SIGNAGE

- A. Provide an engraved plastic laminate sign at all push buttons in occupied spaces to identify the function of the button. Coordinate exact language of each sign with the Owner's representative. Refer to specification section 23 05 53 for sign requirements.

3.09 CLOSEOUT PROCEDURES CONTROL SEQUENCES AND POINTS SCHEDULES

- A. Every connected analog output (AO), analog input (AI), digital output (DO), and digital input (DI) represents a "point" where referred to in this specification. Refer to the attached data sheets for specific control sequences and for complete listing of these points. Each analog output shall have its own distinct control loop. All analog points shall be adjustable through the EMCS
- B. Each air handling unit, exhaust fan, unit heater, or other equipment indicated to be controlled by a time clock schedule through the EMCS shall be capable of being individually programmed for its own schedule of operation.

3.08 SPARE POINTS / EXTRA MATERIALS

1. Provide labor, hardware and programming for an addition 30 control points for spare/future use and integration into the system. Assume a 100 foot distance between controller and equipment.
2. Provide material and installation costs for an additional 5 control valves 2" in size. Actual location and sizes are to be field verify and ordered only after approval from the Engineer.

3. Provide an add/deduct cost for an additional analog control point.
4. Provide an add/deduct cost for an additional digital control point.

END OF SECTION 23 09 00

SECTION 23 09 50

VARIABLE-FREQUENCY MOTOR CONTROLLERS

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. This Section includes solid-state, PWM, VFCs for speed control of three-phase, squirrel-cage induction motors.
- B. Related Sections include the following:
 - 1. Division 26 Section "Electrical Power Monitoring and Control" for monitoring and control of motor circuits.
 - 2. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.

1.03 DEFINITIONS

- A. BMS: Building management system.
- B. IGBT: Integrated gate bipolar transistor.
- C. LAN: Local area network.
- D. PID: Control action, proportional plus integral plus derivative.
- E. PWM: Pulse-width modulated.
- F. VFC: Variable frequency controller.

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of VFC. Include dimensions, mounting arrangements, location for conduit entries, shipping and operating weights, and manufacturer's technical data on features, performance, electrical ratings, characteristics, and finishes.
- C. Shop Drawings: For each VFC.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. 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 each motor-control center unit.
2. Wiring Diagrams: Power, signal, and control wiring for VFCs. Provide schematic wiring diagram for each type of VFC.
- D. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around VFCs where pipe and ducts are prohibited. Show VFC layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- E. Qualification Data: For manufacturer and testing agency.
- F. Field quality-control test reports.
- G. Operation and Maintenance Data: For VFCs, all installed devices, and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
- 1. Routine maintenance requirements for VFCs and all installed components.
 - 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
- H. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.05 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. Testing Agency Qualifications: An independent agency, with the experience and capability to conduct the testing indicated, that is a member company of the InterNational Electrical Testing Association or is a nationally recognized testing laboratory (NRTL) as defined by OSHA in 29 CFR 1910.7, and that is acceptable to authorities having jurisdiction.
- 1. Testing Agency's Field Supervisor: Person currently certified by the InterNational Electrical Testing Association or the National Institute for Certification in Engineering Technologies to supervise on-site testing specified in Part 3.
- C. Source Limitations: Obtain VFCs of a single type through one source from a single manufacturer.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- E. Comply with NFPA 70.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver VFCs in shipping splits of lengths that can be moved past obstructions in delivery path as indicated.

- B. Store VFCs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFCs from exposure to dirt, fumes, water, corrosive substances, and physical damage.
- C. If stored in areas subject to weather, cover VFCs to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

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: 0 to 40 deg C.
 - 2. Humidity: Less than 90 percent (noncondensing).
 - 3. Altitude: Not exceeding 3300 feet.

1.08 COORDINATION

- 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. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- D. Coordinate features of VFCs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- E. Coordinate features, accessories, and functions of each VFC and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

1.09 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. Spare Fuses: Furnish one spare for every five installed, but no fewer than one set of three of each type and rating.
 - 2. Motor Shaft Ground Kits: Furnish and install one grounding kit for every five variable frequency controllers but not less than three. Provide grounding kits at the direction of the Engineer. The Engineer will direct installation upon receipt of the shaft arc test results.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Baldor Electric Company (Graham).
 - 3. Danfoss Inc.; Danfoss Electronic Drives Div.
 - 4. General Electric Company; GE Industrial Systems.

5. Siemens Energy and Automation; Industrial Products Division.
6. Square-D
7. Yaskawa

2.02 VARIABLE FREQUENCY CONTROLLERS

- A. General: Provide variable frequency controllers as indicated on the drawings and as required to accomplish the control intent as described in Division 23 Section 23 09 93 "BAS Sequence of Operations."
- B. Description: NEMA ICS 2, IGBT, PWM, VFC; listed and labeled as a complete unit and arranged to provide variable speed of an NEMA MG 1, Design B, 3-phase induction motor by adjusting output voltage and frequency.
 1. Provide unit suitable for operation of premium-efficiency motor as defined by NEMA MG 1.
- C. Design and Rating: Match load type such as fans, blowers, and pumps; and type of connection used between motor and load such as direct or through a power-transmission connection.
- D. Output Rating: 3-phase; 6 to 60 Hz, with voltage proportional to frequency throughout voltage range.
- E. Unit Operating Requirements:
 1. Input ac voltage tolerance of 208 V, plus or minus 5 or 380 to 500 V, plus or minus 10 percent as required to match motor horsepower.
 2. Input frequency tolerance of 50/60 Hz, plus or minus 6 percent.
 3. Minimum Efficiency: 96 percent at 60 Hz, full load.
 4. Minimum Displacement Primary-Side Power Factor: 96 percent.
 5. Overload Capability: 1.1 times the base load current for 60 seconds; 2.0 times the base load current for 3 seconds.
 6. Starting Torque: 100 percent of rated torque or as indicated.
 7. Speed Regulation: Plus or minus 1 percent.
- F. Isolated control interface to allow controller to follow control signal over an 11:1 speed range.
 1. Electrical Signal: 4 to 20 mA at 24 V.
- G. Internal Adjustability Capabilities:
 1. Minimum Speed: 5 to 25 percent of maximum rpm.
 2. Maximum Speed: 80 to 100 percent of maximum rpm.
 3. Acceleration: 2 to a minimum of 22 seconds.
 4. Deceleration: 2 to a minimum of 22 seconds.
 5. Current Limit: 50 to a minimum of 110 percent of maximum rating.
- H. Self-Protection and Reliability Features:
 1. Input transient protection by means of surge suppressors.
 2. Under- and overvoltage trips; inverter overtemperature, overload, and overcurrent trips.
 3. Motor Overload Relay: Adjustable and capable of NEMA ICS 2, Class 30 performance.

4. Notch filter to prevent operation of the controller-motor-load combination at a natural frequency of the combination.
 5. Instantaneous line-to-line and line-to-ground overcurrent trips.
 6. Loss-of-phase protection.
 7. Reverse-phase protection.
 8. Short-circuit protection.
 9. Motor overtemperature fault.
- I. Automatic Reset/Restart: Attempts three restarts after controller fault or on return of power after an interruption and before shutting down for manual reset or fault correction. Bidirectional autospeed search shall be capable of starting into rotating loads spinning in either direction and returning motor to set speed in proper direction, without damage to controller, motor, or load.
- J. Power-Interruption Protection: To prevent motor from re-energizing after a power interruption until motor has stopped.
- K. Torque Boost: Automatically varies starting and continuous torque to at least 1.5 times the minimum torque to ensure high-starting torque and increased torque at slow speeds.
- L. Motor Temperature Compensation at Slow Speeds: Adjustable current fall-back based on output frequency for temperature protection of self-cooled, fan-ventilated motors at slow speeds.
- M. Status Lights: Door-mounted LED indicators shall indicate the following conditions:
1. Power on.
 2. Run.
 3. Overvoltage.
 4. Line fault.
 5. Overcurrent.
 6. External fault.
- N. Panel-Mounted Operator Station: Start-stop and auto-manual selector switches with manual speed control potentiometer and elapsed time meter.
- O. Indicating Devices: Meters or digital readout devices and selector switch, mounted flush in controller door and connected to indicate the following controller parameters:
1. Output frequency (Hz).
 2. Motor speed (rpm).
 3. Motor status (running, stop, fault).
 4. Motor current (amperes).
 5. Motor torque (percent).
 6. Fault or alarming status (code).
 7. PID feedback signal (percent).
 8. DC-link voltage (VDC).
 9. Set-point frequency (Hz).
 10. Motor output voltage (V).
- P. Control Signal Interface:

1. Electric Input Signal Interface: A minimum of 2 analog inputs (0 to 10 V or 0/4-20 mA) and 6 programmable digital inputs.
 2. Remote Signal Inputs: Capability to accept any of the following speed-setting input signals from the BMS or other control systems:
 - a. 0 to 10-V dc.
 - b. 0-20 or 4-20 mA.
 - c. Potentiometer using up/down digital inputs.
 - d. Fixed frequencies using digital inputs.
 - e. RS485.
 - f. Keypad display for local hand operation.
 3. Output Signal Interface:
 - a. A minimum of 1 analog output signal (0/4-20 mA), which can be programmed to any of the following:
 - 1) Output frequency (Hz).
 - 2) Output current (load).
 - 3) DC-link voltage (VDC).
 - 4) Motor torque (percent).
 - 5) Motor speed (rpm).
 - 6) Set-point frequency (Hz).
 4. Remote Indication Interface: A minimum of 2 dry circuit relay outputs (120-V ac, 1 A) for remote indication of the following:
 - a. Motor running.
 - b. Set-point speed reached.
 - c. Fault and warning indication (overtemperature or overcurrent).
 - d. PID high- or low-speed limits reached.
- Q. Communications: Provide an RS485 interface allowing VFC to be used with an external system within a multidrop LAN configuration. Interface shall allow all parameter settings of VFC to be programmed via BMS control. Provide capability for VFC to retain these settings within the nonvolatile memory.
- R. Isolating Switch: Non-load-break switch arranged to isolate VFC and permit safe troubleshooting and testing, both energized and de-energized, while motor is operating in bypass mode.

2.03 ENCLOSURES

- A. NEMA 250, Type 1.

2.04 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.

E. Standard Displays:

1. Output frequency (Hz).
2. Set-point frequency (Hz).
3. Motor current (amperes).
4. DC-link voltage (VDC).
5. Motor torque (percent).
6. Motor speed (rpm).
7. Motor output voltage (V).

F. Historical Logging Information and Displays:

1. Real-time clock with current time and date.
2. Running log of total power versus time.
3. Total run time.
4. Fault log, maintaining last four faults with time and date stamp for each.

2.05 FACTORY FINISHES

- A. Finish: Manufacturer's standard color paint applied to factory-assembled and -tested VFCs before shipping.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFCs for compliance with requirements, installation tolerances, and other conditions affecting performance.

3.02 APPLICATIONS

- A. Select features of each VFC to coordinate with ratings and characteristics of supply circuit and motor; required control sequence; and duty cycle of motor, controller, and load.
- B. Select horsepower rating of controllers to suit motor controlled.

3.03 INSTALLATION

- A. Variable frequency motor controllers will be installed by the Electrical Contractor. Coordinate equipment delivery schedule and equipment installation requirements with the Electrical Contractor.

3.04 IDENTIFICATION

- A. Identify VFCs, components, and control wiring according to Division 23 Section "Identification for HVAC Piping and Equipment."
- B. Operating Instructions: Frame printed operating instructions for VFCs, including control sequences and emergency procedures. Fabricate frame of finished metal, and cover instructions with clear acrylic plastic. Mount on front of VFC units.

3.05 CONTROL WIRING INSTALLATION

- A. Install wiring between VFCs and remote devices according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 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- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with control circuit 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.

3.06 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed 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 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 solid-state controllers.
 - 3. Report results in writing.
- C. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- D. Perform the following field tests and inspections and prepare test reports:
 - 1. Perform each electrical test and visual and mechanical inspection. Certify compliance with test parameters.
 - 2. Perform shaft arc testing.
 - 3. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

3.07 ADJUSTING

- A. Set field-adjustable switches and circuit-breaker trip ranges.

3.08 DEMONSTRATION

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

END OF SECTION 23 09 50

SECTION 23 09 93

BAS SEQUENCE OF OPERATIONS

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 control sequences for HVAC systems, subsystems, and equipment.
- B. Related Sections include the following:
 - 1. Division 23 Section "Building Automation System" for control equipment and devices and for submittal requirements.

1.03 DEFINITIONS

- A. DDC: Direct digital control.
- B. VAV: Variable air volume.

1.04 HEATING CONTROL SEQUENCES

- A. Refer to the attached control sequences and points schedule for required Building Automation Systems work.

PART 2: PRODUCTS (Not Applicable)

PART 3: EXECUTION (Not Applicable)

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: VAV Boxes with Terminal Reheat

1. GENERAL

- A. Control Sequences for Variable Air Volume with terminal reheat are included in this section.
- B. Provide the electronic VAV box control module and floating point damper motor to the VAV box manufacturer for mounting at the factory.
- C. The VAV box manufacturer will install and wire the electronic VAV box control module and damper motor, and connect air flow sensor to the control module at the factory.
- D. Provide a flat-plate type space sensor for each VAV box and wire it to the respective control module.
- E. Provide control valves and actuators for the reheat coil (RH) and finned tube radiation (FTR), where applicable; refer to equipment schedule for valve type and control. Installation of control valve is work of another DIV 23 specification section.
- F. Retrofit the existing VAV's where noted on plans with new electronic control and control valve. Control as specified here in.

2. CONTROL SEQUENCES

A. Morning Warm-up Cycle

- 1. The air handling unit control module shall broadcast a signal to the respective VAV boxes that a "warm-up" cycle is in progress. See control sequence for air handling units under "Optimal Start/Morning Warm-up".
- 2. Each VAV box shall be assigned a warm-up cycle CFM setpoint and shall maintain that setpoint.
- 3. The reheat coil valves shall be full open.
- 4. As the zone occupied temperature setpoints are satisfied the respective reheat coil valves shall modulate towards closed position.

B. Occupied Mode

- 1. Occupancy Sensor Control (refer to scheduled VAV boxes and electrical for VAV's with Occ sensors)
 - a. An occupancy sensor shall be provided and installed by electrical. Provide wiring and integration to mechanical BAS system.
 - b. The BAS contractor shall coordinate and wire to occupancy sensor for each space.
 - c. Upon a signal for the occupancy sensor the VAV box shall be indexed to Occupied Mode. .
 - d. Upon a signal of vacancy from the occupancy sensor the VAV box shall be indexed to its' Minimum Air Flow and unoccupied space temperature setpoint.
- 2. Cooling
 - a. The VAV boxes shall be indexed to occupied mode by the EMCS.

- b. The maximum/minimum CFM flow rates shall be software adjustable.
- c. The space temperature setpoint shall be definable in the software.
- d. As the space temperature rises above cooling setpoint, the VAV box damper shall be modulated from minimum towards open position.
- e. When the VAV box is in full cooling and the space is still calling for cooling, a "cooling request" shall be transmitted over the network to the respective air-handling unit. This message shall reset the discharge air temperature as described under the air handling unit control sequence.
- f. When the space is satisfied and calling for less cooling, the VAV box damper shall modulate towards minimum position.
- g. When the VAV box damper is in minimum cooling and the space is still calling for less cooling, a "heating request" shall be transmitted over the network to the respective air-handling unit. This message shall reset the discharge air temperature as described under the air handling unit control sequence.

3. Heating

- a. The VAV boxes shall remain in cooling mode unless the "heating available" signal has been broadcast over the network by the central plant control module. VAV boxes shall then be indexed to the heating mode by the EMCS.
- b. As the space temperature drops below heating setpoint, the reheat coil valve shall modulate towards open position and the VAV box airflow control shall modulate open.
- c. When the VAV box is in full heating and the space is still calling for heating, a "heating request" shall be transmitted over the network to the respective air-handling unit. This message shall reset the discharge air temperature as described under the air handling unit control sequence.
- d. When the VAV box is in minimum heating and the space is still calling for cooling, the VAV box damper shall be modulated towards open position.
- e. On a further call for cooling, a "cooling request" shall be transmitted over the network to the respective air-handling unit. This message shall reset the discharge air temperature as described under the air handling unit control sequence.

C. Unoccupied Mode

1. Cooling

- a. The VAV boxes are indexed to unoccupied mode by the EMCS.
- b. The VAV box reheat coil valves are closed.
- c. The "cooling requests" from various zones are ignored by the system and no action is taken.

2. Heating

- a. When the space temperature drops below the unoccupied setpoint, a "heating request" shall be transmitted over the network to the respective air-handling unit.
- b. When the number of heating requests exceeds an operator definable number, the air handling unit shall start with the outside air and relief air dampers fully closed, return air dampers fully open, and the heating coil valve closed.

- c. The VAV boxes shall operate as described in "Morning Warm-up Cycle" (see above).
- d. When the heating requests are satisfied, the air-handling unit shall be turned off.

3. ALARMS

- A. Generate an alarm when the space temperature is 5°F above the occupied/unoccupied cooling temperature setpoint.
- B. Generate an alarm when the space temperature is 5°F below the occupied/unoccupied heating temperature setpoint.

4. POINT SCHEDULE

Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.

- | | |
|---------------------------------|--|
| (AI) VAV Box CFM | (AO) Minimum Heating CFM Setpoint |
| (AO) VAV Box Damper Modulation | (AO) Maximum Heating CFM Setpoint |
| (AI) VAV Box Damper Position | (AO) Minimum Cooling CFM Setpoint |
| (AO) RH Coil Valve Modulation | (AO) Maximum Cooling CFM Setpoint |
| (AI) Space Temperature | (AO) Morning Warm-up CFM Setpoint |
| (AO) Radiation Valve Modulation | (AI) Discharge Air Temperature (after reheat coil) |
| (AI) Occupancy Sensor | |

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Transfer Fans – Temperature Control

1. GENERAL

- A. The following exhaust fan shall be controlled by space temperature:

TF-1 Elec/Data/Equipment rooms

- B. 120/1 and 3 phase volt exhaust fans are furnished with magnetic contractors or motor starter/switches by Division 26. Division 23 to provide all control relays.
- C. Provide space temperature sensor and control sequence for each piece of equipment. Provide a space temperature sensor in each room served by the exhaust fan. Refer to drawings for exhaust fans serving multiple rooms control the exhaust fan to the space with the highest cooling demand.
- D. Provide and wire all electrical interlocks to other equipment associated with this system, as indicated or otherwise necessary for proper system operation.

2. CONTROL SEQUENCE

- A. Control Sequence

1. The space temperature sensor shall cycle the exhaust fan on/off as required to maintain the space temperature setpoint.

3. ALARMS:

- A. Generate an alarm if the space temperature is +5°F above setpoint.
- B. Generate an alarm if the fan is indicated to run but it's status is off.

4. POINTS SCHEDULE:

Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.

- (AI) Space Temperature
(DO) Exhaust Fan Control
(DI) Exhaust Fan Status

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Cabinet Unit Heaters

1. GENERAL

- A. Provide a flat-plate type temperature sensor and control sequence for each cabinet unit heater.
- B. Provide heating control valves and electric valve actuators; installed as work of another Division 23 Section. Cabinet unit heater valves are typically 2-way modulating.
- C. Provide and wire a surface mounted aquastat; mounted as work of another Division 23 Section.
- D. The unit heaters shall be indexed between its occupied and unoccupied modes by a timeclock schedule through the EMCS system.
- E. Retrofit the existing cabinet unit heaters where noted on plans with new electronic controls and control valves. Control as specified here-in.

2. CONTROL SEQUENCE

A. Occupied Mode

- 1. On a call for heat from a space temperature sensor, the heating valve shall modulate open, to maintain a temperature setpoint of 70.0 degrees.
- 2. An aquastat mounted on the return hot water line shall de-energize fan motor when fluid temperature falls below setpoint of aquastat (adjustable). The aquastat and the space temperature call for heat shall be wired in series such that the unit heater fan will run only if there is a call for heat and there is hot water available in the system.

B. Unoccupied Mode

- 1. On a call for heat from a space temperature sensor, the heating valve shall modulate open to maintain a temperature setpoint of 55.0 degrees.
- 2. An aquastat mounted on the return hot water line shall de-energize fan motor when fluid temperature falls below setpoint of aquastat (adjustable). The aquastat and the space temperature call for heat shall be wired in series such that the unit heater fan will run only if there is a call for heat and there is hot water available in the system.

3. ALARMS

- A. Generate an alarm when space temperature drops 5°F below setpoint for 5-minute duration in heating mode.

4. POINTS SCHEDULE

Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.

(AI) Space Temperature	(DO) Fan Control
(AO) Heating Valve Modulation	(DI) Fan Status

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Radiation

1. GENERAL

- A. Provide a flat-plate type temperature sensor and control sequence for each piece of radiation.
- B. Provide heating control valves and electric valve actuators; installed as work of another Division 23 Section.
- C. The radiation shall be indexed between their occupied unoccupied modes by a timeclock schedule through the Building Automation System.
- D. Retrofit the existing radiation where noted on plans with new electronic control and control valve. Control as specified here in.

2. CONTROL SEQUENCE

- A. Occupied Mode
 - 1. On a call for heating, the radiation valves shall open 25% (operator adjustable) before the heating coil valve begins to modulate. On a continued call for heat, the reheat valve shall modulate in unison with the radiation valve to maintain a temperature setpoint of 72.0 degrees.
- B. Unoccupied Mode
 - 1. On a call for heating from the space temperature sensor, the heating valve shall modulate open to maintain a space temperature setpoint of 55.0 degrees.

3. ALARMS

- A. Generate an alarm when the space temperature drops 5°F below setpoint for a 5-minute duration in the heating mode.

4. POINT SCHEDULE

Provide at a minimum the following control points for each system and as required to accomplish the control sequences indicated.

- (AI) Space Temperature
- (AO) Reheat Valve Modulation
- (AO) Radiation Valve Modulation

CONTROL SEQUENCE AND POINTS SCHEDULE

FOR: Equipment Room Air Conditioning Units (split system units)

1. GENERAL

- A. The Computer Room unit wall mounted evaporator sections mounted in the space with remote condensing units. Refer to the drawings for quantity and location.
- B. All controls are provided with the units by another Division 23 Section including a remote mounted micro-processor control. The Building Automation System contractor shall install one wire all controls as required for the complete operation of the unit.

2. CONTROL SEQUENCE

- A. All controls provided by another Division 23 section. There is no control sequence associated with this equipment.

3. ALARMS

- A. Generate an alarm if the space temperature is greater than 5°F above setpoint for a period greater than 30 minutes. Connect to each remote microprocessor control unit as required to receive the following alarm points in the Building Automation System.
 - 1. High return air temperature
 - 2. Low return air temperature
 - 3. Loss of power
 - 4. Low voltage
 - 5. Airflow
 - 6. Filter
 - 7. Compressor low pressure
 - 8. Compressor high pressure

4. POINTS SCHEDULE

Provide at a minimum the following control points and as required to accomplish the control sequences indicated.

- (AI) Space Temperature

END OF SECTION 23 09 93

SECTION 23 11 23

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

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. Service meters.
 - 7. Mechanical sleeve seals.
 - 8. Grout.
 - 9. 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, 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 Space: A space that does not have an opening through its boundary to allow the free passage of air to an occupied space. The opening size and location within the space boundary required for a space to be considered non-concealed is at the discretion of the Engineer and the plumbing inspector. The measure of a space that is defined as non-concealed is that odors from a potential gas leak will be readily detected by a building occupant.

1.04 PERFORMANCE REQUIREMENTS

- A. Minimum Operating-Pressure Ratings:
 - 1. Piping and Valves: 100 psig minimum unless otherwise indicated.
 - 2. Service Regulators: 65 psig minimum unless otherwise indicated.
- B. Natural-Gas System Pressures within Buildings: Two pressure ranges. Primary pressure is more than 0.5 psig but not more than 2 psig, and is reduced to secondary pressure of 0.5 psig or less.

1.05 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of the following:
 - 1. Piping specialties.
 - 2. Corrugated, stainless-steel tubing with associated components.
 - 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.
- C. Welding certificates.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For motorized gas valves and pressure regulators 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.

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 Owner no fewer than two days in advance of proposed interruption of natural-gas service.

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.
- B. Galvanized Steel Pipe and Fittings: Conform to ASTM A53/A 53M, Type E or S, Grade A or B, Schedule 40.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.3, Class 150, standard pattern.
 - 2. 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.
 - 3. 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.
- C. Drawn-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.
 - 2. Bronze Flanges and Flanged Fittings: ASME B16.24, Class 150.
 - a. Gasket Material: ASME B16.20, metallic, flat, asbestos free, aluminum o-rings, and spiral-wound metal gaskets.
 - b. Bolts and Nuts: ASME B18.2.1, carbon steel or stainless steel.
- D. Annealed-Temper Copper Tube: Comply with ASTM B 88, Type K.
 - 1. Copper Fittings: ASME B16.22, wrought copper, and streamlined pattern.

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. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. 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 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

D. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

E. T-Pattern Strainers:

1. Body: Ductile or malleable iron with removable access coupling and end cap for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 57 percent free area.
4. CWP Rating: 750 psig.

F. 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 and Tape: 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 deg 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. Dryseal 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 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. Two-Piece, Full-Port, Bronze Ball Valves 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 Div.
 - c. Lyall, R. W. & Company, Inc.
 - d. McDonald, A. Y. Mfg. Co.
 - e. Perfection Corporation; a subsidiary of American Meter Company.
 - 2. Body: Bronze, complying with ASTM B 584.
 - 3. Ball: Chrome-plated bronze.
 - 4. Stem: Bronze; blowout proof.
 - 5. Seats: Reinforced TFE; blowout proof.
 - 6. Packing: Threaded-body packnut design with adjustable-stem packing.
 - 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 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.
- 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. Co.
 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 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.

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 Div.
 - 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.
- 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 Div.
 - 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 and smaller; flanged for regulators NPS 2-1/2 and larger.

B. Service 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. Fisher Control Valves and Regulators; Division of Emerson Process Management.
 - d. Invensys.
 - e. Richards Industries; Jordan Valve Div.
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. Optional features:
 - a. Overpressure Protection Device: Factory mounted on pressure regulator.
 - b. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - c. Maximum Inlet Pressure: 100 psig.

C. 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 Div.
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. Optional Features:
 - a. Overpressure Protection Device: Factory mounted on pressure regulator.
 - b. Atmospheric Vent: Factory- or field-installed, stainless-steel screen in opening if not connected to vent piping.
 - c. Maximum Inlet Pressure: 2 psig

D. 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 Div.
 - c. Harper Wyman Co.
 - 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: 2 psig.

2.07 DIELECTRIC FITTINGS

A. Dielectric Unions:

1. Minimum Operating-Pressure Rating: 150 psig.
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for natural gas.
4. 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. Minimum Operating-Pressure Rating: 150 psig.
2. Combination fitting of copper alloy and ferrous materials.
3. Insulating materials suitable for natural gas.
4. 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. Minimum Operating-Pressure Rating: 150 psig.
2. Companion-flange assembly for field assembly.
3. Include flanges, full-face- or ring-type neoprene or phenolic gasket, phenolic or PE bolt sleeves, phenolic washers, and steel backing washers.
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.

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. 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.
 - 2. Pressure Plates: Stainless steel.
 - 3. Connecting Bolts and Nuts: 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.

2.11 GROUT

- A. Description: ASTM C 1107, Grade B, nonshrink and nonmetallic, dry hydraulic-cement grout.
 - 1. Characteristics: Post-hardening, volume adjusting, nonstaining, noncorrosive, nongaseous, and recommended for interior and exterior applications.
 - 2. Design Mix: 5000-psi, 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 PIPE APPLICATIONS

- A. Within Building: Install steel pipe with welded joints for all pipe sizes. Steel pipe with threaded joints or copper pipe with brazed joints, may be installed for 2" and smaller piping where routed in locations not defined as a concealed space.
- B. Outside Building: Install galvanized steel pipe with threaded joints and fittings.

3.02 ABOVEGROUND MANUAL GAS SHUTOFF VALVE SCHEDULE

- A. Valves for pipe sizes NPS 2 and smaller shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.
 - 2. Bronze plug valve.
- B. Valves for pipe sizes NPS 2-1/2 and shall be one of the following:
 - 1. Two-piece, full-port, bronze ball valves with bronze trim.

2. Bronze plug valve.
3. Cast-iron, nonlubricated plug valve.

3.03 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 dryseal 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.

3.04 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.

3.05 PREPARATION

- A. Close equipment shutoff valves before turning off natural gas to premises or piping section.
- B. Inspect natural-gas piping according to State Code to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with State Code requirements for prevention of accidental ignition.

3.06 OUTDOOR PIPING INSTALLATION

- A. Comply with State 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 coating on pipe as recommended in writing by protective coating manufacturer.
- 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 gage downstream from each service regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.07 INDOOR PIPING INSTALLATION

- A. Comply with State 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 piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Install escutcheons at penetrations of interior walls, ceilings, and floors. Escutcheons in areas exposed to view shall have a chrome plated finish.
- K. Seal space outside of sleeves in concrete slabs and walls with grout.
- L. Install sleeves that are large enough to provide ¼-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.

- M. Install sleeve materials according to the following applications:
1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
 2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe.
 - a. Extend sleeves 2 inches above finished floor level.
 - b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. 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.
 3. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
 4. Sleeves for Piping Passing through Exterior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
 - c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 5. Sleeves for Piping Passing through Interior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6.
- N. 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."
- O. Verify final equipment locations for roughing-in.
- P. Comply with requirements in Sections specifying gas-fired appliances and equipment for roughing-in requirements.
- Q. 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.
- R. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- S. 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.
- T. Concealed Space: In accordance with the definition in Part 1, the following conditions are considered to be concealed spaces. The following is not intended to be a complete list of all concealed conditions within the building. All piping in a concealed space shall have welded joints and fittings. Mechanical fittings, valves, and unions are not allowed.

1. Above-Ceiling Locations: That are not return plenums or do not have a reasonably sized and located opening to allow free passage of air to the occupied space below.
 2. Piping In Partitions: Piping routed in partition walls shall be open to a non-concealed ceiling space and allow the free passage of air for the entire height of the partition.
- U. Prohibited Locations: Do not install gas piping in or through a circulating air duct, clothes chute, chimney or gas vent, ventilating duct, dumb waiter, elevator shafts within poured concrete floors, or below grade within the building perimeter.
 - V. Use eccentric reducer fittings to make reductions in pipe sizes. Install fittings with level side down.
 - W. Connect branch piping from top or side of horizontal piping.
 - X. Install unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment. Unions are not required at flanged connections.
 - Y. Do not use natural-gas piping as grounding electrode.
 - Z. Install strainer on inlet of each line-pressure regulator and automatic or electrically operated valve.
 - AA. Install pressure gage downstream from each line regulator. Pressure gages are specified in Division 23 Section "Meters and Gages for HVAC Piping."

3.08 SERVICE-METER

- A. Coordinate with the local utility for new service meter installation or for required modifications to the existing meter.
- B. The mechanical contractor shall contact the local utility and verify that the required gas pressure, flow and meter size is provided to serve the new system. The mechanical contractor shall coordinate with the local utility in order to insure all necessary changes to the system are preformed prior to start-up of the building system.

3.09 VALVE INSTALLATION

- A. Install manual gas shutoff valve for each gas appliance ahead of corrugated stainless-steel tubing, aluminum, or copper connector.
- B. Install regulators and overpressure protection devices with maintenance access space adequate for servicing and testing.
- C. Locate gas pressure regulator a minimum distance of 5'-0" from all air handling equipments' furnace burner exhausts.

3.10 HANGER AND SUPPORT INSTALLATION

- A. Comply with requirements for pipe hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Install supports for vertical copper tubing every 10 feet.
- C. Install supports for vertical steel piping every 15 feet.

- D. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to ¾"	4	4	3/8
1" to 2"	6	6	3/8
2½" to 4"	6	6	½
5" and Greater	4	4	7/8

- E. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions and prior approved spacing by the structural engineer.
- F. Provide Anvil-Strut HBS roller series roof support system for all piping on roof.

3.11 CONNECTIONS

- A. Install piping adjacent to appliances to allow service and maintenance of appliances.
- B. 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.
- C. Sediment Traps: Install tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance.

3.12 LABELING AND IDENTIFYING

- A. Comply with requirements in Division 23 Section "Identification for HVAC Piping and Equipment" for piping and valve identification.

3.13 PAINTING

- A. Comply with requirements in Division 09 painting Sections for painting interior and exterior natural-gas piping.

3.14 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
1. Test, inspect, and purge natural gas according to State 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.

END OF SECTION 23 11 23

SECTION 23 21 13

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.

1.02 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 GENERAL REQUIREMENTS

- A. Construct all piping systems in accordance with applicable ASME Codes
- B. Piping shall be installed parallel to building coordinates with vertical drops. Piping in the vicinity of equipment shall be arranged to not interfere with access panels and maintenance space. Provide unions, flanges and shutoff valves to allow removal of the equipment and its subassemblies without having to remove excessive amounts of building piping and to minimize water drainage requirements. Provide a vent valve at the topmost part and a drain valve at the lowest part of all water piping systems. Bull head Tee arrangement is not acceptable
- C. All piping, fittings and valves shall be manufactured in the United States of America.
- D. Provide pipe sleeves for all insulated piping passing through a wall and all piping passing through a floor above grade.

1.04 SUMMARY

- A. This Section includes pipe and fitting materials, joining methods, special-duty valves, and specialties for the following:
 - 1. Hot-water heating piping.
 - 2. Makeup-water piping.
 - 3. Condensate-drain piping.
 - 4. Blowdown-drain piping.
 - 5. Air-vent piping.
 - 6. Safety-valve-inlet and -outlet piping.
- B. Related Sections include the following:
 - 1. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.

1.05 PERFORMANCE REQUIREMENTS

- A. Hydronic piping components and installation shall be capable of withstanding the following minimum working pressure and temperature:
 - 1. Hot-Water Heating Piping: 150 psig at 200 deg F.
 - 2. Makeup-Water Piping: 80 psig at 150 deg F.
 - 3. Condensate-Drain Piping: 150 deg F.
 - 4. Blowdown-Drain Piping: 200 deg F.
 - 5. Air-Vent Piping: 200 deg F.

6. Safety-Valve-Inlet and -Outlet Piping: Equal to the pressure of the piping system to which it is attached.

1.06 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of the following:
 1. Valves. Include flow and pressure drop curves based on manufacturer's testing for calibrated-orifice balancing valves and automatic flow-control valves.
 2. Air control devices.
 3. Chemical treatment.
 4. Hydronic specialties.
- C. Grooved joint couplings and fittings may be shown on drawings and product submittals, and shall be specifically identified by the manufacturer's style or series designation.
- D. Welding certificates.
- E. Qualification Data: For Installer.
- F. Field quality-control test reports including reports on flushing procedures and hydrostatic pressure testing.
- G. Operation and Maintenance Data: For air control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.
- H. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site and recommendation of the chemical treatment consultant.

1.07 QUALITY ASSURANCE

- A. Steel Support Welding: Qualify processes and operators according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. All grooved joint couplings, fittings, valves, and specialties shall be the products of a single manufacturer. Grooving tools shall be of the same manufacturer as the grooved components.
 1. All castings used for coupling housings, fittings, and valve bodies shall be date stamped for quality assurance and traceability.
- C. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.
 1. Comply with provisions in ASME B31 Series, "Code for Pressure Piping."
 2. Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for materials, products, and installation. Safety valves and pressure vessels shall bear the appropriate ASME label. Fabricate and stamp air separators and expansion tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01.

1.08 EXTRA MATERIALS

- A. Water-Treatment Chemicals: Furnish enough chemicals for initial system startup and for preventive maintenance for one year from date of Substantial Completion.
- B. Provide material and installation costs for (10) additional 4" clevis hangers with insulation saddles and all associated rods, clips, bolts, supports, and building attachments for 4" insulated piping. Actual routing, installation and sizes are to be field verified at location required and ordered only after approval from the Engineer.

PART 2: PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.
- B. Annealed-Temper Copper Tubing: ASTM B 88, Type K.
- C. DWV Copper Tubing: ASTM B 306, Type DWV.
- D. Wrought-Copper Fittings: ASME B16.22.
- E. Grooved-Joint Fittings: Copper-tube dimensioned grooved ends; Wrought copper to ASME B16.22, or bronze casting to ASME B16.18. Basis of Design: Victaulic Copper-Connection.
 - 1. Flaring tube or fitting ends to accommodate alternate sized couplings is not permitted.
- F. Grooved Joint Couplings: Manufactured in two segments of cast ductile iron with offsetting, angle-pattern bolt pads, bolt pad design for visual verification of proper installation, conforming to ASTM A-536, Grade 65-45-12, gaskets shall be grade EHP pressure-responsive elastomer suitable for water temperatures to +250 degrees F conforming to ASTM D2000, bolts shall be zinc plated heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Installation-Ready, for direct stab installation on copper-tubing without field disassembly. Equal to Victaulic Style 607H.

2.02 STEEL PIPE AND FITTINGS

- A. Steel Pipe: ASTM A 53/A 53M, black steel with plain ends; type, grade, and wall thickness as indicated in Part 3 "Piping Applications" Article.
- B. Cast-Iron Threaded Fittings: ASME B16.4; Classes 125 and 250 as indicated in Part 3 "Piping Applications" Article.
- C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300 as indicated in Part 3 "Piping Applications" Article.
- D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300 as indicated in Part 3 "Piping Applications" Article.
- E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced as indicated in Part 3 "Piping Applications" Article.
- F. Wrought-Steel Fittings: ASTM A 234/A 234M, wall thickness to match adjoining pipe.
- G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings:
 - 1. Material Group: 1.1.
 - 2. End Connections: Butt welding.

3. Facings: Raised face.
- H. Steel Pipe Nipples: ASTM A 733, made of same materials and wall thicknesses as pipe in which they are installed.

2.03 MECHANICAL COUPLED PIPING SYSTEMS

- A. Grooved Mechanical Coupling Acceptable Manufacturers :
1. Victaulic
- B. Steel Pipe: ASTM A53B, black steel pipe with grooved ends; type, grade and wall thickness as indicated in Part 3 "Piping Applications" Article.
- C. Grooved End Fittings: Standard fittings shall be cast of ductile iron conforming to ASTM A-536, Grade 65-45- 12, forged steel conforming ASTM A-234, Grade WPB 0 .375 inch wall, or factory-fabricated from Std. Wt. Carbon Steel pipe conforming to ASTM A-53, Type F, E or S, Grade B. Fitting provided with an alkyd enamel finish or hot dip galvanized to ASTM A-153 . Zinc electroplated fittings and couplings shall conform to ASTM B-633.
- D. Standard Mechanical Couplings (2 inch and Larger): Manufactured in two segments of cast ductile iron, conforming to ASTM A-536, Grade 65-45-12. Gaskets shall be pressure-responsive synthetic rubber, grade to suit the intended service, conforming to ASTM D-2000. Mechanical Coupling bolts shall be zinc plated (ASTM B- 33) heat treated carbon steel track head conforming to ASTM A-449 and ASTM A-183. Couplings shall comply with ASTM F1476 Standard Specification for the Performance of Gasketed Mechanical Couplings for Use In Piping Applications.
1. Rigid Type Couplings: Housing with offsetting, angle-pattern bolt pads shall be used to provide system rigidity and support and hanging in accordance ANSI B31.1, B31.9 and NFPA 13.
 - a. Equal to Victaulic Style 107H, Installation-Ready, for direct stab installation without field disassembly.
 - b. Equal to Victaulic Style 07 "Zero-Flex"
 2. Flexible Type: For use in locations where vibration attenuation and stress relief are required, and for the elimination of flexible connectors. Equal to Victaulic Installation-Ready Style 177 or Style 77.
 3. 14" and Larger: AGS Series, with lead-in chamfer on housing key and wide width FlushSeal gasket. Equal to Victaulic Style W07 (rigid) and Style W77 (flexible).
 4. Gaskets: Gaskets shall be Grade EHP (EPDM-HP) compound designed for operating temperatures from -30 degrees F to +250 degrees F, or Grade E (EPDM) for operating temperatures from -30 degrees F to +230 degrees F.
- E. Project Inspection and Training Requirements for Mechanical Couplings:
1. The grooved coupling manufacturer's (the "manufacturer") factory trained representative shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and installation of grooved joint products. This shall be at the expense of the installing contractor.
 2. IACET/Training:
 - a. A factory trained manufacturer's representative (direct employee) shall provide on-site training for contractor's field personnel in the use of grooving tools, application of groove, and product installation in compliance with the following:
 - b. Manufacturer must be accredited as an Authorized Provider by the International Association for Continuing Education and Training (IACET)
 - c. Manufacturer must demonstrate that it complies with the ANSI/IACET standard which is recognized as a standard of good practice

3. Inspection:
 - a. A manufacturer's factory trained representative shall periodically visit the job site and review the installation for best practices. This shall be at the expense of the installing contractor. The installing Contractor shall correct any identified deficiencies.
 - b. The mechanical grooved product and overall system shall be examined and if it has not met the visual inspection criteria for proper installation must be corrected and re-examined by Inspection Services prior to the completion of the project. Any product that has not been corrected or was not examined will not be considered as part of the successful completion of Inspection Services.
4. Application:
 - a. Upon completion of the manufacturer's inspection of the installation and any identified corrections, the manufacturer may provide the owner or purchaser with a limited warranty on manufacturer's products.

2.04 JOINING MATERIALS

- A. Pipe-Flange Gasket Materials: Suitable for chemical and thermal conditions of piping system contents.
 1. ASME B16.21, nonmetallic, flat, asbestos free, 1/8-inch maximum thickness unless thickness or specific material is indicated.
 - a. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges.
 - b. Narrow-Face Type: For raised-face, Class 250, cast-iron and steel flanges.
- B. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- C. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- D. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- E. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for joining copper with copper; or BAg-1, silver alloy for joining copper with bronze or steel.
- F. Grooved Joint Lubricants: Lubricate gasket in accordance with manufacturer's recommendations with a lubricant supplied by the coupling manufacturer that is compatible with the gasket elastomer and fluid media. Basis of Design: Equal to Victaulic Vic-Lube.
- G. 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.

2.05 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:
 1. Factory-fabricated union assembly, for 250-psig minimum working pressure at 180 deg F.
- D. Dielectric Flanges:

1. Factory-fabricated companion-flange assembly, for 150- or 300-psig minimum working pressure as required to suit system pressures.
- E. Dielectric-Flange Kits:
1. 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.
 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:
1. Galvanized-steel coupling with inert and noncorrosive thermoplastic lining; threaded ends; and 300-psig minimum working pressure at 225 deg F.
- G. Dielectric Nipples:
1. Electroplated steel nipple or ductile iron casing with inert and noncorrosive, thermoplastic lining; plain, threaded, or grooved ends; and 300-psig minimum working pressure at 225 deg F. Basis of Design: Victaulic Style 47.

2.06 VALVES

- A. Globe, Check, Ball, and Butterfly Valves: Comply with requirements specified in Division 23 Section "General-Duty Valves for HVAC Piping."
- B. Bronze, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Armstrong Pumps, Inc.
 - b. Flow Design Inc.
 - c. Gerand Engineering Co.
 - d. Griswold Controls.
 - e. Taco.
 - f. Victaulic / Tour & Andersson.
 2. Body: Bronze or Ametal (copper-alloy), globe, ball, or plug type with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Plug: Resin.
 5. Seat: PTFE or EPDM.
 6. End Connections: Threaded or socket.
 7. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 8. Handle Style: Handwheel with readout or lever, with memory stop to retain set position.
 9. CWP Rating: Minimum 250 psig.
 10. Maximum Operating Temperature: 230 deg F.
 11. Coil-Hook-up Connections: Equal to Victaulic Koil-Kits Series 799 or 79V may be used at coil connections. The kit shall include a Series 786/787/78K circuit balancing valve, Series 78Y Strainer-Ball, Series 78U Union-Port fitting, with Series 78T ball valve and required coil hoses. A Style 793 and/or 794 differential pressure controller shall be provided as required. A meter shall be provided by the valve manufacturer that shall remain with the building owner after commissioning.
- C. Cast-Iron or Steel, Calibrated-Orifice, Balancing Valves:
1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:

- a. Armstrong Pumps, Inc.
 - b. Flow Design Inc.
 - c. Gerand Engineering Co.
 - d. Griswold Controls.
 - e. Taco.
 - f. Tour & Andersson; available through Victaulic Company of America.
2. Body: Ductile-iron or steel body, ball, plug, or globe pattern with calibrated orifice or venturi.
 3. Ball: Brass or stainless steel.
 4. Stem Seals: EPDM O-rings.
 5. Disc: Ametal or glass and carbon-filled PTFE.
 6. Seat: PTFE or EPDM.
 7. End Connections: Flanged or grooved.
 8. Pressure Gage Connections: Integral seals for portable differential pressure meter.
 9. Handle Style: Handwheel with readout or lever, with memory stop to retain set position.
 10. CWP Rating: Minimum 250 psig.
 11. Maximum Operating Temperature: 230 deg F

D. Liquid Flow Switches

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. McDonald Miller
2. Brass construction for all wetted parts.
3. Packless construction.
4. Paddle with removable segments for pipe size and velocity.
5. Vapor-proof electrical compartment for switches.

E. Pressure/Temperature Safety Relief Valves.

1. Bronze body with test lever, EPDM diaphragm and seat.
2. ASME rated.
3. Pressure relief valve set at 30-psig pressure.
4. Maximum working pressure of 125 psig.
5. Maximum operating temperature of 250-degree F.
6. Bell & Gossett Series 790, 1170, 3301, or 4100 as applicable.

F. Flexible Pump Connectors

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Mason
 - b. La Favorite
 - c. Resistoflex
 - d. Victaulic.
2. Flanged Type
 - a. Neoprene and duck construction of molded teflon.
 - b. Control rods in accordance with manufacturer's published instructions.
 - c. Rated for 225-degree F. temperature and 100-psig pressure.
3. Grooved Type: Three grooved joint (Equal to Victaulic) couplings may be used in lieu of a flexible connector at equipment connections to accommodate vibration attenuation and stress relief. The couplings shall be placed in close proximity to the source of the vibration.

G. Flexible Corrugated Metal Hose

1. Bronze with annular or helical corrugations
2. Single bronze braid covering with threaded end connections.
3. 1" offset motion each side of centerline.
4. Pressure rating of 200 psig.
5. Temperature rating of 250-degree F.
6. All piping connections to equipment with spring isolation shall have flexible pipe connector at all connections to equipment whether specifically shown on drawings or not.

H. Calibrated Balance Valves

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Victaulic
 - b. Armstrong
 - c. Tour Anderson
 - d. Barco
 - e. Amtrol
2. Non-ferrous, bronze body
 - a. ½"-2" threaded or sweat fitting.
 - b. Larger than 2" shall have grooved end or flanged fitting.
3. Positive shutoff rising stem angled globe style design.
4. Double packing to allow service under pressure.
5. Plug tap connections both sides of valve for portable meter.
6. Calibrated memory stop with locking feature.
7. 4-turn (1440-degree) throttling range.
8. Brass tags with flow and meter setting.
9. Size valves for 1 ft. P.D. at 50% open.

I. Flow Measuring Devices- Pitot Tube Type

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Gerand
 - b. Rinco
 - c. KG Co.
2. Averaging type flow element constructed of 316 stainless steel.
3. Consists of three (3) flow sensing chambers
 - a. Upstream high-pressure chamber.
 - b. High pressure interpolating tube.
 - c. Single downstream low pressure located on pipe centerline.
4. Accuracy shall be within $\pm 1\%$ of actual value and $\pm 0.1\%$ repeatability with flow rates scheduled on the drawings.
5. Provide the following accessories:
 - a. Shutoff instrument valves.
 - b. Permanent metal tag indicating design flow rates, meter readings, tag number.
 - c. Flow indicator chart framed under glass and showing tag number, location, and design flow rate.

- d. Meter complete with case, hoses and shutoff valves. Turn over to owner at project completion.
 - 1) Furnish a portable 0 - 50 inch differential pressure meter for balancing. Meter shall be equal to Gerrand Company, Model M-50 , complete with 6 inch dial, steel case, 10 foot meter hoses with disconnect ends, purge valves, blowdown hoses and operating instruction sheet. Meter assembly shall be rated for 250 psig and 250o F.

2.07 AIR CONTROL DEVICES

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

1. Amtrol, Inc.
2. Armstrong Pumps, Inc.
3. Bell & Gossett Domestic Pump; a division of ITT Industries.
4. Taco.

B. Manual Air Vents:

1. Body: Bronze.
2. Internal Parts: Nonferrous.
3. Operator: Screwdriver or thumbscrew.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: **NPS 1/8**.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 225 deg F.

C. Automatic Air Vents:

1. Body: Bronze or cast iron.
2. Internal Parts: Nonferrous.
3. Operator: Noncorrosive metal float.
4. Inlet Connection: NPS 1/2.
5. Discharge Connection: NPS 1/4.
6. CWP Rating: 150 psig.
7. Maximum Operating Temperature: 240 deg F.

D. Diaphragm or Bladder Type Expansion Tanks:

1. Tank: Welded steel, rated for 125-psig working pressure and 240 deg F maximum operating temperature. Factory test with taps fabricated and supports installed and labeled according to ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
2. Diaphragm or Bladder: Securely sealed into tank to separate air charge from system water to maintain required expansion capacity.
3. Air-Charge Fittings: Schrader valve, stainless steel with EPDM seats.

2.08 SIDE STREAM FILTER

A. Provide, pipe and install a side stream application off of heating water and chilled water supply and return mains in each main mechanical room: Equal to Lakos Model SRV-816

B. Filter Housing: Housing shall be a minimum 3/16 inch thick carbon steel with epoxy coated inside.

C. Hinged Lid: Hinged Lid shall be carbon steel with epoxy coated on inside.

D. Basket: Internal basket shall be stainless steel mesh.

- E. Collection Bags: Collection bags shall be polyester mesh.
 - 1. Provide 50 micron rated bags and 25 micron rated bags.
- F. Connections: Inlet and outlet connection shall be ¾ inch female threaded P.P.T. on opposite sides of housing.
 - 1. Housing shall have a ¾ inch drain fitting at bottom of unit.
- G. Capacity:
 - 1. Solids collection capacity of 25 pounds.
 - 2. Liquid retention capacity of 3.1 gallons.
- H. Pressure and Temperature Ratings:
 - 1. Maximum working pressure 125 psi.
 - 2. Maximum operating temperatures 200 degrees F.
- I. Indicator Package: Provide with indicator package consisting of two (2) ball valves, five (5) pipe nipples, two (2) sightglasses, one (1) annunciator, one (1) flow control orifice, one (1) stainless clamp and required tubing with end connectors. Package will indicate a 15 psi pressure drop.
- J. Provide the owner with three (3) extra sets of 50 micron collection bags and three (3) sets of 25 micron collection bags. Obtain a receipt from the owner showing the collections bags were received.

2.09 CHEMICAL TREATMENT

- A. Bypass Chemical Feeder: Welded steel construction; 125-psig working pressure; 5-gal. capacity; with fill funnel and inlet, outlet, and drain valves. Equal to Aqua Pass Plus 8759. Provide at each heating water and cooling water system.
 - 1. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.
- B. Ethylene and Propylene Glycol: Industrial grade with corrosion inhibitors and environmental-stabilizer additives for mixing with water in all systems (new and existing) indicated to contain antifreeze or glycol solutions.
- C. Provide a glycol makeup pump systems for the chilled water and heating water system. The make-up package shall be equal to Wessels Model GMP 2052, preset at 70 psig.

2.010 SLEEVES

- A. Cast-Iron Wall Pipes: Fabricated of cast iron, and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.
- B. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
- C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc-coated, with plain ends.
- 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.

2.011 SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, used to fill annular space between pipe and sleeve.
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.

2.012 HYDRONIC PIPING SPECIALTIES

A. Y-Pattern Strainers:

1. Body:
 - a. ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
 - b. ASTM A 536, Grade 65-45-12, ductile iron with coupled cover and drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; grooved or flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent total free area.
4. CWP Rating: 300 psig.
5. Basis of Design: Victaulic Style 732 / W732.

B. Basket Strainers:

1. Body: ASTM A 126, Class B, high-tensile cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. T-Pattern Strainers:

1. Body:
 - a. Ductile-iron with removable access coupling and end cap for strainer maintenance.
 - b. Factory-fabricated steel with T-bolt hinged closure for strainer maintenance.
2. End Connections: Grooved ends.
3. Strainer Screen: 40 mesh startup strainer, and perforated stainless-steel basket with-2:1 total free area.
4. CWP Rating: 300 psig.
5. Basis of Design: Victaulic Style 730 / W730.

D. Stainless-Steel Bellow, Flexible Connectors:

1. Body: Stainless-steel bellows with woven, flexible, bronze, wire-reinforcing protective jacket.
2. End Connections: Threaded or flanged to match equipment connected.
3. Performance: Capable of 3/4-inch misalignment.
4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.
6. Three grooved joint (Equal to Victaulic) couplings may be used in lieu of a flexible connector at equipment connections to accommodate vibration attenuation and stress relief in applicable piping systems. The couplings shall be placed in close proximity to the source of the vibration.

E. Spherical, Rubber, Flexible Connectors:

1. Body: Fiber-reinforced rubber body.
2. End Connections: Steel flanges drilled to align with Classes 150 and 300 steel flanges.
3. Performance: Capable of misalignment.

4. CWP Rating: 150 psig.
5. Maximum Operating Temperature: 250 deg F.
6. Three grooved joint (Equal to Victaulic) couplings may be used in lieu of a flexible connector at equipment connections to accommodate vibration attenuation and stress relief in applicable piping systems. The couplings shall be placed in close proximity to the source of the vibration.

F. Expansion fittings are specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."

2.013 HYDRONIC (heating and cooling) PIPING MINIMUM RUNOUT PIPE SIZING TO EQUIPMENT

A. Unless noted otherwise on the plans, pipe runout sizes for vav boxes reheat coils, hydronic coils, unit heaters, fintube radiation, etc shall be of the size indicated below:

<u>PIPE SIZE</u>	<u>MBH</u>	<u>GPM</u>
1/2"	0 - 20.0	0 - 2.0
3/4"	21.0 - 40.0	2.1 - 4.0
1"	41.0 - 75	4.1 - 7.5
1-1/4"	76.0 - 110.0	7.6 - 17.0
1-1/2"	111.0 - 170.0	11.1 - 17.0
2"	171.00 - 370.0	17.1 - 37.0

PART 3: EXECUTION

3.01 PIPING APPLICATIONS

A. Hydronic Piping (unless otherwise specified here-in):

1. Up to 1½": Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.
2. 2" and Larger: Rigid Mechanical Couplings with EPDM gasket.

B. Makeup-water piping:

1. Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

C. Makeup-Water Piping Installed Belowground and within Slabs: Type K, annealed-temper copper tubing, wrought-copper fittings, and soldered joints. Use the fewest possible joints.

D. Condensate-Drain Piping: Type L, drawn-temper copper tubing, wrought-copper fittings, and soldered joints.

E. Blowdown-Drain Piping: Same materials and joining methods as for piping specified for the service in which blowdown drain is installed.

F. Air-Vent Piping:

1. Inlet: Same as service where installed with metal-to-plastic transition fittings for plastic piping systems according to the piping manufacturer's written instructions.
2. Outlet: Type K, annealed-temper copper tubing with soldered or flared joints.

G. Safety-Valve-Inlet and -Outlet Piping for Hot-Water Piping: Same materials and joining methods as for piping specified for the service in which safety valve is installed.

3.02 VALVE APPLICATIONS

A. Install shutoff-duty valves at each branch connection to supply mains, and at supply connection to each piece of equipment.

- B. Install calibrated-orifice, balancing valves at each branch connection to return main.
- C. Install calibrated-orifice, balancing valves in the return pipe of each heating or cooling terminal.
- D. Install check valves at each pump discharge and elsewhere as required to control flow direction.
- E. Install safety valves at hot-water generators and elsewhere as required by ASME Boiler and Pressure Vessel Code. Install drip-pan elbow on safety-valve outlet and pipe without valves to the outdoors; and pipe drain to nearest floor drain or as indicated on Drawings. Comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 01, for installation requirements.
- F. Manual Vent Valves
 - 1. Install manual vent valves on each hydronic terminal at highest point.
 - 2. Install at each high point in the piping system which could trap air.
- G. Automatic Vent Valves
 - 1. Install automatic vent valves at top of each hydronic riser and elsewhere as indicated.
 - 2. Install shutoff valves between riser and vent valve, pipe outlet to suitable plumbing drain, or as indicated.
- H. Dip Tube Fittings
 - 1. Install dip tube fittings in boiler outlet in accordance with manufacturer's most current published installation instructions.
 - 2. Run piping to expansion tank with ¼" per foot (2%) upward slope towards tank.
 - 3. Connect boiler outlet piping.
- I. Pump Discharge Valves
 - 1. Install on each pump discharge line.
 - 2. Install in horizontal or vertical position with stem in upwards position.
 - 3. Allow clearance above stem for check mechanism removal.
- J. Liquid Flow Switches
 - 1. Install in horizontal pipe with switch mounted in tee on top of pipe.
 - 2. Minimum of 24" of straight pipe with no fittings both upstream and down stream of switch.
 - 3. Remove segments of paddle to fit pipe in accordance with manufacturer's most current published installation instructions.
 - 4. Wiring of liquid flow switches is specified in Electrical sections.
- K. Pressure/Temperature Safety Relief Valves
 - 1. Install on hot water generators, and elsewhere as indicated.
 - 2. Pipe discharge to floor drain.
 - 3. Comply with ASME Boiler and Pressure Vessel Code criteria.
- L. Flexible Corrugated Metal Hose
 - 1. Install in supply and return connections to coils and unit heaters in vertical or horizontal position and at right angle to the supply mains.
 - 2. Flow Measuring Devices
 - 3. Install in accordance with manufacturer's most current published installation instructions.
 - 4. All piping connections to equipment with spring isolation shall have flexible pipe connector at all connection to equipment

3.03 PIPING INSTALLATIONS

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Coordination Drawings.
- B. Install piping in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- C. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited unless specifically indicated otherwise.
- D. Contractor is responsible for coordination with other trades and systems
- E. No pipe shall pass in front of or interfere with any openings, door or window. Head room in front of openings and doors shall in no case be less than the top of the opening.
- F. Piping shall not pass exposed through electrical rooms or be erected over any switchboard or other electrical gear.
 - 1. Where conflicts are unavoidable, stainless steel drain pans with drain lines piped to an approved waste receptor may be provided, pending written approval from the Owner.
- G. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
- H. Install piping to permit valve servicing.
- I. Install piping at indicated slopes.
- J. Install piping free of sags and bends.
- K. Install fittings for changes in direction and branch connections.
- L. Install piping to allow application of insulation.
- M. Select system components with pressure rating equal to or greater than system operating pressure.
- N. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- O. 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.
- P. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- Q. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- R. Install valves according to Division 23 Section "General-Duty Valves for HVAC Piping.
- S. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.
- T. Install flanges in piping, NPS 2-1/2 and larger, at final connections of equipment and elsewhere as indicated.
- U. Unions and flanges for servicing and disconnect are not required in installations using grooved joint couplings. (The couplings shall serve as disconnect points.)

- V. Install strainers on inlet side of each control valve, pressure-reducing valve, solenoid valve, in-line pump, and elsewhere as indicated. Install NPS 3/4 nipple and ball valve in blowdown connection of strainers NPS 2 and larger. Match size of strainer blowoff connection for strainers smaller than NPS 2.
- W. Install expansion loops, expansion joints, anchors, and pipe alignment guides as specified in Division 23 Section "Expansion Fittings and Loops for HVAC Piping."
- X. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- Y. Install all temperature sensors and flow switches at the direction of the Building Automation System Contractor.
- Z. Identify piping as specified in Division 23 Section "Identification for HVAC Piping and Equipment."
- AA. Install automatic air vents with isolation valve at the highest point in each system. Air vent shall be rated for the system temperature, pressure and water chemistry. Where feasible, automatic air vents installed in glycol systems must be routed to the main recovery tank.
- BB. All piping shall be arranged to completely drain the system. Drain locations shall be located at all system low points. 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.
- CC. Reduced pressure principal back flow preventers shall be installed on all make-up water lines.
- DD. Bull-heading tee connections are prohibited. Main fluid flows shall not enter the side of a tee fitting and then diverge.

3.04 HANGERS AND SUPPORTS

- A. Comply with requirements in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe hanger and support products and installation.
 - 1. Vertical Piping: MSS Type 8 or 42, clamps.
 - 2. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel clevis hangers.
 - 3. Multiple, Straight, Horizontal Piping Runs: Field fabricated, heavy duty trapeze. Fabricate from steel shapes and rod diameters as required for loads per MSS SP-58 and MSS SP-69. Verify rod diameter with structural engineer for multiple pipe trapeze hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install supports for vertical copper tubing every 10 feet.
- E. Install supports for vertical steel piping every 15 feet.
- F. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4"	4	4	3/8
1" to 2"	6	6	3/8
2 1/2" to 4"	6	6	1/2
5" and Greater	4	4	7/8

- G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions and prior approved spacing by the structural engineer.

3.05 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. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter, using copper-phosphorus brazing filler metal complying with AWS A5.8.
- F. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 - 1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
 - 2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Grooved Joints: Grooved joint shall be installed in accordance with the manufacturer's written recommendations. Grooved ends shall be clean and free from indentations, projections, or roll marks. The gasket shall be molded and produced by the coupling manufacturer of an elastomer suitable for the intended service.
 - 1. The coupling manufacturer's factory trained representative shall provide a minimum of two on-site training visits for the contractor's field personnel in the use of grooving tools and installation of product. The representative shall periodically visit the job site to ensure best practices in grooved product installation are being followed. (A distributor's representative is not considered qualified to conduct the training.)
- H. Welded Joints: Construct joints according to AWS D10.12/D10.12M, 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.

3.06 HYDRONIC SPECIALTIES INSTALLATION

- A. Install manual air vents at high points in piping, at heat-transfer coils, and elsewhere as required for system air venting, including any areas up and downs of pipe routing causing "trapping".
- B. Install automatic air vents at high points of system piping in mechanical equipment rooms only. Manual vents at heat-transfer coils and elsewhere as required for air venting.
- C. Install piping from boiler air outlet, air separator, or air purger to expansion tank with a 2 percent upward slope toward tank.
- D. Install in-line air separators in pump suction. Install drain valve on air separators NPS 2 and larger.
- E. Install tangential air separator in pump suction. Install blowdown piping with gate or full-port ball valve; extend full size to nearest floor drain.

- F. Install expansion tanks on the floor. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system Project requirements.

3.07 TERMINAL EQUIPMENT CONNECTIONS

- A. Sizes for supply and return piping connections shall be the same as or larger than equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Install bypass piping with globe valve around control valve. If parallel control valves are installed, only one bypass is required.
- D. Install ports for pressure gages and thermometers at coil inlet and outlet connections according to Division 23 Section "Meters and Gages for HVAC Piping."
- E. Install control valves in accessible locations close to connected equipment. Install ports for pressure gages and thermometers at coil inlet and outlet connections. Comply with requirements in Section 230519 "Meters and Gages for HVAC Piping."
- F. Provide unions and arrangement of sufficient length of removable sections of tubing at valves and equipment connections to allow for easy removal and reinstallation for repairs without having to redo press connections.
- G. Make piping connections to coils and equipment with offsets provided with screwed or flanged unions so arranged that the equipment can be serviced or removed without dismantling the piping. Do not screw unions directly to coil or tube header piping connections.

3.08 SIDE STREAM FILTER INSTALLATION AND MONITORING

1. Install a side stream filter on each new chilled water, heating water, and condenser water application within the project unless otherwise noted and/or shown on the drawings.
2. Provide ball valves on each side of filter for maintenance of each system.
3. Install 50 micron filter prior to start-up of hot water/glycol and cooling water/glycol systems.
4. Daily monitor the pressure drop through the filter.
5. When the pressure drop increases by 15 psi above the initial pressure drop, remove and clean the cartridge with fresh water, and reinstall.
6. When the rate of filtration requires cartridge cleaning no more frequently than once a week, remove the 50 micron cartridges and install a set of 25 micron cartridges. Run system as in statement 5 above and repeat as necessary.
7. When the 25 micron cartridges require cleaning no more frequently than once a week (15 psi increase), turn over the system and unused cartridges to the owner.
8. Instruct the owner on the use of the system. After the initial cleaning of the water/glycol systems the valves to the filters will be closed and the filters will be used only when solution is added to the systems.

3.09 CHEMICAL TREATMENT

- A. Provide the services of a chemical treatment consultant to perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the

following water characteristics. Submit a report to the Engineer to include the initial water analysis and the consultants recommendations.

1. pH: 9.0 to 10.5
 2. "P" Alkalinity: 100 to 500 ppm.
 3. Boron: 100 to 200 ppm.
 4. Chemical Oxygen Demand: Maximum 100 ppm. Modify this value if closed system contains glycol.
 5. Corrosion Inhibitor:
 - a. Sodium Nitrate: 1000 to 1500 ppm
 6. Soluble Copper: Maximum 0.20 ppm
 7. Tolyriazole Copper and Yellow Metal Corrosion Inhibitor: Minimum 10 ppm.
 8. Total Suspended Solids: Maximum 10 ppm.
 9. Ammonia: Maximum 20 ppm.
 10. Free Caustic Alkalinity: Maximum 20 ppm.
 11. Microbiological Limits:
 - a. Total Aerobic Plate Count: Maximum 1000 organisms/ml.
 - b. Total Anaerobic Plate Count: Maximum 100 organisms/ml.
 - c. Nitrate Reducers: 100 organisms/ml.
 - d. Sulfate Reducers: Maximum 0 organisms/ml.
 - e. Iron Bacteria: Maximum 0 organisms/ml.
- B. The existing hydronic system shall be flush and cleaned (2) two times prior to any new work being started. This work shall include cleaning of all strainers to remain.
- C. The entire new and existing hydronic system shall be flush and cleaned a minimum of (2) two after all new work has been completely. Additional flush/cleaning/treatments shall be required if specification requirement cannot be meet with first two cleanings. This work shall include cleaning of all strainers.
1. The contractor shall provide a pre and post flush/clean/treatment report for each cleaning.
- D. Fill the entire system (new and existing) with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water. Provide all additional valves, fitting, temporary piping, piping connections and pumps required to isolate sections of pipe intended to be cleaned and flushed from existing or previously cleaned and finished.
- E. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.
- F. Fill all systems (new and existing) as indicated to have antifreeze or glycol solutions with the following concentrations. Exact amount of glycol (new and existing) shall be determined by the contractor based on their metered fill data. Provide owner with metered data at project completion:
1. Hot-Water Heating Piping: Minimum 30 percent propylene glycol.

3.010 FLUSHING AND CLEANING (New Systems)

- A. The system must be pressure tested and accepted as leak free per the “Hydronic Piping” specification by the owner prior to flushing and cleaning.
- B. Control systems that operate automatic isolation valves, temperature control valves, or other automated hydronic devices must be in place and operational prior to cleaning. Manual operation of automated valves is not acceptable.
- C. On completely new piping system installations, the contractor shall use temporary strainers to flush and clean the piping systems. Do not use Owner’s permanent strainers to trap debris during pipe flushing operations. Fit the temporary construction strainers with a line size blowoff valve.
- D. The contractor shall submit a cleaning and chemical treatment plan to the owner for approval prior to execution.
- E. For new systems that will connect to existing systems utilize section Flushing and Cleaning (Existing / Expanded / Modified systems)
- F. The contractor shall:
 - 1. Fill the system with fresh water. Meter the fill level to ascertain the system volume.
 - 2. Open/close automated valves as required to achieve flow in all areas.
 - a. The Water Treatment Contractor (WTC) shall work with the design engineer, controls contractor and the Mechanical Contractor (MC) to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
 - b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
 - c. Install all piping main bypasses as required to facilitate cleaning.
 - 3. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
 - 4. Flush the system with fresh water for time period as directed by the WTC.
 - 5. Disable the pumps.
 - 6. The WTC will test and verify flush water quality before proceeding.
 - 7. Drain the system.
 - 8. Remove all startup strainers from the system, and clean. This includes strainers at pumps, terminal devices, fill points, etc.
 - 9. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag.
 - 10. Fill the system and chemically clean the system as directed by the WTC.
 - 11. Perform additional strainer cleanings in the defined systems as requested by the WTC.
 - 12. Repeat the cleaning process until the WTC deems the system acceptable.
 - 13. Perform final flush as directed by WTC.
 - 14. The WTC will test and verify the final flush water condition before proceeding.
 - 15. Remove all startup strainers from the system, and replace with the specified operational strainer. This includes strainers at pumps, terminal devices, fill points, etc.
 - 16. Refill system to operating pressure, WTC shall treat the system for normal operation.
 - 17. The WTC will provide test reports of system water quality to the owner for verification.
- G. The WTC shall:
 - 1. Develop an approved cleaning and treatment plan in coordination with the MC and the BAS contractor.
 - 2. Utilizing labor provided by the MC as needed, flush and chemically clean the defined hydronic systems as required to obtain completely clean and scale free internal piping surfaces.
 - a. Criteria for system acceptance:
 - 1) Acceptable water test results within defined ranges from the main pump location.
 - 2) Acceptable water test results within defined ranges from remote areas in quantities and locations defined by the WTC.
 - 3. After system cleaning is complete, provide water treatment as needed to allow the loop water quality parameters to fall within the ranges as specified.

4. Maintain hydronic water system testing and treatment throughout the warranty period of (1) year after project acceptance.
5. Provide a project closeout report and ongoing maintenance plan to the owner
 - a. Domestic water test results
 - b. Initial startup water test results
 - c. Monthly water test results during warranty operation
 - d. System maintenance schedule
 - e. Final water test results, at conclusion of warranty period.
6. At **[four]** week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that chemical treatment program is maintaining water quality within performance requirements specified in this Section. WTC shall schedule the monthly testing with owner representatives. Submit written reports of water analysis advising Owner of changes.

3.011 FLUSHING AND CLEANING (Existing / Expanded / Modified Systems)

- A. Existing systems shall be cleaned and flushed prior to the installation of new work. Existing systems typically have large amounts of debris and contaminants that can cause damage to new components, and once removed, may cause excessive leakage. Every effort shall be made to remove this debris prior to installation and operation of new equipment.
- B. Control systems that operate automatic isolation valves, temperature control valves, or other automated hydronic devices must be in place and operational prior to cleaning. Manual operation of automated valves is not acceptable.
- C. New equipment (or otherwise in very good condition) shall not be used for the circulation of chemical cleaning solutions intended to remove built-up scale and corrosion in existing piping systems at any point, before or after system modification. Options may include the following:
 1. If the existing pump system are already in poor condition and/or would not be appropriate for meeting final operating conditions and are not economical to salvage and thus to be entirely replaced anyway, the contractor may use the existing pump for the circulation of cleaner/dirty fluid prior to replacement.
 2. If the existing pump system is otherwise in good condition and planned to be reused after chemical cleaning operations, then:
 - a. Include all materials and labor for inspection and cleaning of all wetted parts and replacing of worn items, at a minimum the definite replacement of the seals, after all chemical cleaning and flushing is completed and before system is refilled with final clean fluid.
- D. The Mechanical Contractor (MC) shall:
 1. Install bypasses to facilitate system flush as directed by the Engineer or Owner.
 - a. Bypasses are typically located where steel connects to copper, where main piping terminates, or at terminal equipment.
 2. Starting with an existing system where the system is filled and operational.
 3. Remove all strainers from the system, and clean or replace as necessary. This includes strainers at pumps, terminal devices, fill points, etc.
 4. Open/close automated valves as required to achieve flow in all areas.
 - a. The Water Treatment Contractor (WTC) shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
 - b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
 - c. Install all piping main bypasses as required to facilitate cleaning.
 5. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
 6. Flush the system with fresh water for a time period as directed by the WTC.
 7. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag (if present).

8. Remove all strainers from the system, clean and replace. This includes strainers at pumps, terminal devices, fill points, etc.
9. Refill system to normal operating pressure and chemically clean the system as directed by the WTC.
10. Perform additional strainer cleanings in the defined systems as requested by the WTC.
11. Repeat the cleaning process until the WTC deems the system acceptable.
12. Modify the systems per the construction documents/job scope.
13. Fill the system with fresh water. Meter the fill level to ascertain the new system volume.
14. Open/close automated valves as required to achieve flow in all areas.
 - a. The WTC shall work with the design engineer, controls contractor and the MC to develop a circulation plan that will ensure flow throughout the facility. In variable volume systems, the pumping system is not designed to operate the entire system at design flow. A coordinated isolation plan is required to circulate the system in sections.
 - b. The system should be operated as close to 10 ft/sec as possible during the cleaning and flushing operations.
 - c. Install all piping main bypasses as required to facilitate cleaning.
15. Enable the pumps, and circulate the system for a length of time to be determined by the WTC. The circulation cycle time will vary greatly depending on flow, system size and isolation strategy.
16. Flush the system with fresh water for time period as directed by WTC.
17. Remove all startup and existing strainers from the system, clean, and reinstall. This includes strainers at pumps, terminal devices, fill points, etc.
18. Purge the dirt separator (if not connected directly to side stream filter), and replace the side stream filter bag.
19. Fill the system to new operating pressure as defined by Design Engineer and chemically clean the system as directed by the WTC.
20. Perform additional strainer cleanings in the defined systems as requested by the WTC.
21. Repeat the cleaning process until the WTC deems the system acceptable.
22. Remove all startup strainers from the system, and replace with the specified operational strainer. This includes strainers at pumps, terminal devices, fill points, etc.
23. Refill system to operating pressure, WTC shall treat the system for normal operation.
24. Provide test reports of system water quality to the owner for verification.

E. The WTC shall:

1. Develop an approved cleaning and treatment plan in coordination with the MC and the BAS contractor.
2. Utilizing labor provided by the MC as needed, flush and chemically clean the defined hydronic systems as required to obtain completely clean and scale free internal piping surfaces.
 - a. Criteria for system acceptance:
 - 1) Acceptable water test results within defined ranges from the main pump location.
 - 2) Acceptable water test results within defined ranges from remote areas in quantities and locations defined by the WTC and PSU.
3. After system cleaning is complete, provide water treatment as needed to allow the loop water quality parameters to fall within the ranges as.
4. Maintain hydronic water system testing and treatment throughout the warranty period of (1) year after project acceptance.
5. Provide a project closeout report and ongoing maintenance plan to the owner
 - a. Domestic water test results
 - b. Initial startup water test results
 - c. Monthly water test results during warranty operation
 - d. System maintenance schedule
 - e. Final water test results at end of warranty period
6. At [four] week intervals following Substantial Completion, perform separate water analyses on hydronic systems to show that chemical treatment program is maintaining water quality within performance requirements specified in this Section. WTC shall schedule the monthly testing with the owner representatives. Submit written reports of water analysis advising Owner of changes.

3.012 SLEEVE INSTALLATION

- A. General Requirements: Install sleeves for all pipes and tubes passing through penetrations in floors, partitions, roofs, and walls.
- B. Sleeves are not required for core-drilled holes.
- C. Cut sleeves to length for mounting flush with both surfaces unless otherwise indicated.
- D. Install sleeves in new partitions, slabs, and walls as they are built.
- E. For interior wall penetrations, seal annular space between sleeve and pipe or pipe insulation using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
- F. For exterior wall penetrations above grade, seal annular space between sleeve and pipe using joint sealants appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants" for joint sealants.
- G. For exterior wall penetrations below grade, seal annular space between sleeve and pipe using sleeve seals specified in this Section.
- H. Seal space outside of sleeves in concrete slabs and walls with grout.
- I. Install sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation unless otherwise indicated.
- J. Install sleeve materials according to the following applications:
 - 1. Sleeves for Piping Passing through Concrete Floor Slabs: Steel pipe.
 - 2. Sleeves for Piping Passing through Concrete Floor Slabs of Mechanical Equipment Areas or Other Wet Areas: Steel pipe or stack sleeve fittings.
 - a. Extend sleeves 2 inches above finished floor level.
 - b. For pipes penetrating floors with membrane waterproofing, extend cast-iron sleeve fittings below floor slab as required to secure clamping ring if ring is specified. 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.
 - 3. Sleeves for Piping Passing through Gypsum-Board Partitions:
 - a. Galvanized-steel sheet sleeves for pipes NPS 6 and larger.
 - b. Exception: Sleeves are not required for water supply tubes and waste pipes for individual plumbing fixtures if escutcheons will cover openings.
 - 4. Sleeves for Piping Passing through Concrete Roof Slabs: Steel pipe.
 - 5. Sleeves for Piping Passing through Exterior Concrete Walls:
 - a. Steel pipe sleeves for pipes smaller than NPS 6 (DN 150).
 - b. Cast-iron wall pipe sleeves for pipes NPS 6 and larger.
 - c. Install sleeves that are large enough to provide 1-inch annular clear space between sleeve and pipe or pipe insulation when sleeve seals are used.
 - 6. Sleeves for Piping Passing through Interior Concrete Walls:

- a. Steel pipe sleeves for pipes smaller than NPS 6.
- K. 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" for firestop materials and installations.

3.013 SLEEVE SEAL INSTALLATION

- A. Install sleeve seals in sleeves in exterior concrete walls at water-service piping entries into building.
- B. Select type and number of sealing elements required for pipe material and size. Position pipe in center of sleeve. Assemble sleeve seal components and install in annular space between pipe and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.014 IDENTIFICATION

- A. Identify system components. Comply with requirements in Division 22 Section "Identification for Plumbing Piping and Equipment" for identification materials and installation.
- B. Label pressure piping with system operating pressure.

3.015 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. 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.
 - 4. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.
 - 5. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens. Notify the Owner and Engineer one week prior to performing flushing procedures such that procedures can be witnessed.
 - 6. Prepare a written report of flushing procedures indicating the date of flushing and signed by the person performing the procedures validating it has been completed.
- B. Perform the following tests on hydronic piping:
 - 1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
 - 2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
 - 3. Isolate expansion tanks and determine that hydronic system is full of water.
 - 4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix A in ASME B31.9, "Building Services Piping."

5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
 6. Prepare written report of testing indicating the date of testing, the specific procedures and test pressures, and signed by the person performing the work. Submit the report to the Engineer.
 7. Provide at the Engineer's discretion a water quality test by an independent agency to validate flushing procedures have been completed and the chemical treatment has been completed to maintain water quality within the specified ranges.
- C. Perform the following before operating the system:
1. Open manual valves fully.
 2. Inspect pumps for proper rotation.
 3. Set makeup pressure-reducing valves for required system pressure.
 4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
 5. Set temperature controls so all coils are calling for full flow.
 6. Inspect and set operating temperatures of hydronic equipment, such as boilers, chillers, cooling towers, to specified values.
 7. Verify lubrication of motors and bearings.

END OF SECTION 23 21 13

SECTION 23 21 23

HYDRONIC 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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Separately coupled, horizontal, in-line centrifugal pumps.

1.03 DEFINITIONS

- A. Buna-N: Nitrile rubber.
- B. EPT: Ethylene propylene terpolymer.

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- C. Shop Drawings: Show pump layout and connections. Include setting drawings with templates for installing foundation and anchor bolts and other anchorages.
 - 1. Wiring Diagrams: Power, signal, and control wiring.
- D. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain hydronic pumps through one source from a single manufacturer.
- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. UL Compliance: Comply with UL 778 for motor-operated water pumps.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

- B. Store pumps in dry location.
- C. Retain protective covers for flanges and protective coatings during storage
- D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.
- E. Comply with pump manufacturer's written rigging instructions.

1.07 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.

1.08 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. Mechanical Seals: One mechanical seal for each pump.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 1. Inline Pumps
 - a. Armstrong Pumps Inc.
 - b. Bell & Gossett; Div. of ITT Industries.
 - c. Patterson
 - d. Taco, Inc.
 - e. Grundfos

2.02 SEPARATELY COUPLED, HORIZONTAL, IN-LINE CENTRIFUGAL PUMPS

- A. Description: Factory-assembled and -tested, centrifugal, overhung-impeller, separately coupled, in-line pump as defined in HI 1.1-1.2 and HI 1.3; designed for installation with pump and motor shafts mounted horizontally. Rate pump for 175-psig minimum working pressure and a continuous water temperature of 225 deg F.
- B. Pump Construction:
 - 1. Casing: Radially split, cast iron, with threaded gage tappings at inlet and outlet, and threaded companion-flange connections.
 - 2. Impeller: ASTM B 584, cast bronze; statically and dynamically balanced, and keyed to shaft. Trim impeller to match specified performance.
 - 3. Pump Shaft: Stainless steel.
 - 4. Mechanical Seal: Carbon rotating ring against a ceramic seat held by a stainless-steel spring, and Buna-N bellows and gasket. Include water slinger on shaft between motor and seal.
 - 5. Pump Bearings: Permanently lubricated ball bearings.

- C. Shaft Coupling: Molded rubber insert with interlocking spider capable of absorbing vibration.
- D. Motor: Single speed, with permanently lubricated ball bearings, unless otherwise indicated; and resiliently mounted to pump casing. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."

2.03 VIBRATION ISOLATION AND SEISMIC CONTROL

- A. Provide concrete inertial bases with open spring isolators for all base mounted and end mounted suction pumps.
- B. Provide open spring isolator with minimum deflection of 1.5 inch for in-line pumps.
 - 1. Springs: All springs shall have a minimum additional travel to solid equal to 50% of the rated deflection. All springs except internal nested springs shall have an outside diameter not less than 0.8 of the compressed height of the spring. Ends of springs shall be square and ground for stability. Laterally stable springs shall have k_x/k_y ratios of at least 0.9. All springs shall be fully color-coded to indicate capacity – color striping is not considered adequate.
 - 2. Corrosion Protection: All springs shall be powder-coated enamel. Housings shall be galvanized, powder-coated enamel, or painted with rust-resistant paint. Hot-dipped galvanized housings shall be provided as indicated on the Schedule.
 - 3. Steel Equipment Base: Bases shall be of welded construction with cross members to form an integral support platform. Structural steel members shall be designed to match supported equipment.
 - 4. Vibration bases for fans shall have adjustable motor slide rails as indicated on their Schedule, and shall accommodate motor overhang.
 - 5. Bases for exterior use shall be painted or hot-dipped galvanized for complete corrosion resistance.
 - 6. Minimum clearance under steel equipment bases shall be 1”.
 - 7. Concrete Inertia Base: Inertia bases shall be of welded steel construction with concrete in-fill supplied by the installing contractor on site and shall incorporate reinforcing bars, spaced 12” maximum on centers each way.
 - 8. Inertia bases for pumps shall be of sufficient size to accommodate supports for pipe elbows at pump suction and discharge connections (if this information has been provided for configuration).
 - 9. Inertia bases for fans shall include motor slide rails as indicated on their Schedule.
 - 10. The weight of each inertia base shall be sufficient to lower the center of gravity to or below the isolator support plane.
 - 11. Inertia bases shall be a minimum of 6” thick.
 - 12. Spring Hangers: Vibration isolator hanger supports with steel springs and welded steel housings. The hanger bracket shall be designed to carry a 500% overload without failure and to allow a support rod misalignment through a 30-degree arc without metal-to-metal contact or other short circuit. Hangers serving lightweight loads 200 lbs and less may be exempt from this requirement.

2.04 PUMP SPECIALTY FITTINGS

- A. Suction Diffuser: Angle pattern, 175-psig pressure rating, cast-iron body and end cap, pump-inlet fitting; with bronze startup and bronze or stainless-steel permanent strainers; bronze or stainless-steel straightening vanes; drain plug; and factory-fabricated support.

- B. Grooved-End Suction Diffuser – Flanged outlet with grooved inlet connections, rated to 300 psi (2065 kPa). Ductile iron (ASTM A-536) body, 304 stainless steel frame and perforated sheet diffuser with 5/32" (4,0mm) diameter holes. Removable 20 mesh 304 stainless steel start-up pre-filter, outlets for pressure/temperature drain connections, and base support boss. Equal to Victaulic Series 731-G and W731-G.
- C. Triple-Duty Valve: Angle or straight pattern, 175-psig pressure rating, cast-iron body, pump-discharge fitting; with drain plug and bronze-fitted shutoff, balancing, and check valve features. Brass gage ports with integral check valve, and orifice for flow measurement.
- D. Tri-Service Valve Assembly: Combination shut-off, throttling and non-slam check valve.
 - 1. 2-1/2" through 12": Equal to Vic-300 MasterSeal butterfly valve with memory stop feature assembled with Series 716 (2-1/2" & 3") or Style 779 Venturi Check (4" – 12"). Series 779 check valve with venturi like taps for flow measurement. Working pressures to 300 psi (2065 kPa).

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine equipment foundations and anchor-bolt locations for compliance with requirements for installation tolerances and other conditions affecting performance of work.
- B. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation.
- C. Examine foundations and inertia bases for suitable conditions where pumps are to be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 PUMP INSTALLATION

- A. Comply with manufacturer's written instructions and guidelines.
- 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. Set base-mounted pumps on concrete foundation. Disconnect coupling before setting. Do not reconnect couplings until alignment procedure is complete.
 - 1. Support pump baseplate on rectangular metal blocks and shims, or on metal wedges with small taper, at points near foundation bolts to provide a gap of 3/4 to 1-1/2 inches between pump base and foundation for grouting.
 - 2. Adjust metal supports or wedges until pump and driver shafts are level. Check coupling faces and suction and discharge flanges of pump to verify that they are level and plumb.
- E. Automatic Condensate Pump Units: Install units for collecting condensate and extend to open drain.

3.03 ALIGNMENT

- A. Align pump and motor shafts and piping connections after setting on foundation, grout has been set and foundation bolts have been tightened, and piping connections have been made.
- B. Comply with pump and coupling manufacturers' written instructions.

- C. Adjust pump and motor shafts for angular and offset alignment by methods specified in HI 1.1-1.5, "Centrifugal Pumps for Nomenclature, Definitions, Application and Operation."
- D. After alignment is correct, tighten foundation bolts evenly but not too firmly. Completely fill baseplate with nonshrink, nonmetallic grout while metal blocks and shims or wedges are in place. After grout has cured, fully tighten foundation bolts.
- E. Grout pump mounting base full after piping is connected but before pump drive is aligned. After grouting, align pump drive shaft to 5 mils, even if pump is factory aligned, and conduct vibration test.

3.04 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Connect piping to pumps. Install valves that are same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles.
- E. Install check valve and throttling valve on discharge side of pumps.
- F. Install suction diffuser and shutoff valve on suction side of pumps.
- G. Install flexible connectors on suction and discharge sides of base-mounted pumps between pump casing and valves.
- H. Install pressure gages on pump suction and discharge, at integral pressure-gage tapping, or install single gage with multiple input selector valve.
- I. Install check valve and gate or ball valve on each condensate pump unit discharge.

3.05 STARTUP SERVICE

- A. Complete pump start-up procedures in accordance with the manufacturer's instructions and guidelines. At a minimum perform the following:
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Check piping connections for tightness.
 - 3. Clean strainers on suction piping.
 - 4. Perform the following startup checks for each pump before starting:
 - a. Verify bearing lubrication.
 - b. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
 - c. Verify that pump is rotating in the correct direction.
 - 5. Prime pump by opening suction valves and closing drains, and prepare pump for operation.
 - 6. Start motor.
 - 7. Open discharge valve slowly.

3.06 DEMONSTRATION

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

END OF SECTION 23 21 23

SECTION 23 23 00

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. This Section includes refrigerant piping used for air-conditioning applications.

1.03 PERFORMANCE REQUIREMENTS

- A. Line Test Pressure for Refrigerant R-134a:
 - 1. Suction Lines for Air-Conditioning Applications: 115 psig.
 - 2. Suction Lines for Heat-Pump Applications: 225 psig.
 - 3. Hot-Gas and Liquid Lines: 225 psig.
- B. Line Test Pressure for Refrigerant R-410A:
 - 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.

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of valve and refrigerant piping specialty indicated. Include pressure drop, based on manufacturer's test data, for the following:
 - 1. Thermostatic expansion valves.
 - 2. Solenoid valves.
 - 3. Hot-gas bypass valves.
 - 4. Filter dryers.
 - 5. Strainers.
 - 6. Pressure-regulating valves.

- C. Shop Drawings: 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. Show interface and spatial relationships between piping and equipment.
 - 1. Shop Drawing Scale: 1/4 inch equals 1 foot.
 - 2. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, double risers, specialties, and pipe and tube sizes to accommodate, as a minimum, equipment provided, elevation difference between compressor and evaporator, and length of piping to ensure proper operation and compliance with warranties of connected equipment.
- D. Welding certificates.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.05 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- C. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.06 PRODUCT STORAGE AND HANDLING

- A. Store piping in a clean and protected area with end caps in place to ensure that piping interior and exterior are clean when installed.

1.07 COORDINATION

- A. Coordinate size and location of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2: PRODUCTS

2.01 COPPER TUBE AND FITTINGS

- A. Copper Tube: ASTM B 280, Type ACR, ASTM B88, Type L or K.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Solder Filler Metals: ASTM B 32. Use 95-5 tin antimony or alloy HB solder to join copper socket fittings on copper pipe.
- E. Brazing Filler Metals: AWS A5.8.
- F. Flexible Connectors:
 - 1. Body: Tin-bronze bellows with woven, flexible, tinned-bronze-wire-reinforced protective jacket.
 - 2. End Connections: Socket ends.

3. Offset Performance: Capable of minimum 3/4-inch misalignment in minimum 7-inch- long assembly.
4. Pressure Rating: Factory test at minimum 500 psig.
5. Maximum Operating Temperature: 250 deg F.

2.02 VALVES AND SPECIALTIES

A. Diaphragm Packless Valves:

1. Body and Bonnet: Forged brass or cast bronze; globe design with straight-through or angle pattern.
2. Diaphragm: Phosphor bronze and stainless steel with stainless-steel spring.
3. Operator: Rising stem and hand wheel.
4. Seat: Nylon.
5. End Connections: Socket, union, or flanged.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

B. Packed-Angle Valves:

1. Body and Bonnet: Forged brass or cast bronze.
2. Packing: Molded stem, back seating, and replaceable under pressure.
3. Operator: Rising stem.
4. Seat: Nonrotating, self-aligning polytetrafluoroethylene.
5. Seal Cap: Forged-brass or valox hex cap.
6. End Connections: Socket, union, threaded, or flanged.
7. Working Pressure Rating: 500 psig.
8. Maximum Operating Temperature: 275 deg F.

C. Check Valves:

1. Body: Ductile iron, forged brass, or cast bronze; globe pattern.
2. Bonnet: Bolted ductile iron, forged brass, or cast bronze; or brass hex plug.
3. Piston: Removable polytetrafluoroethylene seat.
4. Closing Spring: Stainless steel.
5. Manual Opening Stem: Seal cap, plated-steel stem, and graphite seal.
6. End Connections: Socket, union, threaded, or flanged.
7. Maximum Opening Pressure: 0.50 psig.
8. Working Pressure Rating: 500 psig.
9. Maximum Operating Temperature: 275 deg F.

D. Service Valves:

1. Body: Forged brass with brass cap including key end to remove core.
2. Core: Removable ball-type check valve with stainless-steel spring.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Copper spring.
5. Working Pressure Rating: 500 psig.

E. Solenoid Valves: Comply with ARI 760 and UL 429; listed and labeled by an NRTL.

1. Body and Bonnet: Plated steel.
2. Solenoid Tube, Plunger, Closing Spring, and Seat Orifice: Stainless steel.
3. Seat: Polytetrafluoroethylene.
4. End Connections: Threaded.
5. Electrical: Molded, watertight coil in NEMA 250 enclosure of type required by location with 1/2-inch conduit adapter, and [24] [115] [208]-V ac coil.
6. Working Pressure Rating: 400 psig.
7. Maximum Operating Temperature: 240 deg F.
8. Manual operator.

- F. Safety Relief Valves: Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
1. Body and Bonnet: Ductile iron and steel, with neoprene O-ring seal.
 2. Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Seat Disc: Polytetrafluoroethylene.
 4. End Connections: Threaded.
 5. Working Pressure Rating: 400 psig.
 6. Maximum Operating Temperature: 240 deg F.
- G. Thermostatic Expansion Valves: Comply with ARI 750.
1. Body, Bonnet, and Seal Cap: Forged brass or steel.
 2. Diaphragm, Piston, Closing Spring, and Seat Insert: Stainless steel.
 3. Packing and Gaskets: Non-asbestos.
 4. Capillary and Bulb: Copper tubing filled with refrigerant charge.
 5. Suction Temperature: 40 deg F.
 6. Superheat: Adjustable.
 7. Reverse-flow option (for heat-pump applications).
 8. End Connections: Socket, flare, or threaded union.
 9. Working Pressure Rating: 700 psig.
- H. Straight-Type Strainers:
1. Body: Welded steel with corrosion-resistant coating.
 2. Screen: 100-mesh stainless steel.
 3. End Connections: Socket or flare.
 4. Working Pressure Rating: 500 psig.
 5. Maximum Operating Temperature: 275 deg F.
- I. Moisture/Liquid Indicators:
1. Body: Forged brass.
 2. Window: Replaceable, clear, fused glass window with indicating element protected by filter screen.
 3. Indicator: Color coded to show moisture content in ppm.
 4. Minimum Moisture Indicator Sensitivity: Indicate moisture above 60 ppm.
 5. End Connections: Socket or flare.
 6. Working Pressure Rating: 500 psig.
 7. Maximum Operating Temperature: 240 deg F.
- J. Replaceable-Core Filter Dryers: Comply with ARI 730.
1. Body and Cover: Painted-steel shell with ductile-iron cover, stainless-steel screws, and neoprene gaskets.
 2. Filter Media: 10 micron, pleated with integral end rings; stainless-steel support.
 3. Desiccant Media: Activated alumina.
 4. Designed for reverse flow (for heat-pump applications).
 5. End Connections: Socket.
 6. Access Ports: NPS 1/4 connections at entering and leaving sides for pressure differential measurement.
 7. Working Pressure Rating: 500 psig.
 8. Maximum Operating Temperature: 240 deg F.
- K. Receivers: Comply with ARI 495.
1. Comply with ASME Boiler and Pressure Vessel Code; listed and labeled by an NRTL.
 2. Comply with UL 207; listed and labeled by an NRTL.
 3. Body: Welded steel with corrosion-resistant coating.
 4. Tappings: Inlet, outlet, liquid level indicator, and safety relief valve.

5. End Connections: Socket or threaded.
6. Working Pressure Rating: 500 psig.
7. Maximum Operating Temperature: 275 deg F.

L. Liquid Accumulators: Comply with ARI 495.

1. Body: Welded steel with corrosion-resistant coating.
2. End Connections: Socket or threaded.
3. Working Pressure Rating: 500 psig.
4. Maximum Operating Temperature: 275 deg F.

2.03 REFRIGERANTS

- A. ASHRAE 34, R-134a: Tetrafluoroethane.
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3: EXECUTION

3.01 PIPING APPLICATIONS

- A. Suction Lines NPS 1-1/2 and smaller for Conventional Air-Conditioning Applications: Copper, Type ACR, annealed-temper tubing or Type L drawn temper tubing and wrought-copper fittings with brazed joints.
- B. Suction Lines NPS 2 to NPS 4 for Conventional Air-Conditioning Applications: Copper, Type L, drawn-temper tubing and wrought-copper fittings with brazed joints.
- C. Hot-Gas and Liquid Lines:
 1. NPS 1-1/2: Copper, Type ACR, annealed-temper tubing and wrought-copper fittings with brazed joints.
 2. NPS 2 to NPS 4: Copper, Type L, annealed- or drawn-temper tubing and wrought-copper fittings with brazed joints.
- D. Safety-Relief-Valve Discharge Piping: Copper, Type K, drawn-temper tubing and wrought-copper fittings with soldered joints.

3.02 VALVE AND SPECIALTY APPLICATIONS

- A. Install service valves for gage taps at inlet and outlet of hot-gas bypass valves and strainers if they are not an integral part of valves and strainers.
- B. Install a check valve at the compressor discharge and a liquid accumulator at the compressor suction connection.
- C. Except as otherwise indicated, install diaphragm packless valves on inlet and outlet side of filter dryers.
- D. Install a full-sized, three-valve bypass around filter dryers.
- E. Install solenoid valves upstream from each expansion valve and hot-gas bypass valve. Install solenoid valves in horizontal lines with coil at top. Solenoid valves shall be provided by, installed and wired by the mechanical contractor.

- F. Install thermostatic expansion valves as close as possible to distributors on evaporators.
 - 1. Install valve so diaphragm case is warmer than bulb.
 - 2. 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.
 - 3. If external equalizer lines are required, make connection where it will reflect suction-line pressure at bulb location.
- G. Install safety relief valves where required by ASME Boiler and Pressure Vessel Code. Pipe safety-relief-valve discharge line to outside according to ASHRAE 15.
- H. Install moisture/liquid indicators in liquid line at the inlet of the thermostatic expansion valve or at the inlet of the evaporator coil capillary tube.
- I. Install strainers upstream from and adjacent to the following unless they are furnished as an integral assembly for device being protected:
 - 1. Solenoid valves.
 - 2. Thermostatic expansion valves.
 - 3. Hot-gas bypass valves.
 - 4. Compressor.
- J. Install filter dryers in liquid line between compressor and thermostatic expansion valve.
- K. Install receivers sized to accommodate pump-down charge where recommended by the equipment manufacturer.
- L. Install flexible connectors at compressors.

3.03 PIPING INSTALLATION

- A. 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 Shop Drawings.
- B. Install refrigerant piping according to ASHRAE 15.
- 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 adjacent to machines to allow service and maintenance.
- G. Install piping free of sags and bends.
- H. Install fittings for changes in direction and branch connections.
- I. Select system components with pressure rating equal to or greater than system operating pressure.
- J. Refer to Division 23 Sections "Instrumentation and Control for HVAC" and "Sequence of Operation" for solenoid valve controllers, control wiring, and sequence of operation.
- K. Install piping as short and direct as possible, with a minimum number of joints, elbows, and fittings.

- L. Arrange piping to allow inspection and service of refrigeration equipment. Install valves and specialties in accessible locations to allow for service and inspection. Install access doors or panels as specified in Division 08 Section "Access Doors and Frames" if valves or equipment requiring maintenance is concealed behind finished surfaces.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Install refrigerant piping in rigid or flexible conduit in locations where exposed to mechanical injury.
- O. 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.
- P. When brazing or soldering, 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.
- Q. Install pipe sleeves at penetrations in exterior walls and floor assemblies.
- R. Seal penetrations through fire and smoke barriers according to Division 07 Section "Penetration Firestopping."
- S. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- T. Install sleeves through floors, walls, or ceilings, sized to permit installation of full-thickness insulation.
- U. Seal pipe penetrations through exterior walls according to Division 07 Section "Joint Sealants" for materials and methods.
- V. Identify refrigerant piping and valves according to Division 23 Section "Identification for HVAC Piping and Equipment."

3.04 PIPE JOINT CONSTRUCTION

- A. Ream ends of pipes and tubes and remove burrs. Bevel plain ends of steel pipe.
- B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.
- C. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Soldered Joints: Construct joints according to ASTM B 828 or CDA's "Copper Tube Handbook.
- E. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 1. Use Type BcuP, copper-phosphorus alloy for joining copper socket fittings with copper pipe.
 2. Use Type BA9, cadmium-free silver alloy for joining copper with bronze or steel.
- F. Threaded Joints: Thread steel pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:
 1. Apply appropriate tape or thread compound to external pipe threads unless dry-seal threading is specified.

2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Steel pipe can be threaded, but threaded joints must be seal brazed or seal welded.
- H. Welded Joints: Construct joints according to AWS D10.12/D10.12M.
- I. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

3.05 HANGERS AND SUPPORTS

- A. Comply with requirements in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment" for pipe hanger and support products and installation.
1. Vertical Piping: MSS Type 8 or 42, clamps.
 2. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel clevis hangers.
 3. Multiple, Straight, Horizontal Piping Runs: Field fabricated, heavy duty trapeze. Fabricate from steel shapes and rod diameters as required for loads per MSS SP-58 and MSS SP-69. Verify rod diameter with structural engineer for multiple pipe trapeze hangers.
- B. Support vertical piping and tubing at base and at each floor.
- C. Rod diameter may be reduced one size for double-rod hangers, to a minimum of 3/8 inch.
- D. Install supports for vertical copper tubing every 10 feet.
- E. Install supports for vertical steel piping every 15 feet.
- F. Install hangers for horizontal piping with the following minimum rod sizes and maximum spacing for trapeze type hangers with multiple rise runs of varying sizes. The hangers shall be spaced based upon the smallest diameter pipe.

Nom. Pipe Size – Inches	Steel Pipe Max. Span – Ft.	Copper Tube Max. Span – Ft.	Min. Rod Dia. - Inches
Up to 3/4"	4	4	3/8
1" to 2"	6	6	3/8
2 1/2" to 4"	6	6	1/2
5" and Greater	4	4	7/8

- G. Support piping and tubing not listed in this article according to MSS SP-69 and manufacturer's written instructions and prior approved spacing by the structural engineer.

3.06 FIELD QUALITY CONTROL

- 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 gage 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.

3.07 SYSTEM CHARGING

- A. Charge system using the following procedures:
 1. Install core in filter dryers after leak test but before evacuation.
 2. Evacuate entire refrigerant system with a vacuum pump to 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.

3.08 ADJUSTING

- A. Adjust thermostatic expansion valve to obtain proper evaporator superheat.
- B. Adjust high- and low-pressure switch settings to avoid short cycling in response to fluctuating suction pressure.
- C. Adjust set-point temperature of air-conditioning or chilled-water controllers to the system design temperature.
- D. Perform the following adjustments before operating the refrigeration system, according to manufacturer's written instructions:
 1. Open shutoff valves in condenser water circuit.
 2. Verify that compressor oil level is correct.
 3. Open compressor suction and discharge valves.
 4. Open refrigerant valves except bypass valves that are used for other purposes.
 5. Check open compressor-motor alignment and verify lubrication for motors and bearings.
- E. Replace core of replaceable filter dryer after system has been adjusted and after design flow rates and pressures are established.

END OF SECTION 23 23 00

SECTION 23 31 13

DUCTWORK

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 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 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.

- B. Related Sections:

1. Section 01 45 43 "Testing, Adjusting and Balancing" for testing, adjusting, and balancing requirements for metal ducts.
2. Division 23 Section "HVAC Casings" for factory- and field-fabricated casings for mechanical equipment.
3. Division 23 Section "Air Duct Accessories" for dampers, sound-control devices, duct-mounting access doors and panels, turning vanes, and flexible ducts.

1.04 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.

- 1. Static-Pressure Classes:

- a. Supply Ducts (non-variable air volume systems): 3-inch.
- b. Supply Ducts (Upstream from Air Terminal Units): 4 inch.
- c. Supply Ducts (Downstream from Air Terminal Units): 1 inch.
- d. Return Ducts (Negative Pressure): 2-inch wg.
- e. Exhaust Ducts (Negative Pressure): 2-inch wg.

1.05 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.

C. Shop Drawings

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.

D. Coordination Drawings: Refer to requirements in Section 23 05 00 "Common Work Results for HVAC."

E. Welding certificates.

F. Field quality-control reports.

1.06 QUALITY ASSURANCE

A. Welding Qualifications: Qualify procedures and personnel according to the following:

1. AWS D1.1/D1.1M, "Structural Welding Code - Steel," for hangers and supports.
2. AWS D1.2/D1.2M, "Structural Welding Code - Aluminum," for aluminum supports.
3. AWS D9.1M/D9.1, "Sheet Metal Welding Code," for duct joint and seam welding.

B. Leakage Tests: Perform tests as directed by the Testing Agent and submit reports.

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." and IECC-2012 Class A.

1. Transverse Joints in Ducts Larger Than 24 Inches in length or width: Flanged.

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." and IECC-2012 Class A

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." and IECC-2012 Class A. All rectangular ductwork elbows shall be fabricated with turning vanes.

2.02 SINGLE-WALL ROUND 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." and IECC-2012 Class A
 - 1. Transverse Joints in Ducts Larger Than 24 Inches in Diameter: Flanged.
- 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." and IECC-2012 Class A
 - 1. Fabricate round ducts larger than 30 inches in diameter with butt-welded longitudinal seams.
 - 2. Fabricate flat-oval ducts larger than 40 inches in width (major dimension) with butt-welded longitudinal seams.
- 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." and IECC-2012 Class A

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.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. PVC-Coated, Galvanized Sheet Steel: Comply with ASTM A 653/A 653M.
 - 1. Galvanized Coating Designation: G90.
 - 2. Minimum Thickness for Factory-Applied PVC Coating: 4 mils thick.
 - 3. Coating Materials: Acceptable to authorities having jurisdiction for use on ducts listed and labeled by an NRTL for compliance with UL 181, Class 1.
- D. Carbon-Steel Sheets: Comply with ASTM A 1008/A 1008M, with oiled, matte finish for exposed ducts.
- E. 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.

- F. Aluminum Sheets: Comply with ASTM B 209 Alloy 3003, H14 temper; with mill finish for concealed ducts, and standard, one-side bright finish for duct surfaces exposed to view.
- G. 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.
- H. 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 Ductwork Fabrication Schedules:

- A. All ductwork shall be constructed of at a minimum gauge as followings. All sheetmetal, unless specified otherwise, shall be the best grade, of gauge indicated below and complying with SMACNA HVAC Duct Construction Standards and applicable codes.

<u>Rectangular Duct Width</u>	<u>Round Duct Width</u>	<u>Low Pressure Gauge</u>	<u>Medium Pressure Gauge</u>
4" thru 30"	3" thru 26"	24	22
31" thru 54"	27" thru 36"	22	20
55" thru 84"	37" thru 50"	20	18
85" and above	51" thru 72"	18	16

- B. All panels over 12-inches wide or deep shall be cross-broken for strength.
- C. The Architect/Engineer reserves the right to require additional bracing at no additional cost to the Owner, if deemed necessary.

2.05 DUCT LINER

- A. Flexible Elastomeric Duct Liner: Preformed, cellular, closed-cell, sheet materials complying with ATSM E 84 and ASTM C 534 guidelines, Type II, Grade 1; and with NFPA 90A or NFPA 90B.
 - 1. Surface-Burning Characteristics: Maximum flame-spread index of 25 and maximum smoke-developed index of 50 when tested according to UL 723; certified by an NRTL.
 - 2. Closed cell foam, 0.27 BTU/in/Sq.ft at 75 deg F mean temperature.
 - 3. 1" thickness, 3 lb density.
 - 4. Shall meet minimum sound absorption coefficiency rating of .48 at 500 Hertz frequency.
 - 5. Shall not support microbial growth.
 - 6. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
 - a. Provide at all transfer ducts shown on the drawings.
 - b. Provide at all supply and return ductwork a minimum distance of 15 feet from the air handling and/or roof top unit unless addition length is shown on drawings. Supply and Return ductwork shall also be provided with external insulation per specification.
- 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 1-1/2-inch galvanized carbon-steel washer.

2. Insulation-Retaining Washers: Self-locking washers formed from 0.016-inch- thick stainless steel; with beveled edge sized as required to hold insulation securely in place but not less than 1-1/2 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.
 - c. Upstream edges of transverse joints in ducts where air velocities are higher than 2500 fpm or where indicated.
 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.

2.06 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.
- B. Two-Part Tape Sealing System:
1. Tape: Woven cotton fiber impregnated with mineral gypsum and modified acrylic/silicone activator to react exothermically with tape to form hard, durable, airtight seal.
 2. Tape Width: 4 inches.
 3. Sealant: Modified styrene acrylic.
 4. Water resistant.
 5. Mold and mildew resistant.
 6. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
 7. Service: Indoor and outdoor.
 8. Service Temperature: Minus 40 to plus 200 deg F.
 9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum.
- C. Water-Based Joint and Seam Sealant:
1. Application Method: Brush on.
 2. Solids Content: Minimum 65 percent.
 3. Shore A Hardness: Minimum 20.

4. Water resistant.
5. Mold and mildew resistant.
6. VOC: Maximum 75 g/L (less water).
7. Maximum Static-Pressure Class: 10-inch wg, positive and negative.
8. Service: Indoor or outdoor.
9. Substrate: Compatible with galvanized sheet steel (both PVC coated and bare), stainless steel, or aluminum sheets.

D. 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.

E. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.

F. Round Duct Joint O-Ring Seals:

1. Seal shall provide maximum leakage class of 3 cfm/100 sq. ft. at 1-inch wg and shall be rated for 10-inch wg static-pressure class, positive or negative.
2. EPDM O-ring to seal in concave bead in coupling or fitting spigot.
3. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.07 HANGERS AND SUPPORTS

A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Corrosive Environments: 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, "Rectangular Duct Hangers Minimum Size," and Table 4-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.

E. Steel Cables for Stainless-Steel Ducts: Stainless steel complying with ASTM A 492.

F. Steel Cable End Connections: Cadmium-plated steel assemblies with brackets, swivel, and bolts designed for duct hanger service; with an automatic-locking and clamping device.

G. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.

H. 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

A. Intermediate Reinforcement:

1. Galvanized-Steel Ducts: Galvanized steel.

2. Stainless-Steel Ducts: Galvanized steel.
 3. Aluminum Ducts: Aluminum or galvanized sheet steel coated with zinc chromate.
- B. Liner (all transfer air ducts and as noted on the plans):
1. Supply- and Return-Air Ducts: Closed Cell Foam, Type I, 1 inch thick unless otherwise noted on the plans.
 - a. Provide liner in all supply and return air ducts a minimum distance of 15 feet from all air handling / rooftop units.
 2. Transfer Ducts: Closed Cell Foam, Type I, 1 inch thick.
- C. Elbow Configuration:
1. Rectangular Duct: At a minimum Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Elbows."
 - a. Velocity 1000 fpm or Lower
 - 1) Radius Type RE 1 with minimum 0.5 radius-to-diameter ratio.
 - 2) Mitered Type RE 4 without vanes.
 - b. Velocity 1000 to 1500 fpm:
 - 1) Radius Type RE 1 with minimum 1.0 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 0.5 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 - c. Velocity 1500 fpm or Higher:
 - 1) Radius Type RE 1 with minimum 1.5 radius-to-diameter ratio.
 - 2) Radius Type RE 3 with minimum 1.0 radius-to-diameter ratio and two vanes.
 - 3) Mitered Type RE 2 with vanes complying with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-3, "Vanes and Vane Runners," and Figure 2-4, "Vane Support in Elbows."
 2. Round Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-3, "Round Duct Elbows."
 - a. Minimum Radius-to-Diameter Ratio and Elbow Segments: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 3-1, "Mitered Elbows." Elbows with less than 90-degree change of direction have proportionately fewer segments.
 - 1) Velocity 1000 fpm or Lower: 0.5 radius-to-diameter ratio and three segments for 90-degree elbow.
 - 2) Velocity 1000 to 1500 fpm: 1.0 radius-to-diameter ratio and four segments for 90-degree elbow.
 - 3) Velocity 1500 fpm or Higher: 1.5 radius-to-diameter ratio and five segments for 90-degree elbow.
 - b. Round Elbows, 12 Inches and Smaller in Diameter: Stamped or pleated.
 - c. Round Elbows, 14 Inches and Larger in Diameter: Welded.
- D. Branch Configuration:
1. Rectangular Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-6, "Branch Connections."
 - a. Rectangular Main to Rectangular Branch: 45-degree entry.

- b. Rectangular Main to Round Branch: Spin in.
2. Round and Flat Oval: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-4, "90 Degree Tees and Laterals," and Figure 3-5, "Conical Tees." Saddle taps are permitted in existing duct.
- a. Velocity 1000 fpm or Lower: 90-degree tap.
 - b. Velocity 1000 to 1500 fpm: Conical tap.
 - c. Velocity 1500 fpm or Higher: 45-degree lateral.

3.02 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 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 non-fire-rated interior partitions and exterior walls and are located above an enclosed ceiling area not exposed to view, cover the opening between the partition and duct or duct insulation with 22 gauge sheet metal flanges. Overlap openings on four sides by at least 1-1/2 inches.
- L. Where ducts pass through fire-rated interior partitions and exterior walls, install fire dampers. Comply with requirements in Division 23 Section "Air Duct Accessories" for fire and smoke dampers.
- M. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "Duct Cleanliness for New Construction Guidelines."

3.03 SEAM AND JOINT SEALING

- A. Seal duct seams and joints for duct static-pressure and leakage classes specified in "Performance Requirements" Article, according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements," and IECC-2012 Class A.

1. For static-pressure classes 1- and 1/2-inch wg, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," and IECC-2012 Seal Class A:
- B. Seal Classes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 1-2, "Standard Duct Sealing Requirements." and IECC-2012 Class A
1. For static-pressure classes 1- and 1/2-inch wg, comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," and IECC-2012 Class A:

3.04 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 4, "Hangers and Supports."
- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
1. Where practical, install concrete inserts before placing concrete.
 2. Install powder-actuated concrete fasteners after concrete is placed and completely cured.
 3. Use powder-actuated concrete fasteners for standard-weight aggregate concretes or for slabs more than 4 inches thick.
 4. Do not use powder-actuated concrete fasteners for lightweight-aggregate concretes or for slabs less than 4 inches thick.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 4-1, "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.
- D. Hangers Exposed to View: Threaded rod and angle or channel supports.
- E. Support vertical ducts with steel angles or channel secured to the sides of the duct with welds, bolts, sheet metal screws, or blind rivets; support at each floor and at a maximum intervals of 16 feet
- F. Install upper attachments to structures. Select and size upper attachments with pull-out, tension, and shear capacities appropriate for supported loads and building materials where used.

3.05 INSTALLATION OF DOUBLE WALL EXTERIOUR DUCTWORK

- A. Installation of the double wall exterior duct ducting system to be in strict accordance with manufacturer Installation Guide Lines.
- B. All ductwork shall be fabricated in accordance with methods as approved by manufacturer.
- C. Air Leakage
1. Ductwork system air leakage shall be in accordance with the requirements of the relevant jurisdiction. (Consult the DOE (US Department of Energy) ComCheck / ResCheck or the relevant authority for applicable codes / standards).
- D. SUPPORT
1. It shall be the responsibility of the installer to ensure that the ductwork system is properly and adequately supported. A number of support systems are approved for use by the manufacturer. It shall be the

responsibility of the installer to ensure that the chosen method of support is compatible with ductwork fabricated from the manufacturer.

2. Supports on straight runs of the ductwork System shall be positioned at center's not exceeding 10 ft for ductwork sections fabricated in 10 ft lengths, and 13 ft for ductwork sections fabricated in 13 ft lengths.
3. Additionally, ductwork shall be supported at changes of direction, at branch duct connections, tee fittings and etc.
4. All ductwork accessories such as dampers shall be independently supported.

E. HANGERS AND SUPPORTS

1. Hanger Materials: SMACNA Approved duct supports shall be utilized in accordance with SMACNA Standards for Phenolic Duct.
2. Penetration into the duct system duct is not permitted.
3. Trapeze and Riser Supports: Steel shapes complying with ASTM A 36/A 36M.
4. Exterior Duct Supports:
5. To meet all SMACNA and ASHRA requirements.
6. Supports to be installed on the outside finished duct System
7. Supports to be manufactured by PHP System/Design, Miro or Approved Equal.

F. STORAGE AND HANDLING

1. Care shall be exercised in the handling and transportation of ductwork sections in order to prevent physical damage.
2. All ductwork sections shall be stored under cover, clear of the ground or roof and protected from the weather and sunlight by an opaque and light colored waterproof material. In cases where the ductwork sections are to be stored for prolonged periods, the open ends of the ductwork sections shall be sealed with a polythene sheet or other suitable material to prevent the ingress of foreign matter.

3.06 CONNECTIONS

- A. Make connections to equipment with flexible connectors complying with Division 23 Section "Air Duct Accessories."
- B. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" for branch, outlet and inlet, and terminal unit connections.

3.07 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.

3.08 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." and most current IECC code
 2. Test the following systems:
 - a. Supply air.
 3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
 4. Test for leaks before insulation application.
 5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test entire system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure. Give seven days' advance notice for testing.
- C. Duct system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.

END OF SECTION 23 31 13

SECTION 23 33 00

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. Section Includes:

1. Backdraft and pressure relief dampers.
2. Barometric relief dampers.
3. Manual volume dampers.
4. Control dampers.
5. Combination fire and smoke dampers.
6. Flange connectors.
7. Duct silencers.
8. Turning vanes.
9. Remote damper operators.
10. Duct-mounted access doors.
11. Flexible connectors.
12. Flexible ducts.
13. Duct accessory hardware.

- B. Related Sections:

1. Division 23 Section "Air Handling" for roof-mounted ventilator caps.
2. Division 28 Section "Fire Detection and Alarm" for duct-mounted fire and smoke detectors.

1.03 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.

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

1. For duct silencers, include pressure drop and dynamic insertion loss data. Include breakout noise calculations for high transmission loss casings.

- C. Shop Drawings: For duct accessories. Include plans, elevations, sections, details and attachments to other work.

1. Detail duct accessories fabrication and installation in ducts and other construction. Include dimensions, weights, loads, and required clearances; and method of field assembly into duct systems and other construction. Include the following:

- a. Special fittings.

- b. Manual volume damper installations.
 - c. Control damper installations.
 - d. Fire-damper, smoke-damper, combination fire- and smoke-damper, ceiling, and corridor damper installations, including sleeves; and duct-mounted access doors and remote damper operators.
 - e. Duct security bars.
- D. Coordination Drawings: Reflected ceiling plans, drawn to scale, on which ceiling-mounted access panels and access doors required for access to duct accessories are shown and coordinated with each other, using input from Installers of the items involved.
- E. Source quality-control reports.
- F. 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.
 - 2. Combination Fire/Smoke Damper: Provide material and installation costs for 5 extra fire/smoke dampers. Assume a damper size of 24 x 24. Damper sizes are to be field verified at locations required and ordered only after approval from the Engineer. At project close-out provide a credit of \$1,000 per damper for any and all unused dampers.

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.
 - 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 No. 4 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, 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 BACKDRAFT AND PRESSURE RELIEF DAMPERS

- A. Description: Gravity balanced.
- B. Maximum Air Velocity: 2000 fpm.
- C. Maximum System Pressure: 2-inch wg.
- D. Frame: 0.063-inch- thick extruded aluminum, with welded corners and mounting flange.
- E. Blades: Multiple single-piece blades, maximum 6-inch width, 0.050-inch- thick aluminum sheet with sealed edges.
- F. Blade Action: Parallel.
- G. Blade Seals: Extruded vinyl, mechanically locked or Neoprene, mechanically locked.
- H. Blade Axles:
 - 1. Material: Aluminum.
 - 2. Diameter: 0.20 inch.
- I. Tie Bars and Brackets: Aluminum.
- J. Return Spring: Adjustable tension.
- K. Bearings: Steel ball or synthetic pivot bushings.
- L. Accessories:
 - 1. Adjustment device to permit setting for varying differential static pressure.
 - 2. Counterweights and spring-assist kits for vertical airflow installations.
 - 3. Electric actuators.
 - 4. Chain pulls.
 - 5. Front of rear screens.
 - 6. 90-degree stops.
- M. Sleeve: Minimum 20-gage thickness.

2.03 BAROMETRIC RELIEF DAMPERS

- A. Suitable for horizontal or vertical mounting.
- B. Maximum Air Velocity: 2000 fpm.
- C. Maximum System Pressure: 2-inch wg.
- D. Frame: 0.063-inch- thick extruded aluminum, with welded corners and mounting flange.
- E. Blades:

1. Multiple, 0.050-inch- thick aluminum sheet.
 2. Maximum Width: 6 inches.
 3. Action: Parallel.
 4. Balance: Gravity.
 5. Eccentrically pivoted.
- F. Blade Seals: Vinyl or Neoprene.
- G. Blade Axles: Nonferrous metal.
- H. Tie Bars and Brackets:
1. Material: Aluminum.
 2. Rattle free with 90-degree stop.
- I. Return Spring: Adjustable tension.
- J. Bearings: Synthetic or Stainless steel.
- K. Accessories:
1. Flange on intake.
 2. Adjustment device to permit setting for varying differential static pressures.

2.04 MANUAL VOLUME DAMPERS

- A. Provide manual volume balancing dampers at all branch ductwork on the supply, return and exhaust systems where the duct branches are taken from another duct whether specifically shown on the plans or not and as required for balancing. Install minimum 2 duct widths from duct take-off.
- B. Provide manual volume balancing dampers at each branch duct serving a diffuser, register or grille, regardless of whether dampers are specified as part of the diffuser, grille or register assembly. Provide whether specifically shown on the plans or not.
- C. Standard, Steel, Manual Volume Dampers:
1. Standard leakage rating 20 cfm/sqft.
 2. Suitable for horizontal or vertical applications.
 3. Frames:
 - a. Hat-shaped, galvanized-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.
 4. 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.
 5. Blade Axles: Galvanized steel.
 6. Bearings:

- a. Oil-impregnated bronze or Molded synthetic.
 - 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.
 - 7. Tie Bars and Brackets: Galvanized steel.
- D. Standard, Aluminum, Manual Volume Dampers:
- 1. Standard leakage rating.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames: Hat-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Roll-Formed Aluminum Blades: 0.10-inch- thick aluminum sheet.
 - 5. Blade Axles: Stainless steel or Nonferrous metal.
 - 6. Bearings:
 - a. Oil-impregnated bronze or Molded synthetic.
 - 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.
 - 7. Tie Bars and Brackets: Aluminum.
- E. Low-Leakage, Steel, Manual Volume Dampers:
- 1. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage 20 cfm/ft.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames:
 - a. Hat, U or Angle shaped.
 - b. Galvanized-steel channels, 0.064 inch thick.
 - c. Mitered and welded corners.
 - d. Flanges for attaching to walls and flangeless frames for installing in ducts.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Stiffen damper blades for stability.
 - d. Galvanized, roll-formed steel, 0.064 inch thick.
 - 5. Blade Axles: Galvanized steel.
 - 6. Bearings:

- a. Oil-impregnated bronze or Molded synthetic.
 - 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.
 - 7. Blade Seals: Vinyl or Neoprene.
 - 8. Jamb Seals: Cambered aluminum.
 - 9. Tie Bars and Brackets: Galvanized steel.
 - 10. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- F. Low-Leakage, Aluminum, Manual Volume Dampers:
- 1. Low-leakage rating and bearing AMCA's Certified Ratings Seal for both air performance and air leakage 20 cfm/ft.
 - 2. Suitable for horizontal or vertical applications.
 - 3. Frames: Hat, U or Angle-shaped, 0.10-inch- thick, aluminum sheet channels; frames with flanges for attaching to walls and flangeless frames for installing in ducts.
 - 4. Blades:
 - a. Multiple or single blade.
 - b. Parallel- or opposed-blade design.
 - c. Extruded-Aluminum Blades: 0.050-inch- thick extruded aluminum.
 - 5. Blade Axles: Galvanized steel.
 - 6. Bearings:
 - a. Oil-impregnated bronze or Molded synthetic.
 - 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.
 - 7. Blade Seals: Vinyl or Neoprene.
 - 8. Jamb Seals: Cambered aluminum.
 - 9. Tie Bars and Brackets: Aluminum.
 - 10. Accessories:
 - a. Include locking device to hold single-blade dampers in a fixed position without vibration.
- G. Jackshaft:
- 1. Size: 1-inch diameter.
 - 2. Material: Galvanized-steel pipe rotating within pipe-bearing assembly mounted on supports at each mullion and at each end of multiple-damper assemblies.

3. Length and Number of Mountings: As required to connect linkage of each damper in multiple-damper assembly.

H. Damper Hardware:

1. Zinc-plated, die-cast core with dial and handle made of 3/32-inch- thick zinc-plated steel, and a 3/4-inch hexagon locking nut.
2. Include center hole to suit damper operating-rod size.
3. Include elevated platform for insulated duct mounting.

2.05 CONTROL DAMPERS

- A. Provide motorized dampers unless otherwise specified to be provided in Section 23 09 00 "Building Automation System."

- B. Low-leakage rating, and bearing AMCA's Certified Ratings Seal for both air performance and air leakage 4 cfm/ft.

C. Frames:

1. Hat, U or Angle shaped.
2. Galvanized-steel channels, 0.064 inch thick.
3. Mitered and welded corners.

D. Blades:

1. Multiple blade with maximum blade width of 8 inches.
2. Parallel- and opposed-blade design.
3. Galvanized steel.
4. 0.064 inch thick.
5. Blade Edging: Closed-cell neoprene edging.

- E. Blade Axles: 1/2-inch- diameter; galvanized steel; blade-linkage hardware of zinc-plated steel and brass; ends sealed against blade bearings.

1. Operating Temperature Range: From minus 40 to plus 200 deg F.

F. Bearings:

1. Oil-impregnated bronze or Molded synthetic.
2. 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.
3. Thrust bearings at each end of every blade.

2.06 COMBINATION FIRE AND SMOKE DAMPERS

- A. Type: Dynamic; rated and labeled according to UL 555 and UL 555S by an NRTL.

- B. Closing rating in ducts up to 4-inch wg static pressure class and minimum 2000-fpm velocity.

- C. Fire Rating: 1-1/2 hours unless otherwise indicated on the drawings.

- D. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners. Provide Type 304, stainless steel construction for dampers in corrosive environments

including all installations within aluminum duct or PVC coated construction. Confirm damper sizes and configuration prior to ordering dampers. Show all locations on the coordination drawings as required in Section 23 05 00.

- E. Heat-Responsive Device: Replaceable, 165 deg F rated, fusible links unless otherwise indicated on the drawings.
- F. Smoke Detectors shall be provided and wired by electrical and installed by the mechanical contractor.
- G. Frame: Multiple-blade type; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- H. Blades: Roll-formed, horizontal, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- I. Leakage: Class I unless indicated to be Class II on the drawings.
- J. Rated pressure and velocity to exceed design airflow conditions.
- K. Mounting Sleeve: Factory-installed, 0.052-inch- thick, galvanized sheet steel; length to suit wall or floor application with factory-furnished silicone caulking. Provide with Type 304 stainless steel sleeves where stainless steel dampers are indicated.
- L. Master control panel for use in dynamic smoke-management systems.
- M. Damper Motors: Two-position action.
- N. Comply with NEMA designation, temperature rating, service factor, enclosure type, and efficiency requirements for motors specified in Division 23 Section "Common Motor Requirements for HVAC Equipment."
 - 1. Motor Sizes: Minimum size as indicated. If not indicated, large enough so driven 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 23 Section "Instrumentation and Control for HVAC."
 - 3. Permanent-Split-Capacitor or Shaded-Pole Motors: With oil-immersed and sealed gear trains.
 - 4. Spring-Return Motors: Equip with an integral spiral-spring mechanism where indicated. Enclose entire spring mechanism in a removable housing designed for service or adjustments. Size for running torque rating of 150 in. x lbf and breakaway torque rating of 150 in. x lbf.
 - 5. Outdoor Motors and Motors in Outdoor-Air Intakes: Equip with O-ring gaskets designed to make motors weatherproof. Equip motors with internal heaters to permit normal operation at minus 40 deg F.
 - 6. Nonspring-Return Motors: For dampers larger than 25 sq. ft., size motor for running torque rating of 150 in. x lbf and breakaway torque rating of 300 in. x lbf.
 - 7. Electrical Connection: 115 V, single phase, 60 Hz.
- O. Accessories:
 - 1. Test and reset switches

2.7 DUCT SILENCERS

- A. General Requirements:

1. Factory fabricated.
 2. Fire-Performance Characteristics: Adhesives, sealants, packing materials, and accessory materials shall have flame-spread index not exceeding 25 and smoke-developed index not exceeding 50 when tested according to ASTM E 84.
- B. Shape:
1. Rectangular straight with splitters or baffles.
 2. Round straight with center bodies or pods.
 3. Rectangular elbow with splitters or baffles.
 4. Round elbow with center bodies or pods.
 5. Rectangular transitional with splitters or baffles.
- C. Rectangular Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel, 0.040 inch thick.
- D. Round Silencer Outer Casing: ASTM A 653/A 653M, G90, galvanized sheet steel.
1. Sheet Metal Thickness for Units up to 24 Inches in Diameter: 0.034 inch thick.
 2. Sheet Metal Thickness for Units 26 through 40 Inches in Diameter: 0.040 inch thick.
 3. Sheet Metal Thickness for Units 42 through 52 Inches in Diameter: 0.052 inch thick.
 4. Sheet Metal Thickness for Units 54 through 60 Inches in Diameter: 0.064 inch thick.
- E. Inner Casing and Baffles: ASTM A 653/A 653M, G90 galvanized sheet metal, 0.034 inch thick, and with 1/8-inch-diameter perforations.
- F. Special Construction:
1. Suitable for outdoor use.
 2. High transmission loss.
- G. Connection Sizes: Match connecting ductwork unless otherwise indicated.
- H. Principal Sound-Absorbing Mechanism:
1. Dissipative type with fill material.
 - a. Fill Material: Moisture proof insulation containing natural cotton fibers treated with an EPA registered, non-toxic borate solution, “flash dried” to actively inhibit the growth of mold, mildew, bacteria and fungi. Media shall not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC’s) that can off-gas and/or cause health concerns. Media shall be 100% recyclable. Media shall comply with UL181 and NFPA 90A. Insulation shall be packed with a minimum of 15% compression during silencer assembly. Media shall not cause or accelerate corrosion of aluminum or steel.
- I. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Do not use mechanical fasteners for unit assemblies.
1. Lock form and seal or continuously weld joints or Flange connections.
 2. Suspended Units: Factory-installed suspension hooks or lugs attached to frame in quantities and spaced to prevent deflection or distortion.
 3. Reinforcement: Cross or trapeze angles for rigid suspension.

J. Accessories:

1. Factory-installed end caps to prevent contamination during shipping.
2. Removable splitters.

K. Source Quality Control: Test according to ASTM E 477.

1. Record acoustic ratings, including dynamic insertion loss and generated-noise power levels with an airflow of at least 2000-fpm face velocity.

L. Capacities and Characteristics (Refer to drawings for attenuation requirements):

1. Configuration: Straight or 90-degree elbow as indicated on the drawings.
2. Shape: Rectangular or Round as indicated on the drawings
3. Attenuation Mechanism: Acoustical glass fiber with protective film liner.
4. Maximum Pressure Drop: 0.35-inch wg.
5. Casing:
 - a. Attenuation: Standard.
 - b. Outer Material: Galvanized steel.
 - c. Inner Material: Galvanized steel.

2.8 TURNING VANES

A. Turning vanes shall be installed in all rectangular elbows whether or not specifically shown on the drawings.

B. 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.

1. Acoustic Turning Vanes: Fabricate airfoil-shaped aluminum extrusions with perforated faces and fibrous-glass fill.

C. General Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-3, "Vaness and Vane Runners," and 2-4, "Vane Support in Elbows."

D. Vane Construction: Single wall for ducts up to 48 inches wide and double wall for larger dimensions.

2.9 REMOTE DAMPER OPERATORS

A. Description: Cable system designed for remote manual damper adjustment. Provide where indicated on the drawings.

B. Tubing: Brass.

C. Cable: Stainless steel.

D. Wall-Box Mounting: Recessed, 2 inches deep.

E. Wall-Box Cover-Plate Material: Stainless steel.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. Duct-Mounted Access Doors: Fabricate access panels according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible"; Figures 2-10, "Duct Access Doors and Panels," and 2-11, "Access Panels - 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.
 - d. Access Doors Larger Than 24 by 48 Inches: Four hinges and two compression latches with outside and inside handles.

2.11 DUCT ACCESS PANEL ASSEMBLIES

- A. Labeled according to UL 1978 by an NRTL for fire rated duct systems including kitchen exhaust systems.
- B. Panel and Frame: Minimum thickness 0.0528-inch carbon steel.
- C. Fasteners: Carbon steel. Panel fasteners shall not penetrate duct wall.
- D. Gasket: Comply with NFPA 96; grease-tight, high-temperature ceramic fiber, rated for minimum 2000 deg F.
- E. Minimum Pressure Rating: 10-inch wg, positive or negative.

2.12 FLEXIBLE CONNECTORS

- A. Materials: Flame-retardant or noncombustible fabrics.
- B. Coatings and Adhesives: Comply with UL 181, Class 1.
- C. Metal-Edged Connectors: Factory fabricated with a fabric strip 5-3/4 inches wide attached to 2 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.
- D. 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 deg F.
- E. Outdoor System, Flexible Connector Fabric: Glass fabric double coated with weatherproof, synthetic rubber resistant to UV rays and ozone.
 - 1. Minimum Weight: 24 oz./sq. yd..

2. Tensile Strength: 530 lbf/inch in the warp and 440 lbf/inch in the filling.
 3. Service Temperature: Minus 50 to plus 250 deg F.
- F. Thrust Limits: Combination coil spring and elastomeric insert with spring and insert in compression, and with a load stop. Include rod and angle-iron brackets for attaching to fan discharge and duct.
1. Frame: Steel, fabricated for connection to threaded rods and to allow for a maximum of 30 degrees of angular rod misalignment without binding or reducing isolation efficiency.
 2. Outdoor 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.
 7. Coil Spring: Factory set and field adjustable for a maximum of 1/4-inch movement at start and stop.

2.13 FLEXIBLE DUCTS

- A. Insulated, Flexible Duct: UL 181, Class 1, black polymer film supported by helically wound, spring-steel wire; fibrous-glass insulation; reinforced aluminized, polyethylene vapor-barrier film.
1. Pressure Rating: 10-inch wg positive and 2-inch wg negative.
 2. Maximum Air Velocity: 4000 fpm.
 3. Temperature Range: Minus 20 to plus 250 deg F.
 4. Minimum R-Value: R-6
 5. Flame spread < 25, Smoke developed < 50.
- B. Flexible Duct Connectors:
1. Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action in sizes 3 through 18 inches, to suit duct size.

2.14 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 backdraft 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. 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.
- E. Provide manual volume balancing dampers at all branch ductwork on the supply, return and exhaust systems where the duct branches are taken from another duct whether specifically shown on the plans or not and as required for balancing. Install minimum 2 duct widths from duct take-off.
- F. Provide manual volume balancing dampers at each branch duct serving a diffuser, register or grille, regardless of whether dampers are specified as part of the diffuser, grille or register assembly. Provide whether specifically shown on the plans or not.
 - 1. Coordinate subparagraphs below with Division 23 Section "Metal Ducts." Install steel volume dampers in steel ducts.
 - 2. Install aluminum volume dampers in aluminum ducts.
- G. Set dampers to fully open position before testing, adjusting, and balancing.
- H. Install test holes at fan inlets and outlets and elsewhere as indicated.
- I. Install fire and smoke dampers according to UL listing.
- J. Connect ducts to duct silencers rigidly.
- K. 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. Downstream from manual volume dampers, control dampers, turning vanes, and equipment.
 - 3. 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.
 - 4. At each change in direction and at maximum 50-foot spacing.
 - 5. Upstream of turning vanes.
 - 6. Elsewhere as indicated.
- L. Install access doors with swing against duct static pressure.
- M. Access Door Sizes:
 - 1. One-Hand or Inspection Access: 8 by 5 inches.
 - 2. Two-Hand Access: 12 by 6 inches.
 - 3. Head and Hand Access: 18 by 10 inches.
 - 4. Head and Shoulders Access: 21 by 14 inches.
 - 5. Body Access: 25 by 14 inches.
 - 6. Body plus Ladder Access: 25 by 17 inches.

- N. Label access doors according to Division 23 Section "Identification for HVAC Piping and Equipment" to indicate the purpose of access door.
- O. Install flexible connectors to connect ducts to equipment.
- P. For fans developing static pressures of 5-inch wg and more, cover flexible connectors with loaded vinyl sheet held in place with metal straps.
- Q. Connect supply diffusers and supply grilles to ducts directly with maximum 60-inch lengths of flexible duct clamped or strapped in place. Contractor to provide and field fabricate diffuser and/ grille plenum for duct connection as required.
- R. Connect return and exhaust grilles/registers to ducts directly with maximum 30-inch lengths of flexible duct clamped or strapped in place.
- S. Connect flexible ducts to metal ducts with adhesive plus sheet metal screws.
- T. Install duct test holes where required for testing and balancing purposes.
- U. Install thrust limits at centerline of thrust, symmetrical on both sides of equipment. Attach thrust limits at centerline of thrust and adjust to a maximum of 1/4-inch movement during start and stop of fans.

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, smoke, and combination fire and smoke dampers to verify full range of movement and verify that proper heat-response device is installed.
 - 4. Inspect turning vanes for proper and secure installation.
 - 5. Operate remote damper operators to verify full range of movement of operator and damper.

END OF SECTION 23 33 00

SECTION 23 34 16

AIR HANDLING

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. This Section includes the following:

1. Centrifugal roof ventilators.
2. In-line centrifugal fans.

1.03 PERFORMANCE REQUIREMENTS

- A. Project Altitude: Base fan-performance ratings on sea level.
- B. Operating Limits: Classify according to AMCA 99.

1.04 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and 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.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 1. Wiring Diagrams: Power, signal, and control wiring.
 2. Design Calculations: Calculate requirements for selecting vibration isolators and seismic restraints and for designing vibration isolation bases.
 3. Vibration Isolation Base Details: Detail fabrication, including anchorages and attachments to structure and to supported equipment. Include auxiliary motor slides and rails, and base weights.
- D. Coordination Drawings: Reflected ceiling plans and other details, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:

1. Roof framing and support members relative to duct penetrations.
 2. Ceiling suspension assembly members.
 3. Size and location of initial access modules for acoustical tile.
 4. Ceiling-mounted items including light fixtures, diffusers, grilles, speakers, sprinklers, access panels, and special moldings.
- E. Field quality-control test reports.
- F. Operation and Maintenance Data: For power ventilators 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. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal.
- C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.
- D. UL Standard: Power ventilators shall comply with UL 705.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering. Unit shall bear an engraved aluminum nameplate and shall be shipped in ISTA certified transit tested packaging.
- B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.
- C. Lift and support units with manufacturer's designated lifting or supporting points.

1.07 COORDINATION

- A. Coordinate size and location of structural-steel support members.
- B. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

1.08 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. Belts: One set(s) for each belt-driven unit.

PART 2: PRODUCTS

2.01 CENTRIFUGAL ROOF VENTILATORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Acme Engineering & Mfg. Corp.
 2. Aerovent; a Twin City Fan Company
 3. Greenheck.
 4. Loren Cook Company.
 5. Penn Ventilation.
 6. Twin City Fan and Blower Co.
- B. Description: Direct- or belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.
- C. Housing: Removable, spun-aluminum, dome top and outlet baffle; square, one-piece, aluminum base with venturi inlet cone A two piece top cap shall have stainless steel quick release latches to provide access into the motor compartment without the use of tools.
1. Upblast Units: Provide spun-aluminum discharge baffle to direct discharge air upward, with rain and snow drains.
 2. Hinged Subbase: Galvanized-steel hinged arrangement permitting service and maintenance.
- D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.
- E. Belt-Driven Drive Assembly: Resiliently mounted to housing, with the following features:
1. Fan Shaft: Turned, ground, and polished steel; keyed to wheel hub.
 2. Shaft Bearings: Permanently lubricated, permanently sealed, self-aligning ball bearings.
 3. Pulleys: Cast-iron, adjustable-pitch motor pulley.
 4. Fan and motor isolated from exhaust airstream.
- F. Accessories:
1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent. Provide on all direct drive fans and as noted on the drawings.
 2. Lifting lugs shall be provided to help prevent damage from improper lifting.
 3. Disconnect Switch: Nonfusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.
 4. Bird Screens: Removable, 1/2-inch mesh, aluminum or brass wire.
 5. Gravity Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
- G. Roof Curbs: Galvanized steel; 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 suit roof opening and fan base.
1. Configuration: Self-flashing without a cant strip, with mounting flange or built-in raised cant and mounting flange as required for roofing type.
 2. Overall Height: minimum 9.5 inches.

3. Sound Curb: Curb with sound-absorbing insulation matrix.
4. Pitch Mounting: Manufacture curb for roof slope.
5. Metal Liner: Galvanized steel.
6. Mounting Pedestal: Galvanized steel with removable access panel.
7. Vented Curb: Unlined with louvered vents in vertical sides.

2.02 IN-LINE CENTRIFUGAL FANS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 1. Acme Engineering & Mfg. Corp.
 2. Greenheck.
 3. Loren Cook Company.
 4. Penn Ventilation.
 5. Twin City Fan
- B. Description: In-line, direct or belt-driven centrifugal fans as indicated on the drawings, consisting of housing, wheel, outlet guide vanes, fan shaft, bearings, motor and disconnect switch, drive assembly, mounting brackets, and accessories.
- C. Housing: Split, spun aluminum with aluminum straightening vanes, inlet and outlet flanges, and support bracket adaptable to floor, side wall, or ceiling mounting.
- D. Direct-Driven Units: Motor mounted in airstream, factory wired to disconnect switch located on outside of fan housing.
- E. Belt-Driven Units: Motor mounted on adjustable base, with adjustable sheaves, enclosure around belts within fan housing, and lubricating tubes from fan bearings extended to outside of fan housing.
- F. Fan Wheels: Aluminum, airfoil blades welded to aluminum hub.
- G. Accessories:
 1. Variable-Speed Controller: Solid-state control to reduce speed from 100 to less than 50 percent. Provide on all direct drive fans and as noted on the drawings.
 2. Volume-Control Damper: Manually operated with quadrant lock, located in fan outlet.
 3. Companion Flanges: For inlet and outlet duct connections.
 4. Fan Guards: 1/2- by 1-inch mesh of galvanized steel in removable frame. Provide guard for inlet or outlet for units not connected to ductwork.
 5. Motor and Drive Cover (Belt Guard): Epoxy-coated steel.
 6. Vibration Isolators: Elastomeric hangers.

2.03 MOTORS

- A. Comply with requirements in Division 23 Section "Common Motor Requirements for HVAC Equipment."
- B. Enclosure Type: Totally enclosed, fan cooled.

2.04 SOURCE QUALITY CONTROL

- A. Sound-Power Level Ratings: Comply with 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. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

PART 3: EXECUTION

3.01 INSTALLATION

- A. Install power ventilators level and plumb.
- B. Support units using elastomeric mounts, restrained elastomeric mounts, spring isolators or restrained spring isolators having a static deflection of 1 inch.
- C. Install floor-mounting units on concrete bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- D. Install floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- E. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 07 Section "Roof Accessories" for installation of roof curbs.
- F. Ceiling Units: Suspend units from structure; use steel wire or metal straps.
- G. Support suspended units from structure using threaded steel rods and elastomeric hangers or spring hangers as specified having a static deflection of 1 inch.
- H. Install units with clearances for service and maintenance.
- I. Label units according to requirements specified in Division 23 Section "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 "Air Duct Accessories."
- B. Install ducts adjacent to power ventilators to allow service and maintenance.
- C. Label fans according to requirements specified in Division 23 Section "Identification for HVAC Piping and Equipment."

3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 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.
- B. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

3.04 ADJUSTING

- A. Adjust damper linkages for proper damper operation.
- B. Adjust belt tension.
- C. Refer to Division 1 Section "Testing, Adjusting, and Balancing" 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 centrifugal fans. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 23 34 16

SECTION 23 36 00

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. This Section includes the following:
 - 1. Single-duct air terminal units.

1.03 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of product indicated, include rated capacities, furnished specialties, sound-power ratings, and accessories.
- C. Shop Drawings: Detail equipment assemblies and indicate dimensions, required clearances, method of field assembly, components, and location and size of each field connection.
 - 1. Include a schedule showing unique model designation, room location, model number, size, and accessories furnished.
 - 2. Wiring Diagrams: Power, signal, and control wiring.
- D. Coordination Drawings: Refer to requirements in Section 23 05 00.
- E. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data" include the following:
 - 1. Instructions for resetting minimum and maximum air volumes.
 - 2. Instructions for adjusting software set points.

1.04 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, and dimensional requirements of air terminal units 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. 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 that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified.
 - 1. Manufacturers:
 - a. Envrio-Tec
 - b. Price Industries.
 - c. Titus.
 - d. Trane

2.02 SINGLE-DUCT AIR TERMINAL UNITS

- A. Configuration: Volume-damper assembly inside unit casing with control components located inside a protective metal shroud.
- B. Casing: 0.034-inch steel.
 - 1. Casing Lining: Adhesive attached, ½ inch thick, fiber free polyolefin 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 Outlet: S-slip and drive connections.
 - 4. Access: Removable panels for access to dampers, upstream of heating coils, and other parts requiring service, adjustment, or maintenance; with airtight gasket and quarter-turn latches.
- C. Regulator Assembly: Extruded-aluminum or galvanized-steel components; key damper blades onto shaft with nylon-fitted pivot points located inside unit casing.
 - 1. Factory-calibrated and field-adjustable assembly with shaft extension for connection to externally mounted control actuator.
- 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 open.
- E. Velocity Sensor: Provide multi-point, center averaging velocity sensor.
- F. Hot-Water Heating Coil: Copper tube, mechanically expanded into aluminum-plate fins; leak tested underwater to 200 psig; and factory installed.

- G. Electronic Controls: Factory install and wire the single-duct terminal unit controller and actuator assembly as furnished by the Division 23 Building Automation System Contractor. Coordinate required devliery schedule of materials to the factory.

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 level and plumb. Maintain sufficient clearance for normal service and maintenance.

3.02 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to air terminal units to allow service and maintenance.
- C. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, control valve, and union or flange; and to return with balancing valve and union or flange.
- D. Connect ducts to air terminal units according to Division 23 Section "Ductwork."
- E. Ground units with electric heating coils according to Division 26 Section "Grounding and Bonding for Electrical Systems."
- F. Connect wiring according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 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.

3.03 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:
 - 1. After installing air terminal units and after electrical circuitry has been energized, test for compliance with requirements.
 - 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.

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 and do the following:
 - a. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - b. Verify that controls and control enclosure are accessible.
 - c. Verify that control connections are complete.
 - d. Verify that nameplate and identification tag are visible.
 - e. Verify that controls respond to inputs as specified.

3.05 DEMONSTRATION

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

END OF SECTION 23 36 00

SECTION 23 37 13

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.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. Related Sections:
 - 1. Division 08 Section "Louvers and Vents" for fixed and adjustable louvers and wall vents, whether or not they are connected to ducts.
 - 2. Division 23 Section "Air Duct Accessories" for fire and smoke dampers and volume-control dampers not integral to diffusers, registers, and grilles.

1.03 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. 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.

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. Provide attic stock to the owner of two complete diffusers, grilles and/or registers of each type installed. Assume size of attached stock GRD's to be of the most common size (in quantity provided) for the project. Attic stock types and sizes should be identified separately on the shops drawings for final review by the engineer.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, provide products by one of the manufacturers specified:
 - 1. Anemostat
 - 2. Titus
 - 3. Price

4. Raymon Donco
5. Performance Air Products

2.02 CEILING AIR DIFFUSERS

- A. General: Except as otherwise indicated, provide manufacturer's standard ceiling air diffusers where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide ceiling air diffusers that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Ceiling Compatibility: Provide diffusers with border styles that are compatible with adjacent ceiling systems, and that are specifically manufactured to fit into ceiling module with accurate fit and adequate support. Refer to general construction drawings and specifications for types of ceiling systems which will contain each type of ceiling air diffuser.
- D. Types: Provide ceiling diffusers of type, capacity, and with accessories and finishes as listed on diffuser schedule. The following requirements shall apply to nomenclature indicated on schedule:
 1. Diffuser Faces:
 - a. Round: Round housing, core of concentric rings, round duct connection.
 - b. Square: Square housing, core of square concentric louvers, square or round duct connection.
 - c. Linear: Extruded aluminum continuous slot, single or multiple.
 2. Diffuser Mountings:
 - a. Lay-in: Diffuser housing sized to fit between ceiling exposed suspension tee bars and rest on top surface of tee bar.
 - b. Duct-mounted.
 3. Diffuser Patterns:
 - a. Fixed: Fixed position core with concentric rings or louvers for radial air flow around entire perimeter of diffuser.
 - b. Adjustable: Manual adjustable core with concentric rings or louvers, fully adjustable for horizontal to vertical air flow.
 4. Diffuser Dampers:
 - a. Provide only on diffusers located in an inaccessible ceiling system and/or where a branch duct manual balancing damper can not be installed.
 - 1) Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of diffuser.
 - 2) Integral: Combination volume control and pattern adjustment for linear diffusers.
 5. Diffuser Accessories:
 - a. Equalizing Deflectors: Adjustable parallel blades in frame for straightening air flow.
 - b. Blank-Off Baffles: Arc segments designed to fit into diffuser housing to divert air flow from impinging on obstruction, and to create directional pattern.
 - c. Operating Keys: Tools designed to fit through diffuser face and operate volume control device and/or pattern adjustment.

6. Diffuser Finishes:
 - a. White Enamel: Semi-gloss white enamel prime finish.

2.03 WALL REGISTERS AND GRILLES

- A. General: Except as otherwise indicated, provide manufacturer's standard wall registers and grilles where shown; of size, shape, capacity and type indicated; constructed of materials and components as indicated, and as required for complete installation.
- B. Performance: Provide wall registers and grilles that have, as minimum, temperature and velocity traverses, throw and drop, and noise criteria ratings for each size device as listed in manufacturer's current data.
- C. Wall Compatibility: Provide registers and grilles with border styles that are compatible with adjacent wall systems, and that are specifically manufactured to fit into wall construction with accurate fit and adequate support. Refer to general construction drawings and specifications for types of wall construction which will contain each type of wall register and grille.
- D. Types: Provide wall registers and grilles of type, capacity, and with accessories and finishes as listed on register and grille schedule. The following requirements shall apply to nomenclature indicated on schedule:
 1. Register and Grille Materials:
 - a. Steel Construction (ST): Manufacturer's standard stamped sheet steel frame and adjustable blades.
 - b. Aluminum Construction (AL): Manufacturer's standard extruded aluminum frame and adjustable blades.
 2. Register and Grille Faces:
 - a. Horizontal Straight Blades: Horizontal blades, individually adjustable, at manufacturer's standard spacing.
 - b. Vertical Straight Blades: Vertical blades, individually adjustable, at manufacturer's standard spacing.
 - c. Horizontal 45⁰ Fixed Blades: Horizontal blades, fixed at 45⁰, at manufacturer's standard spacing.
 3. Register and Grille Patterns:
 - a. Single Deflection: 1 set of blades in face.
 - b. Double Deflection: 2 sets of blades in face, rear set at 90⁰ to face set.
 4. Register and Grille Dampers:
 - a. Opposed Blade: Adjustable opposed blade damper assembly, key operated from face of register.
 5. Register and Grille Accessories:
 - a. Operating Keys: Tools designed to fit through register or grille face and operate volume control device and/or pattern adjustment.
 6. Register and Grille Finishes:
 - a. White Enamel: Semi-gloss white enamel prime finish.

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 37 13

SECTION 23 81 24

SPLIT SYSTEM AIR CONDITIONING UNIT

PART 1: GENERAL

1.01 RELATED DOCUMENTS

- A. The system shall consist of a wall mounted or ceiling mounted evaporator and direct expansion (DX), air-cooled, condensing unit. The outdoor unit is a horizontal discharge air variable speed condenser fan using a single phase power supply. The system shall have a self diagnostic function, 3-minute time delay mechanism and have a factory pre-charge of R-410A. The system shall have automatic restart capability after a power failure has occurred and a low voltage cut-off feature to prevent stalling during power supply issues. The system shall have a low ambient capability for -40 degF operation.
- B. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 01 Specification Sections, apply to this Section.

1.01 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.02 SUMMARY

- A. Section Includes:
 - 1. Ceiling/Wall-mounted mini split computer-room air conditioners.

1.03 SUBMITTALS

- A. Refer to specification section 23 05 00 for additional requirements.
- B. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- C. Shop Drawings:
 - 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.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: To include operation and maintenance manuals.

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. ASHRAE Compliance:
 - 1. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1

1.05 COORDINATION

- A. Coordinate layout and installation of unit with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.
- B. Coordinate sizes and locations of roof curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Subject to compliance with requirements, manufacturers offering products which may be incorporated in the Work include the following:
 - 1. Daikin
 - 2. Data Aire Inc
 - 3. Liebert Corporation

2.02 CEILING/WALL-MOUNTED UNITS

A. INDOOR UNIT

- 1. The indoor unit shall be factory assembled and pre-wired with all necessary electronic and refrigerant controls. Both liquid and suction lines must be individually insulated between the outdoor and indoor units.
- 2. Unit Cabinet:
 - a. The indoor unit shall have a white, “flat screen” finish.
 - b. The drain and refrigerant piping shall be accessible from six (6) positions for flexible installation (right side, right back, and right bottom; and left side, left back, and left bottom).
 - c. The cabinet shall be supplied with a mounting plate to be installed onto a wall for securely mounting the cabinet.
 - d. The cabinet includes an “intelligent-eye” motion sensor capable of setting back the set point temperature for energy savings. This feature may be disengaged on the wireless remote controller.
- 3. Fan:
 - a. The evaporator fan shall be an assembly consisting of a direct-driven fan by a single motor.
 - b. The fan shall be statically and dynamically balance and operate on a motor with permanent lubricated bearings.
 - c. An auto-swing louver for adjustable air flow both vertically and horizontally) is standard via the wireless remote control furnished with each system.
 - d. The indoor fan shall offer a choice of five speeds, plus quiet and auto settings.
- 4. Filter:
 - a. The return air filter provided will be a mildew proof, removable and washable filter.

5. Coil:

- a. The evaporator coil shall be a nonferrous, aluminum fin on copper tube heat exchanger.
- b. All tube joints shall be brazed with silver alloy or phoscopper.
- c. All coils will be factory pressure tested.
 1. A condensate pan shall be provided under the coil with a drain connection.

6. Electrical:

- a. The outdoor unit shall be powered with 208-230 volts, 1 phase, and 60 hertz power. The indoor unit shall receive 208-230 volt, 1 phase, 60 hertz power from the outdoor unit.

7. Control:

- a. The unit shall have a wireless remote infra-red controller capable to operate the system. It shall have Automatic Operation, Dry Operation and Fan Only Operation.
- b. The controller shall consist of an On/Off Power switch, Mode Selector, Silent Button (for outdoor unit), Fan Setting, Swing Louver, On/Off Timer Setting, Temperature Adjustment, "Intelligent Eye" sensor, Home Leave Operation, Powerful Operation.
 - i. On/Off switch power the system on or off mode.
 - ii. Mode selector shall operate the system in auto, cool, heat, fan or dry operation
 - iii. Silent operation shall lower the sound level of the outdoor unit by slowing the inverter driven fan speed.
 - iv. Fan setting shall provide five fan speeds.
 - v. Swing louver shall adjust the airflow (horizontal and vertical) blades.
 - vi. On/Off timer is used for automatically switching the unit on or off.
 - vii. Temperature adjustment allows for the increase or decrease of the desired temperature.
 - viii. Intelligent eye provides an infrared sensor which detects movement and adjusts the temperature by 3.6°F up or down depending on operating mode.
 - ix. Home leave operation allows you to record your favorite temperature and airflow setting and allow the system to set back by 3°F.
 - x. Powerful operation allows quick cool down or heating up in the desired space to achieve maximum desired temperature in the shortest allowable time period.
- c. The remote control shall perform Fault Diagnostic functions which may be system related, indoor unit or outdoor unit related depending on the fault code. Temperature range on the remote control shall be 64°F to 90°F in cooling mode and 50°F to 86°F in heating mode.
- d. The indoor unit microprocessor has the capability to receive and process commands via return air temperature and indoor coil temperature sensors enabled by commands from the remote control.

B. OUTDOOR UNIT

1. The outdoor unit shall be specifically matched to the corresponding indoor unit size. The outdoor unit shall be complete factory assembled and pre-wired with all necessary electronic and refrigerant controls.
2. Provide with code heater and crank case heater for -40degF low ambient operation.
3. Unit Cabinet:

- a. The cabinet shall be ivory white with a finished powder coated backed enamel paint.
4. Fan:
 - a. The fan shall be a direct drive, propeller type fan.
 - b. The motor shall be inverter drive, permanently lubricated type bearings, inherent.
 - c. The fan shall be capable of operating in “silent operation” which lowers the outdoor fan speed in either cool, heat or auto modes.
 - d. A fan guard is provided on the outdoor unit to prevent contact with fan operation.
 - e. Airflow shall be horizontal discharge.
5. Coil:
 - a. The outdoor coil shall be nonferrous construction with corrugated fin tube.
 - b. Refrigerant flow from the condenser will be controlled via a metering device.
6. Compressor:
 - a. The compressor shall be a rotary swing inverter-driven compressor.
 - b. The outdoor unit shall have an accumulator, four-way reversing valve.
 - c. The compressor shall have an internal thermal overload.
 - d. The outdoor unit can operate with a maximum vertical height difference of 66 feet and overall maximum length of 98 feet without any oil traps, liquid or suction line changes.
7. Electrical:
 - a. The electrical power requirement is 208-230 volt, 1-phase, and 60 Hz power.
 - b. The outdoor shall be controlled by a microprocessor located in the outdoor and indoor units via commands from the infrared remote controller.
8. Dedicated EEVs shall be provided for capacity control during part load of each connected indoor unit.

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 the Work.
- B. Examine walls, floors, and roofs for suitable conditions where air conditioners will be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Suspended Computer-Room Air Conditioners: Install using continuous-thread hanger rods and elastomeric hangers of size required to support weight of computer-room air conditioner.

1. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment." Fabricate brackets or supports as required.
 2. Comply with requirements for hangers and supports specified in Division 23 Section "Hangers and Supports for HVAC Piping and Equipment."
- B. Air-Cooled Refrigerant Condenser Mounting: Install using elastomeric pads. Comply with requirements for vibration isolation devices specified in Division 23 Section "Vibration and Seismic Controls for HVAC Piping and Equipment."
1. Minimum Deflection: 1 inch.

3.03 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to machine to allow service and maintenance.
- C. Water and Drainage Connections: Comply with applicable requirements in Division 22 Section "Domestic Water Piping." Provide adequate connections for water-cooled units, condensate drain, and humidifier flushing system.
- D. Refrigerant Piping: Comply with applicable requirements in Division 23 Section "Refrigerant Piping." Provide shutoff valves and piping.

3.04 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. 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.
- C. Tests and Inspections:
 1. Inspect for and remove shipping bolts, blocks, and tie-down straps.
 2. After installing computer-room air conditioners and after electrical circuitry has been energized, test for compliance with requirements.
 3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- D. Computer-room air conditioners will be considered defective if they do not pass tests and inspections.
- E. Prepare test and inspection reports.
- F. After startup service and performance test, change filters and flush humidifier.

3.05 ADJUSTING

- A. Adjust initial temperature and humidity set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

3.06 DEMONSTRATION AND TRAINING

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain computer-room air conditioners.

END OF SECTION 23 81 23

SECTION 23 82 33

HEATING TERMINAL UNITS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 ADDITIONAL REQUIREMENTS

- A. Refer to specification section 23 05 00 for additional equipment and project requirements.

1.03 SUMMARY

- A. This Section includes the following:

1. Finned tube radiation.
2. Cabinet heaters.

1.04 QUALITY ASSURANCE

- A. Codes and Standards:

1. I=B=R Compliance: Test and rate baseboard and finned tube radiation in accordance with I=B=R, provide published ratings bearing emblem of I=B=R.
2. ARI Compliance: Provide coil ratings in accordance with ARI Standard 410 "Forced-Circulation Air-Cooling and Air-Heating Coils".
3. ASHRAE Compliance: Test coils in accordance with ASHRAE Standard 33 "Methods of Testing Forced Circulation Air Cooling and Heating Coils".
4. ARI Compliance: Test and rate fan-coil units in accordance with ARI Standard 440 "Room Fan-Coil Air-Conditioners".
5. UL Compliance: Construct and install fan-coil units in compliance with UL 883 "Safety Standards for Fan Coil Units and Room Fan Heater Units.
6. ARI Compliance: Test and rate unit ventilators in accordance with ARI Standard 330 "Unit Ventilators".
7. UL Compliance: Provide electrical components for terminal units, which have been listed and labeled by UL.

1.05 SUBMITTALS

- A. Product Data: Submit manufacturer's specifications for terminal units showing dimensions, capacities, ratings, performance characteristics, gages and finishes of materials, and installation instructions.
- B. Shop Drawings: Submit assembly-type shop drawings showing unit dimensions, construction details, and field connection details.

- C. Wiring Diagrams submit manufacturer's electrical requirements for power supply wiring to terminal units. Submit manufacturer's ladder-type wiring diagrams for interlock and control wiring. Clearly differentiate between portions of wiring that are factory-installed and portions to be field-installed.
- D. Maintenance Data: Submit maintenance instructions, including lubrication instructions, filter replacement, motor and drive replacement, and spare parts lists. Include this data, product data, and shop drawings in maintenance manuals in accordance with requirements of Division 1.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Handle terminal units and components carefully to prevent damage, breaking, denting and scoring. Do not install damaged terminal units or components; replace with new.
- B. Store terminal units and components in clean dry place. Protect from weather, dirt, fumes, water, construction debris, and physical damage.
- C. Comply with Manufacturer's rigging and installation instructions for unloading terminal units, and moving them to final location.
- D. Deliver terminal units to job site tagged with label indicating project name, model number, unit number, and details of installation (i.e. room number orientation, etc.).

PART 2: PRODUCTS

2.01 FINNED TUBE RADIATION

- A. Manufacturers: Subject to compliance with requirements, manufacturers offering finned tube radiation which may be incorporated in the work include the following:
 - 1. Sterling Radiator, Div. of Reed National Corp.
 - 2. Trane (The) Co.
 - 3. Vulcan Radiator Co.
 - 4. Rittling.
 - 5. Dunham Bush.
 - 6. Sigma Corporation.
- B. General: Provide finned tube radiation of lengths and in locations as indicated, and of capacities, style, and having accessories as scheduled.
- C. Cabinets: Minimum 18-ga cold-rolled steel full backplate, minimum 16-ga front. Brace and reinforce front minimum of 4'-0" o.c. without visible fasteners.
- D. Elements: Copper tube and aluminum fins, with tube mechanically expanded into fin collars to eliminate noise and ensure durability and performance at scheduled ratings.
- E. Finish: Factory finished baked enamel, standard colors as selected by the Architect, on fronts and accessories.
- F. Accessories:
 - 1. End panels, inside and outside corners, and enclosure extensions.
 - 2. Access panels in front of valves, balancing cocks, and traps.
 - 3. Sill extensions.
 - 4. Mullion channels.
 - 5. Pilaster covers.

2.02 CABINET HEATERS

- A. Manufacturer: Subject to compliance with requirements, provide cabinet heaters of one of the following:
1. Airtherm Mfg. Co.
 2. Dunham-Bush, Inc.
 3. McQuay, Inc.
 4. Modine Mfgr. Co.
 5. Sterling Radiator Co.
 6. Rittling
- B. General: Provide cabinet heaters having cabinet sizes and in locations as indicated, and of capacities, style, and having accessories as scheduled. Include in basic unit chassis, coil, fanboard, fan wheels, housings, motor, motor starter switch and insulation.
- C. Coil Section Insulation: Comply with NFPA 90A or NFPA 90B. Unicellular polyethylene thermal plastic, preformed sheet insulation complying with ASTM C 534, Type II, except for density.
1. Thickness: 3/4 inch.
 2. Thermal Conductivity (k-Value): 0.24 Btu x in./h x sq. ft. at 75 deg F mean temperature.
 3. Fire-Hazard Classification: Maximum flame-spread index of 25 and smoke-developed index of 50 when tested according to ASTM C 411.
 4. Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A or NFPA 90B.
- D. Cabinet: Steel with baked-enamel finish with manufacturer's standard paint, in color selected by Architect, baked-enamel finish with manufacturer's custom paint, in color selected by Architect.
1. Vertical Unit, Exposed Front Panels: Minimum 0.0528-inch- thick, sheet steel, removable panels with channel-formed edges secured with tamperproof cam fasteners.
 2. Horizontal Unit, Exposed Bottom Panels: Minimum 0.0528-inch-thick, sheet steel, removable panels secured with tamperproof cam fasteners and safety chain.
 3. Recessing Flanges: Steel, finished to match cabinet.
 4. Control Access Door: Key operated.
 5. Base: Minimum 0.0528-inch- thick steel, finished to match cabinet, 6 inches high with leveling bolts.
 6. Extended Piping Compartment: 8-inch-wide piping end pocket.
 7. False Back: Minimum 0.0428-inch- thick steel, finished to match cabinet.
- E. Filters: Minimum arrestance according to ASHRAE 52.1 and a minimum efficiency reporting value (MERV) according to ASHRAE 52.2.
1. Glass Fiber Treated with Adhesive: 80 percent arrestance and 5 MERV.
- F. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering-water temperature of 220 deg F. Include manual air vent and drain.

G. Fan and Motor Board: Removable.

1. Fan: Forward curved, double width, centrifugal; directly connected to motor. Thermoplastic or 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 Division 23 Section "Common Motor Requirements for HVAC Equipment."
3. Wiring Terminations: Connect motor to chassis wiring with plug connection.

PART 3: EXECUTION

3.01 INSPECTION

- A. Examine areas and conditions under which terminal units are to be installed. Do not proceed with work until unsatisfactory conditions have been corrected in manner acceptable to Installer.

3.02 INSTALLATION OF FINNED TUBE RADIATION

- A. General: Install finned tube radiation as indicated, and in accordance with manufacturer's installation instructions.
- B. Center elements under windows. Where multiple windows occur over units, divide element into equal segments centered under each window.
- C. Install units level and plumb.
- D. Install enclosure continuously around corners, using outside and inside corner fittings.
- E. Join sections with splice plates and filler pieces to provide continuous enclosure.
- F. Install access doors for access to valves.
- G. Install enclosure continuously from wall to wall unless otherwise shown on the drawings.
- H. Terminate enclosures with manufacturer's end caps, except where enclosures are indicated to extend to adjoining walls.
- I. Install valves within reach of access door provided in enclosure.
- J. Install piping within pedestals for freestanding units.

3.03 INSTALLATION OF CABINET HEATERS

- A. General: Install cabinet heaters as indicated, and in accordance with manufacturer's installation instructions.
- B. Locate cabinet heaters as indicated, coordinate with other trades to assure correct recess size for recessed units.
- C. Install units plumb and level.
- D. Install piping as indicated.
- E. Protect units with protective covers during balance of construction.

3.04 CONNECTIONS

- A. Piping installation requirements are specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect hot-water units and components to piping according to Division 23 Section "Hydronic Piping."
 - 1. Install shutoff valves on inlet and outlet, and balancing valve on outlet.
- C. Connect steam units and components to piping according to Division 23 Section "Steam and Condensate Heating Piping."
 - 1. Install shutoff valve on inlet; install strainer, steam trap, and shutoff valve on outlet.
- D. Install control valves as required by Division 23 Section "Instrumentation and Control for HVAC."
- E. Install piping adjacent to convection heating units to allow service and maintenance.

3.05 ELECTRICAL WIRING

- A. General: Install electrical devices furnished by manufacturer but not specified to be factory-mounted. Furnish copy of manufacturer's wiring diagram submittal to Electric Installer.
 - 1. Verify that electrical wiring installation is in accordance with manufacturer's submittal and requirements of Division-26 sections. Do not proceed with equipment start-up until wiring installation is acceptable to equipment installer.

3.6 ADJUSTING AND CLEANING

- A. General: After construction is completed, including painting, clean unit exposed surfaces, vacuum clean terminal coils and inside of cabinets.
- B. Retouch any marred or scratched surfaces of factory-finished cabinets, using finish materials furnished by manufacturer.
- C. Install new filter units for terminals requiring it.

3.7 DEMONSTRATION AND TRAINING

- A. Provide demonstration and training for Owner's representative in accordance with Division 1 Section "Demonstration and Training."

END OF SECTION 23 82 33

SECTION 26 05 00

COMMON WORK RESULTS FOR ELECTRICAL

PART 1: GENERAL

1.01 ELECTRICAL SCOPE OF WORK

- A. The work included under the Electrical Scope of work shall consist of furnishing labor and materials necessary for the complete installation of electrical systems shown on the Contract Documents and as defined and described in the specifications.
- B. Include minor items which are obviously and reasonably necessary to complete the installation and usually included in similar work whether or not specifically mentioned in the Contract Documents.
- C. Provide coordination and documentation to the utility required for light fixture energy rebates. Copy owner CM, Architect and Engineer on communications and turn rebates over to the owner.
- D. Refer to Architectural & Mechanical plans for all phasing and Alternate bid requirements.
- E. Deviations due to a particular manufacturer's requirements shall be provided at no additional cost to the Owner.
- F. Where material quantities are shown, they are for the convenience of the Contractor only. The Contractor shall be responsible to verify all quantities and include as required for a complete installation.
- G. Coordinate with the Owner to provide temporary electrical services as required and coordinate their installation with the construction progress of this project. Coordinate exact requirements with the Owner and provide all components necessary for a complete and proper installation.
- H. Provide Coordination drawings and review with the mechanical and other trades to verify ceiling types, clearances above ceilings, ceiling mounted devices, required electrical clearances over electrical equipment, saw cutting of floors, heights of fintube and counters and routing of electrical within millwork.

1.02 RELATED DOCUMENTS

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

1.03 SUMMARY

- A. Section Includes:
 - 1. Electrical equipment coordination and installation.
 - 2. Sleeves for raceways and cables.

3. Sleeve seals.
4. Grout.
5. Common electrical installation requirements.

1.04 PERMITS, LICENSES AND FEES

- A. Provide both temporary and permanent permits and licenses required for the completion of the work on each of the two buildings included under this contract. Fees and expenses required to obtain such permits shall be paid for by the electrical contractor.
- B. Fees and all associated costs charged by utility companies for utility services shall be paid for by the owner.
- C. Provide inspections as requested by each contractor and as required by regulating agencies or where required by code. Include and pay all charges for inspection agencies and provide the Owner with a certificate of final inspection and approval by authority having jurisdiction.
- D. Refer to General Conditions for state and local sales tax requirements. If paid for by this contractor, provide records of these taxes to the Owner upon request.

1.05 REFERENCES

- A. Material and workmanship to comply with applicable codes. As a minimum, codes include all State and Federal laws, local ordinances, Utility Company regulations and requirements and interpretations of the following by the local authority having jurisdiction:
 - a. State and Local Building Codes.
 - b. State and Local Fire Codes.
 - c. National Electric Code.
 - d. State and Local Electric Codes.
 - e. OSHA Regulations.
- B. If drawings and specifications are in conflict with these codes, notify Engineer prior to rough-in.
- C. The following is a list of organizations and their abbreviations where referred to in the specifications as standards of construction.
 - a. ANSI - American National Standards Institute
 - b. ASHRAE - American Society of Heating, Refrigerating and Air Conditioning Engineers
 - c. ADA - Americans with Disabilities Act
 - d. ASTM - American Society for Testing and Materials
 - e. FM - Factory Mutual
 - f. IRI - Industrial Risk Insurance
 - g. IEEE - Institute of Electrical and Electronic Engineers
 - h. NBFU - National Board of Fire Underwriters
 - i. NBS - National Bureau of Standards

- j. NEC - National Electrical Code
- k. NEMA - National Electrical Manufacturers Association
- l. NFPA - National Fire Protection Association
- m. OSHA - Occupational Safety and Health Administration
- n. UL - Underwriters' Laboratories, Inc.
- o. Uniform Federal Accessibility Standards
- p. State Board of Health

1.06 DEFINITIONS

- A. EPDM: Ethylene-propylene-dieneterpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.
- C. Furnish: Obtain, coordinate, deliver to the job site and guarantee.
- D. Install: Furnished by others, received on site, unload, store, set in place, connect, place in operation and guarantee workmanship of installation.
- E. Provide: Furnish and install.
- F. Connect: Bring service to the equipment and make final attachments, including necessary disconnect switches, VFD's, control switches, outlets, etc...
- G. Conduit: In addition to conduit, includes all fittings, hangers, pull boxes, supports, etc, as required for a complete and proper installation.
- H. Concealed: Hidden from sight in walls, ceilings, or floors.
- I. Exposed: Surfaced mounted, not hidden from sight.
- J. Building: StructureColumns, beams, joists, walls. Metal decking, joist bridging shall not be used for supporting electrical equipment.

1.07 SUBMITTALS

- A. Product Data: For sleeve seals.

1.08 TEMPORARY ELECTRICAL SERVICES

- A. Provide and maintain a complete temporary electrical power service for use by all trades during construction.
- B. Refer to General Conditions for responsibilities for energy costs charges.
- C. Locate duplex receptacles throughout and on each floor so that any point within the construction area can be reached by a 100'-0" extension cord. Provide all duplex receptacles with GFCI protection.

- D. Any special service requirements, such as large heating loads, welders, three phase equipment, etc shall be paid for by the Contractor requiring such services.
- E. Provide and maintain a complete temporary electrical lighting service for use by all trades during construction.
- F. Provide adequate lighting suitable for conditions for high quality workmanship and for safety lighting throughout the areas of construction. Provide minimum requirements of one (1) 200 watt lighting fixture per each 400 square feet or per room.
- G. Provide and maintain an exit, egress and safety lighting system where required by code and OSHA.
- H. Provide and maintain electrical and telephone service to the construction trailers as defined under the General Conditions. Coordinate requirements with the Local Telephone service provider and with the Owner.

1.09 WARRANTY

- A. Provide guarantee and maintain the stability of workmanship and materials used and keep same in good operating condition for a period of one year after final completion of the work as evidenced by the issuance of the final certificate by the Architect.
- B. Correct any deficiencies/defects of any kind immediately and; at the Contractors expense due to faulty workmanship or materials that arise during the above mentioned period of time. Corrections shall be done to the satisfaction of the Engineer/Architect. Such reconstruction and/or repairs shall include damages to the finishes or the building resulting from the original defect.

1.010 COORDINATION

- A. Coordinate arrangement, mounting, and support of electrical equipment
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, etc will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2: PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

- 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
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3: EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRICAL INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electrical equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.
- F. Consult the Contract Drawings and Specifications of all other Divisions and other trades for correlating information and layout work so that it will not interfere with other trades. Verify all dimensions and conditions; i.e., finished ceiling types and heights, wall elevations, sections, footing and foundation elevations, beam depths, ductwork and piping, etc., with architectural, mechanical and structural drawings. If conflicts occur such that resolution is not possible by the affected trades on the job, the Engineer or Architect shall be notified and a resolution will be worked out. Where Work must be replaced due to failure to verify conditions existing on the job, such replacement shall be accomplished at no extra cost to Owner. This shall apply to shop fabricated Work as well as Work fabricated in place.

3.02 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Electrical penetrations occur when raceways, cables, wireways, cable trays, or busways penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry

1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.
- N. Provide a minimum of three (3) 3" conduit sleeves through each interior wall of all new IT/Data Rooms unless noted otherwise.

3.03 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.04 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electrical installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.05 PROTECTION

- A. Contractor shall be responsible for any damage of electrical equipment or materials and shall keep clean all materials installed by him until final acceptance of the entire building by the Owner. Contractor shall touch-up all equipment with chips or scratch marks.

- B. When a portion of the building is to be occupied by the Owner prior to Substantial Completion of the entire Project, arrangements will be made to transfer responsibility for protection and housekeeping tasks from the Contractor to the Owner.

3.06 CLEANING

- A. Keep the premises free from accumulations of waste materials or rubbish caused by execution of the Work. At the completion of the Work, remove all rubbish, tools, scaffolding and surplus materials from and about the premises. The premises shall be "broom-cleaned" or its equivalent, at the end of every working day, unless more exactly specified. In case of dispute, the Owner may remove the rubbish and charge the cost to the Contractor as the Engineer shall determine to be fair.

3.07 PAINTING

- A. Refinish electrical equipment damaged during shipping or installation to its original condition.
- B. Remove rust, prime, and paint per manufacturer's recommendations for finish equal to original.
- C. Do not paint nameplates, labels, tags, stainless steel or items such as shafts, levels, handles, trim or terminal strips

END OF SECTION 26 05 00

SECTION 26 05 19

ELECTRICAL POWER CONDUCTORS AND CABLES

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. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
 - 3. Sleeves and sleeve seals for cables.
- B. Related Sections include the following:
 - 1. Division 27 Section "Communications Horizontal Cabling" for cabling used for voice and data circuits.

1.03 DEFINITIONS

- A. EPDM: Ethylene-propylene-dieneterpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

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

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. Comply with NFPA 70.

1.06 COORDINATION

- A. Set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.

PART 2: PRODUCTS

2.01 CONDUCTORS AND CABLES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Alcan Products Corporation; Alcan Cable Division.
 - 2. American Insulated Wire Corp.; a Leviton Company.
 - 3. General Cable Corporation.
 - 4. Senator Wire & Cable Company.
 - 5. Southwire Company.
- B. Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70 for Types THW, THHN-THWN, XHHW.

2.02 CONNECTORS AND SPLICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Hubbell Power Systems, Inc.
 - 3. O-Z/Gedney; EGS Electrical Group LLC.
 - 4. 3M; Electrical Products Division.
 - 5. Tyco Electronics Corp.
- B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 SLEEVES FOR CABLES

- 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."

2.04 SLEEVE SEALS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Advance Products & Systems, Inc.
 - 2. Calpico, Inc.
 - 3. Metraflex Co.
 - 4. Pipeline Seal and Insulator, Inc.

- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
 - 1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 2. Pressure Plates: Plastic or Carbon steel. Include two for each sealing element.
 - 3. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

PART 3: EXECUTION

3.01 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Service Entrance: Type THHN-THWN, single conductors in raceway.
- B. Exposed Feeders: Type THHN-THWN, single conductors in raceway.
- C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway.
- D. Feeders Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.
- E. Exposed Branch Circuits, Including in Crawlspace: Type THHN-THWN, single conductors in raceway.
- F. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway.
- G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and underground: Type THHN-THWN, single conductors in raceway.
- H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- I. Lighting fixture whips not exceeding 12': Armored Cable (AC or MC) shall be allowed. No AC or MC cable with be allowed to cross the visible area between sections of ceilings and exposed areas for the architectural "Cloud" configuration. AC & MC cable is not allowed for receptacle or similar power connections.
- J. Class 1 Control Circuits: Type THHN-THWN, in raceway.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

- A. Conceal cables in finished walls, ceilings, and floors, unless otherwise indicated.
- B. 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.
- C. Use pulling means; including fish tape, cable, rope, and basket-weave wire/cable grips that will not damage cables or raceway.
- D. Install exposed cables parallel and perpendicular to surfaces of exposed structural members, and follow surface contours where possible.
- E. Support cables according to Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Identify and color-code conductors and cables according to Division 26 Section "Identification for Electrical Systems."

3.04 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 and UL 486B.
- B. Make splices and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches of slack.

3.05 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Rectangular Sleeve Minimum Metal Thickness:
 - 1. For sleeve rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 - 2. For sleeve rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- F. Cut sleeves to length for mounting flush with both wall surfaces.
- G. Extend sleeves installed in floors 4 inches (50 mm) above finished floor level.

- H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and cable unless sleeve seal is to be installed.
- I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and cable, using joint sealant appropriate for size, depth, and location of joint according to Division 07 Section "Sealants and Caulking."
- K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at cable penetrations. Install sleeves and seal with firestop materials according to Division 07 Section "Firestopping."
- L. Roof-Penetration Sleeves: Seal penetration of individual cables with flexible boot-type flashing units applied in coordination with roofing work.
- M. Aboveground Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Size sleeves to allow for 1-inch annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- N. Underground Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between cable and sleeve for installing mechanical sleeve seals.

3.06 SLEEVE-SEAL INSTALLATION

- A. Install to seal underground exterior-wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for cable material and size. Position cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.07 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly according to Division 07 Section "Firestopping."

END OF SECTION 26 05 19

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

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 methods and materials for extending the existing building grounding systems and equipment, plus the following special applications:
 - 1. Provide an extension of the existing building grounding system around the new building addition.
 - 2. In electrical service room #2, the existing grounding conductor to the water main is to be removed to accommodate new construction and the main water service is being relocated to Room G126. Provide a new grounding conductor for the main electrical service(s) in the lower level of area H to the new water main line as required with 33/0 ground conductor.

1.03 SUBMITTALS

- A. Product Data: For each type of product provided.
- B. Qualification Data: For testing agency and testing agencies field supervisor.
- C. Field quality-control test reports.
- D. Operation and Maintenance Data: For grounding to include the following in emergency, operation, and maintenance manuals:
 - 1. Instructions for periodic testing and inspection of grounding extension components.
 - a. Tests shall be to determine if ground resistance or impedance values remain within specified maximums, and instructions shall recommend corrective action if they do not.
 - b. Include recommended testing intervals.

1.04 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2: PRODUCTS

2.01 CONDUCTORS

- A. Insulated Conductors: Copper wire or cable insulated for 600 V unless otherwise required by applicable Code or authorities having jurisdiction.
- B. Bare Copper Conductors:
 - 1. Solid Conductors: ASTM B 3.
 - 2. Stranded Conductors: ASTM B 8.
 - 3. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, 1/4 inch (6 mm) in diameter.
 - 4. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 - 5. Bonding Jumper: Copper tape, braided conductors, terminated with copper ferrules; 1-5/8 inches (41 mm) wide and 1/16 inch (1.6 mm) thick.
- C. Bare Grounding Conductor and Conductor Protector for Wood Poles:
 - 1. No. 4 AWG minimum, soft-drawn copper.
 - 2. Conductor Protector: Half-round PVC or wood molding. If wood, use pressure-treated fir or cypress or cedar.
- D. Grounding Bus: Rectangular bars of annealed copper, ¼ thick by 2 inches by 6 inches, unless otherwise indicated; with insulators.

2.02 CONNECTORS

- A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.
- B. Bolted Connectors for Conductors and Pipes: Copper, bolted pressure-type, with at least two bolts
 - 1. Pipe Connectors: Clamp type, sized for pipe.
- C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad, Zinc-coated steel 3/4 inch by 10 feet (19 mm by 3 m) in diameter.
 - 1. Termination: Factory-attached No. 4/0 AWG bare conductor at least 48 inches (1200 mm) long.
 - 2. Backfill Material: Electrode manufacturers recommended material.

PART 3: EXECUTION

3.01 APPLICATIONS

- A. Conductors: Install solid conductor for No. 8 AWG and smaller and stranded conductors for No. 6 AWG and larger, unless otherwise indicated.
- B. Underground Grounding Conductors: Install bare copper conductor, No. 500 Kcmil AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
 - 2. Duct-Bank Grounding Conductor: Bury 12 inches (300 mm) above duct bank when indicated as part of duct-bank installation.
- C. Isolated Grounding Conductors: Green-colored insulation with continuous yellow stripe. On feeders with isolated ground, identify grounding conductor where visible to normal inspection, with alternating bands of green and yellow tape, with at least three bands of green and two bands of yellow.
- D. Grounding Bus: Install in electrical, data and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
 - 2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.
- E. Conductor Terminations and Connections:
 - 1. Pipe and Equipment Grounding Conductor Terminations: Bolted connectors.
 - 2. Underground Connections: Welded connectors except at test wells and as otherwise indicated.
 - 3. Connections to Ground Rods at Test Wells: Bolted connectors.
 - 4. Connections to Structural Steel: Welded connectors.

3.02 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits for motors.
- B. Install insulated equipment grounding conductors with the following items, in addition to those required by NFPA 70:
 - 1. Feeders and branch circuits.
 - 2. Single-phase motor and appliance branch circuits.
 - 3. Three-phase motor and appliance branch circuits.
 - 4. Flexible raceway runs.
 - 5. Armored and metal-clad cable runs, where allowed specifically by Engineer.
 - 6. Busway Supply Circuits: Install insulated equipment grounding conductor from grounding bus in the switchgear, switchboard, or distribution panel to equipment grounding bar terminal on busway.
 - 7. Computer and Rack-Mounted Electronic Equipment Circuits: Install insulated equipment grounding conductor in branch-circuit runs from equipment-area power panels and power-distribution units.
- C. Air-Duct Equipment Circuits: Install insulated equipment grounding conductor to duct-mounted electrical devices operating at 120 V and more, including air cleaners, heaters, dampers, humidifiers, and other duct electrical equipment. Bond conductor to each unit and to air duct and connected metallic piping.

- D. Water Heater, Heat-Tracing, and Antifrost Heating Cables: Install a separate insulated equipment grounding conductor to each electric water heater and heat-tracing cable. Bond conductor to heater units, piping, connected equipment, and components.
- E. Isolated Grounding Receptacle Circuits: Install an insulated equipment grounding conductor connected to the receptacle grounding terminal. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- F. Isolated Equipment Enclosure Circuits: For designated equipment supplied by a branch circuit or feeder, isolate equipment enclosure from supply circuit raceway with a nonmetallic raceway fitting listed for the purpose. Install fitting where raceway enters enclosure, and install a separate insulated equipment grounding conductor. Isolate conductor from raceway and from panelboard grounding terminals. Terminate at equipment grounding conductor terminal of the applicable derived system or service, unless otherwise indicated.
- G. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location
 - 1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
 - 2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.
- H. Metal and Wood Poles Supporting Outdoor Lighting Fixtures: Install grounding electrode and a separate insulated equipment grounding conductor in addition to grounding conductor installed with branch-circuit conductors.

3.03 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.
- 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 so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.
- C. Grounding and Bonding for Piping:
 - 1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes, using a bolted clamp

connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.

2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
 3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.
- D. Bonding Interior Metal Ducts: Bond metal air ducts to equipment grounding conductors of associated fans, blowers, electric heaters, and air cleaners. Install bonding jumper to bond across flexible duct connections to achieve continuity.
- E. Grounding for Steel Building Structure: Install a driven ground rod at base of each corner column and at intermediate exterior columns at distances not more than 60 feet (18 m) apart.
- F. Ground Ring: Install a grounding conductor, electrically connected to each building structure ground rod and to each steel column, extending around the perimeter of building.
1. Install tinned-copper conductor not less than No. 2/0 AWG for ground ring and for taps to building steel.
 2. Bury ground ring not less than 24 inches (600 mm) from building foundation.
- G. Ufer Ground (Concrete-Encased Grounding Electrode): Fabricate according to NFPA 70, using a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.
1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
 2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building grounding grid or to grounding electrode external to concrete.

3.04 FIELD QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing and inspecting agency to perform the following field tests and inspections and prepare test reports:
- B. Perform the following tests and inspections and prepare test reports:
1. After installing the extension of the existing building grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
 2. Test completed grounding system extension at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at individual ground rods. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance not less 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. Report measured ground resistances that exceed the following values:
 - 1. Power and Lighting Equipment or System with Capacity 500 kVA and less: 10 ohms.
 - 2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.
 - 3. Power and Lighting Equipment or System with Capacity More Than 1000 kVA: 3 ohms.
 - 4. Power Distribution Units or Panelboards Serving Electronic Equipment: 3 ohms.
 - 5. Substations and Pad-Mounted Equipment: 5 ohms.
- D. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Engineer promptly and include recommendations to reduce ground resistance.

END OF SECTION 26 05 26

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

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. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.

1.03 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.04 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.
- D. Components and installation shall comply with NFPA 70 (NEC) and shall be listed and labeled by U.L., ETL, CSA, or other nationally approved recognized testing and listing agencies that provide third party certification follow up services.

1.05 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

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 installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."

PART 2: PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. 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:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. ERICO International Corporation.
 - d. GS Metals Corp.
 - e. Thomas & Betts Corporation.
 - f. Unistrut; Tyco International, Ltd.
 - g. Kindorf
 - 2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 3. Nonmetallic Coatings: Manufacturer's standard PVC, polyurethane, or polyester coating applied according to MFMA-4.
 - 4. Painted Coatings: Manufacturer's standard painted coating applied according to MFMA-4.
 - 5. Channel Dimensions: Selected for applicable load criteria.
- B. Nonmetallic Slotted Support Systems: Structural-grade, factory-formed, glass-fiber-resin channels and angles with 9/16-inch- (14-mm-) diameter holes at a maximum of 8 inches (200 mm) o.c., in at least 1 surface.
 - 1. 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:
 - 2. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Allied Tube & Conduit.
 - b. Cooper B-Line, Inc.; a division of Cooper Industries.
 - c. Fabco Plastics Wholesale Limited.
 - d. Seasafe, Inc.

3. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 4. Rated Strength: Selected to suit applicable load criteria.
- C. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- D. Conduit and Cable Support Devices: Steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- E. Support for Conductors in Vertical Conduit: Factory-fabricated assembly consisting of threaded body and insulating wedging plug or plugs for non-armored electrical conductors or cables in riser conduits. Plugs shall have number, size, and shape of conductor gripping pieces as required to suit individual conductors or cables supported. Body shall be malleable iron.
- F. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized
- G. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:
1. Powder-Actuated Fasteners: Threaded-steel stud, for use in hardened Portland cement concrete, steel, or wood, with tension, shear, and pullout capacities appropriate for supported loads and building materials where used.
 - a. 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) Hilti Inc.
 - 2) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 3) MKT Fastening, LLC.
 - 4) Simpson Strong-Tie Co., Inc.; Masterset Fastening Systems Unit.
 2. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated steel, for use in hardened Portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.
 - a. 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) Cooper B-Line, Inc.; a division of Cooper Industries.
 - 2) Empire Tool and Manufacturing Co., Inc.
 - 3) Hilti Inc.

- 4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
 - 5) MKT Fastening, LLC.
3. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
 4. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
 5. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
 6. Toggle Bolts: All-steel springhead type.
 7. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3: EXECUTION

3.01 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be 1/4 inch (6 mm) in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.
- D. Spring-steel clamps designed for supporting single conduits without bolts may be used for 1-1/2-inch (38-mm) and smaller raceways serving branch circuits and communication systems above suspended ceilings and for fastening raceways to trapeze supports.

3.02 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.
- C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

- D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:
1. To Wood: Fasten with lag screws or through bolts.
 2. To New Concrete: Bolt to concrete inserts.
 3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
 4. To Existing Concrete: Expansion anchor fasteners.
 5. Instead of expansion anchors, powder-actuated driven threaded studs provided with lock washers and nuts may be used in existing standard-weight concrete 4 inches (100 mm) thick or greater. Do not use for anchorage to lightweight-aggregate concrete or for slabs less than 4 inches (100 mm) thick.
 6. To Steel: Welded threaded studs complying with AWS D1.1/D1.1M, with lock washers and nuts or Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69 or Spring-tension clamps.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate.
- E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 Section "Metal Fabrications" for site-fabricated metal supports
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.
- C. Field Welding: Comply with AWS D1.1/D1.1M.

3.04 CONCRETE BASES

- A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.
- B. Use 3000-psi (20.7-MPa) 28-day compressive-strength concrete. Concrete materials, reinforcement, and placement requirements are specified in Division 03 Section "Cast-in-Place Concrete".
- C. Anchor equipment to concrete base.
 1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 2. Install anchor bolts to elevations required for proper attachment to supported equipment.
 3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.
 - 1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).
- B. Touchup: Comply with requirements in Division 09 Painting Sections for cleaning and touchup painting of field welds, bolted connections, and abraded areas of shop paint on miscellaneous metal.
- C. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 26 05 29

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

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 raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

1.03 DEFINITIONS

- A. EMT: Electrical metallic tubing
- B. ENT: Electrical nonmetallic tubing.
- C. EPDM: Ethylene-propylene-dieneterpolymer rubber.
- D. FMC: Flexible metal conduit
- E. IMC: Intermediate metal conduit.
- F. LFMC: Liquidtight flexible metal conduit.
- G. LFNC: Liquidtight flexible nonmetallic conduit.
- H. NBR: Acrylonitrile-butadiene rubber.
- I. RNC: Rigid nonmetallic conduit.

1.04 SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.
- B. Coordination Drawings: Conduit routing plans, drawn to scale, on which the following items are shown and coordinated with each other, based on input from installers of the items involved:
 - 1. Structural members in the paths of conduit groups with common supports.
 - 2. HVAC and plumbing items and architectural features in the paths of conduit groups with common supports.

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. Comply with NFPA 70.

PART 2: PRODUCTS

2.01 METAL CONDUIT AND TUBING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. AFC Cable Systems, Inc.
 - 2. Alflex Inc.
 - 3. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 4. Anamet Electrical, Inc.; Anaconda Metal Hose.
 - 5. Electri-Flex Co.
 - 6. Manhattan/CDT/Cole-Flex.
 - 7. Maverick Tube Corporation.
 - 8. O-Z Gedney; a unit of General Signal.
 - 9. Wheatland Tube Company.
- B. Rigid Steel Conduit: ANSI C80.1.
- C. IMC: ANSI C80.6.
- D. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit IMC.
 - 1. Comply with NEMA RN 1.
 - 2. Coating Thickness: 0.040 inch, minimum.
- E. EMT: ANSI C80.3.
- F. FMC: Zinc-coated steel or aluminum.
- G. LFMC: Flexible steel conduit with PVC jacket.
- H. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.
 - 1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
 - 2. Fittings for EMT: Steel or die-cast, compression type.
 - 3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch, with overlapping sleeves protecting threaded joints.
- I. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

NONMETALLIC CONDUIT AND TUBING

- J. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. AFC Cable Systems, Inc.
 2. Anamet Electrical, Inc.; Anaconda Metal Hose.
 3. Arnco Corporation.
 4. CANTEX Inc.
 5. CertainTeed Corp.; Pipe & Plastics Group.
 6. Condux International, Inc.
 7. ElecSYS, Inc.
 8. Electri-Flex Co.
 9. Lamson & Sessions; Carlon Electrical Products.
 10. Manhattan/CDT/Cole-Flex.
 11. RACO; a Hubbell Company.
 12. Thomas & Betts Corporation.
- K. ENT: NEMA TC 13.
- L. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.
- M. LFNC: UL 1660.
- N. Fittings for ENT and RNC: NEMA TC 3; match to conduit or tubing type and material.
- O. Fittings for LFNC: UL 514B.

2.02 METAL WIREWAYS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Cooper B-Line, Inc.
 2. Hoffman.
 3. Square D; Schneider Electric.
- B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type as required, unless otherwise indicated.
- C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Hinged type.
- E. Finish: Manufacturer's standard enamel finish.

2.03 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
 2. EGS/Appleton Electric.
 3. Erickson Electrical Equipment Company.
 4. Hoffman.
 5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
 6. O-Z/Gedney; a unit of General Signal.
 7. RACO; a Hubbell Company.
 8. Robroy Industries, Inc.; Enclosure Division.
 9. Scott Fetzer Co.; Adalet Division.
 10. Spring City Electrical Manufacturing Company.
 11. Thomas & Betts Corporation.
 12. Walker Systems, Inc.; Wiremold Company (The).
 13. Woodhead, Daniel Company; Woodhead Industries, Inc. Subsidiary.
- B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.
- C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, aluminum, Type FD, with gasketed cover.
- D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.
- E. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- F. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, galvanized, cast iron with gasketed cover.
- G. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.
1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
- H. Cabinets:
1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 2. Hinged door in front cover with flush latch and concealed hinge.
 3. Key latch to match panelboards.
 4. Metal barriers to separate wiring of different systems and voltage.
 5. Accessory feet where required for freestanding equipment.

2.04 SLEEVES FOR RACEWAYS

- 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch thickness as indicated and of length to suit application.

- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."

2.05 SLEEVE SEALS

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following:
1. Easy-path 33 Series
 2. Equal
- B. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and cable.
1. Sealing Elements: EPDM interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 2. Pressure Plates: Carbon steel. Include two for each sealing element.
 3. All data, video, and communications cable routes shall utilize an enclosed fire-rated pathway device wherever said cables penetrate rated walls. The fire-rated pathway shall contain a built-in fire sealing system sufficient to maintain the hourly fire rating of the barrier being penetrated. The self-contained sealing system shall automatically adjust to the installed cable loading and shall permit cables to be installed, removed, or retrofitted without the need to remove or reinstall firestop materials. The pathway shall be UL Classified and/or FM Systems Approved and tested to the requirements of ASTM E814 (UL1479).
 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.06 FLOOR BOXES FOR CONCRETE FLOORS AND WOOD FLOORS

- A. Floor Boxes, General: Legrand RFB E Series Floor Boxes for use in on-grade concrete floors, raised floors or wood floors. Provide boxes with a component to permit installation in floors indicated on Architectural drawings. Boxes shall be compatible with complete line of connectivity outlets and modular inserts for devices indicated on the drawings.
1. Floor boxes provide the interface between power, communication and audio/video (A/V) cabling in above-grade floors, on-grade concrete floors, raised floors, wood floors, and fire-classified floors and the workstation or activation location where power and communication and/or A/V device outlets are required. Boxes shall provide recessed device outlets that will not obstruct the floor area. Refer to Drawings for size and types.
- B. Evolution 6CT Series Covers Round Covers: Manufactured of die-cast aluminum. Activation covers shall be flush versions. Provide covers with two gaskets - one for carpet and one for tile - to go under the trim flange to maintain scrub water tightness. Covers shall be round. Provide 6CFFTC Series furniture feed cover assembly for all furniture feed locations. Covers shall be available with a carpet recess area or a solid lid. Secure the cover to the flange and enable cover to rotate greater than 180 degrees to reduce trip hazards and provide maximum amount of working space. Provide covers with spring-loaded self-closing slide egress doors to reduce egress opening when cables are exiting and reduce trip hazards. Each of the two egress openings shall have a minimum of 2 sq inch (102 sq mm), or a minimum of 4 sq inch (203 sq mm) per cover assembly.

1. Powder Coat Finish:
 - a. Color: Black or as otherwise specified by architect

2.07 POKE-THRU SYSTEMS

C. Classification and Use: Poke-thru device use is limited by the UL Fire Resistance Directory to a minimum spacing of 2 feet (610 mm) on center and not more than one device per 65 square feet (6 square meters) of floor area in each span. Poke-thru devices must have been examined and tested by Underwriters Laboratories Inc. to comply with UL 514A and/or UL 514C, as applicable and tested to Canadian Standard C22.2 and bear the cULus mark. The poke-thru shall conform to the standards set in the National Electrical Code, Section 300-21.

1. Poke-thru device shall be for use in 1, 1-1/2, or 2-hour rated, unprotected reinforced concrete floors and 1, 1-1/2, or 2 hour rated floors employing unprotected steel floor units and concrete toppings (D900 Series designs), or concrete floors with suspended ceilings. Fire resistive designs with suspended ceilings shall have provisions for accessibility in the ceiling below the poke-thru device fittings.
2. Poke-thru devices must have been evaluated by UL to meet the applicable U.S. and Canadian safety standards for scrub water exclusion when used on tile, terrazzo, wood, and carpet covered floors.
3. Poke-thru device shall be suitable for use in air handling spaces in accordance with Section 300-22C of the National Electrical Code.

D. Recessed Poke-Thru Systems:

1. Acceptable Product: Evolution 6AFF Series Poke-Thru Devices by Wiremold.
2. This assembly consists of an insert and an activation cover. Overall poke-thru assembly length shall be 16-3/4 inches (425mm).
3. Insert: The insert body shall have the necessary channels to provide complete separation of power and communication services. There shall be two channels that allow for up to ten #10 AWG conductors in the power channel and twenty-eight category 6A data cables through the communication channel.
 - a. The body will consist of an intumescent fire stop material to maintain the fire rating of the floor slab. The intumescent material will be held securely in place in the insert body and shall not have to be adjusted to maintain fire rating of the unit and the floor slab. The insert shall have retaining feature that will hold the poke-thru device in the floor slab without additional fasteners. The poke-thru insert shall also consist of a 3/4 inches trade size conduit stub that is connected to the insert body and a stamped steel junction box for wire splices and connections. The stamped steel junction box shall also contain the necessary means to electrically ground the poke-thru device to the system ground.
4. Activation Cover: The activation covers shall be round 6CT2 Series and manufactured of die-cast aluminum alloy and be available in powder-coated gray, black, or plated in brass, nickel or bronze finish. Two gaskets (one for carpet and one for tile) are provided to go under the trim flange to maintain scrub water tightness. The activation covers shall be flush version. The cover shall have one 3/4 inch (19.05 mm) trade size opening for power and one 1-1/4 inches / 2 inches (31.75/50.8) combination trade size opening for communications. Provide 6CFFTC Series furniture feed cover assembly for all furniture feed locations.
5. Communication Modules Mounting Accessories: The poke-thru manufacturer shall have available open modular inserts to facilitate mounting UTP (including Category 5, 5e, 6), STP, fiber optic, coaxial, and data/communications devices. The AV3 series shall accommodate

Extron MAAP mini architectural adapter plates. Where indicated, provide connectivity outlets and modular inserts by Ortronics or approved equal.

6. Mounting: Units shall permit wiring to be completed at floor level. The units shall mount in either a 3 inch or 4 inch (76 mm or 102 mm) core hole as applicable. Installation shall be completed by pushing unit down into a cored hole. The specified poke-thru shall be UL listed to US and Canadian standards for use on carpet, tile, terrazzo, and wood covered floors.

PART 3: EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit RNC, Type EPC-80-PVC.
2. Underground Conduit: RNC, Type EPC-80-PVC, direct buried.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC.
4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:
 - a. Loading dock.
 - b. Mechanical rooms.
4. Concealed in Ceilings and Interior Walls and Partitions: EMT RNC, Type EPC-40-PVC.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit.
7. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, stainless steel in damp or wet locations.

C. Minimum Raceway Size: 3/4-inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Do not install aluminum conduits in contact with concrete.

3.02 INSTALLATION

- A. Provide an Easy-Path device thru every corridor to corridor wall.
- B. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.
- 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. Complete raceway installation before starting conductor installation.
- E. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."
- F. Arrange stub-ups so curved portions of bends are not visible above the finished slab.
- G. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.
- H. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.
- I. Devices Located in Precast Wall:
 - 1. Coordinate with all trades for location of required boxes.
 - 2. All boxes and conduits shall be roughed-into the wall at the manufacturing site.
 - 3. Coordinate with the wall manufacturing facility for rough-in requirements.
 - 4. Visit manufacturing site and install boxes and conduits prior to manufacturing of wall panel.
- J. Raceways Embedded in Slabs:
 - 1. Run conduit larger than 1-inch trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
 - 2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
 - 3. Change from ENT to RNC, Type EPC-40-PVC, rigid steel conduit, or IMC before rising above the floor.
- K. 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.
- L. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.
- M. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than 200-lb tensile strength. Leave at least 12 inches of slack at each end of pull wire.
- N. Install raceway sealing fittings at suitable, approved, and accessible locations 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 at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where otherwise required by NFPA 70.
- O. Provide a blank coverplate for all existing device boxes that are remaining after demolition of devices and not reused. Provide a blank coverplate on all new boxes that are empty; this includes spare, future and boxes for owners devices that will not be used at the time of occupancy.
- P. Flexible Conduit Connections: Use maximum of 72 inches of flexible conduit for recessed and semi-recessed lighting fixtures, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations subject to severe physical damage.
 2. Use LFMC or LFNC in damp or wet locations not subject to severe physical damage.
- Q. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

3.03 INSTALLATION OF UNDERGROUND CONDUIT

A. Direct-Buried Conduit:

1. Excavate trench bottom to provide firm and uniform support for conduit. Prepare trench bottom as specified in Division 31 Section "Earth Work" for pipe less than 6 inches in nominal diameter.
2. Install backfill as specified in Division 31 Section "Earth Work."
3. 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 Division 31 Section "Earth Work."
4. Warning Planks: Bury warning planks approximately 12 inches above direct-buried conduits, placing them 24 inches o.c. Align planks along the width and along the centerline of conduit.

3.04 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls

- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening. Rectangular Sleeve Minimum Metal Thickness:
1. For sleeve cross-section rectangle perimeter less than 50 inches and no side greater than 16 inches, thickness shall be 0.052 inch.
 2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches and 1 or more sides equal to, or greater than, 16 inches, thickness shall be 0.138 inch.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 4 inches above finished floor level.
- G. Seal space outside of sleeves with grout for penetrations of concrete and masonry.
- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Sealants and Caulking" for materials and installation.
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Firestopping."
- J. Aboveground, Exterior-Wall 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.
- K. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch annular clear space between raceway and sleeve for installing mechanical sleeve seals.

SLEEVE-SEAL INSTALLATION

- L. Install to seal underground, exterior wall penetrations.
- M. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.05 FIRESTOPPING

- A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Firestopping."

3.06 PROTECTION

- A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.
 - 1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
 - 2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION 26 05 33

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

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. Identification for raceway.
 - 2. Identification for conductors and communication and control cable.
 - 3. Instruction signs.
 - 4. Equipment identification labels.
 - 5. Miscellaneous identification products.

1.03 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and ANSI C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.145.

1.04 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in the Contract Documents, Shop Drawings, manufacturer's wiring diagrams, and the Operation and Maintenance Manual, and with those required by codes, standards, and 29 CFR 1910.145. Use consistent designations throughout Project.
- B. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.
- C. Coordinate installation of identifying devices with location of access panels and doors.
- D. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2: PRODUCTS

2.01 RACEWAY IDENTIFICATION MATERIALS

- A. Self-Adhesive Vinyl Tape: Colored, heavy duty, waterproof, fade resistant; 2 inches (50 mm) wide; compounded for outdoor use where required.

- B. Identify raceways with color coded bandings. Provide at each end of raceway, at each side of a penetration through a floor ceiling, etc and at 50 foot intervals for horizontal, straight runs.
- C. Color Coded as follows:
 - 1. 208/480 volt, single and three phase systems: Black (normal/utility power) and Red (emergency power).
 - 2. Fire Alarm System: Red.
 - 3. Fire-Suppression Supervisory and Control System: Red and yellow.
 - 4. Combined Fire Alarm and Security System: Red and blue.
 - 5. Security System: Blue and yellow.
 - 6. Mechanical and Electrical Supervisory System: Green and blue.
 - 7. Telecommunication System: Green and yellow.
 - 8. Control Wiring: Green and red.

2.02 CONDUCTOR AND COMMUNICATION AND CONTROL CABLE IDENTIFICATION MATERIALS

- A. Color-Coding Conductor Tape: Colored, self-adhesive vinyl tape not less than 3 mils (0.08 mm) thick by 1 to 2 inches (25 to 50 mm) wide.
- B. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

2.03 WARNING LABELS AND SIGNS

- A. Comply with NFPA 70 and 29 CFR 1910.145.
- B. Self-Adhesive Warning Labels: Factory printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment, unless otherwise indicated.
- C. Baked-Enamel Warning Signs: Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 7 by 10 inches (180 by 250 mm).
- D. Metal-Backed, Butyrate Warning Signs: Weather-resistant, non-fading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application. 1/4-inch (6.4-mm) grommets in corners for mounting. Nominal size, 10 by 14 inches (250 by 360 mm).
- E. Warning label and sign shall include, but are not limited to, the following legends:
 - 1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD - EQUIPMENT HAS MULTIPLE POWER SOURCES."
 - 2. Workspace Clearance Warning: "WARNING - OSHA REGULATION - AREA IN FRONT OF ELECTRICAL EQUIPMENT MUST BE KEPT CLEAR FOR 36 INCHES (915 MM)."

2.04 EQUIPMENT IDENTIFICATION LABELS

- A. Provide engraved, three layer laminated plastic black nameplate.

1. White letters for normal/utility power.
 2. Red letters for emergency power.
- B. All engraved nameplates shall be installed level and square, attached with stainless steel screws with nuts and lock washers on clean surfaces of dead front barrier of electrical equipment.
- C. Nameplate engraving schedule as follows:
1. Switchboards, Distribution Boards, Panelboards: ¼"; identify equipment designation. 1/8"; identify voltage, rating and source.
 2. Individual circuit breakers and switches in switchboards and distribution boards: 1/8"; identify circuit, load served and location of served load.
 3. Individual circuit breakers, enclosed switches and motor starters: 1/8" identify source, load served and location of load served.
 4. All other enclosures, to include contactors, disconnect switches, etc: 1/8" identify source and load served.

PART 3: EXECUTION

3.01 APPLICATION

- A. Branch-Circuit Conductor Identification: Where there are conductors for more than three branch circuits in same junction or pull box, use write-on tags. Identify each ungrounded conductor according to source and circuit number.
- B. Conductors to Be Extended in the Future: Attach write-on tags to conductors and list source and circuit number as well as load to be served.
- C. Auxiliary Electrical Systems Conductor Identification: Identify field-installed alarm, control, signal, sound, intercommunications, voice, and data connections.
1. Identify conductors, cables, and terminals in enclosures and at junctions, terminals, and pull points. Identify by system and circuit designation.
 2. Use system of marker tape designations that is uniform and consistent with system used by manufacturer for factory-installed connections.
 3. Coordinate identification with Project Drawings, manufacturer's wiring diagrams, and Operation and Maintenance Manual.
- D. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable
- E. Instruction Signs:
1. Operating Instructions: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.
 2. Emergency Operating Instructions: Install instruction signs with white legend on a red background with minimum 3/8-inch- (10-mm-) high letters for emergency instructions at equipment used for power transfer, load shedding or other emergency operations.

F. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and Operation and Maintenance Manual. Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

- a. Indoor Equipment: Engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where 2 lines of text are required, use labels 2 inches (50 mm) high.
- b. Outdoor Equipment: Engraved, laminated acrylic or melamine label 4 inches (100 mm) high.
- c. Elevated Components: Increase sizes of labels and letters to those appropriate for viewing from the floor.

2. Equipment to Be Labeled:

- a. Panelboards, electrical cabinets, and enclosures.
- b. Access doors and panels for concealed electrical items.
- c. Electrical switchgear and switchboards.
- d. Transformers.
- e. Emergency system boxes and enclosures.
- f. Disconnect switches.
- g. Motor starters.
- h. Push-button stations.
- i. Contactors.
- j. Remote-controlled switches, dimmer modules, and control devices.
- k. Battery inverter units.
- l. Voice and data cable terminal equipment.
- m. Master clock and program equipment.
- n. Television/audio components, racks, and controls.
- o. Fire-alarm control panel and annunciator.
- p. Security and intrusion-detection control stations, control panels, terminal cabinets, and racks.
- q. Monitoring and control equipment.
- r. Uninterruptible power supply equipment.
- s. Terminals, racks, and patch panels for voice and data communication and for signal and control functions.

3.02 INSTALLATION

- A. Verify identity of each item before installing identification products.
- B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.
- C. Apply identification devices to surfaces that require finish after completing finish work.
- D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.
- E. Attach non-adhesive signs and plastic labels with screws and auxiliary hardware appropriate to the location and substrate.

- F. System Identification Color Banding for Raceways and Cables: Each color band shall completely encircle cable or conduit. Place adjacent bands of two-color markings in contact, side by side. Locate bands at changes in direction, at penetrations of walls and floors, at 50-foot (15-m) maximum intervals in straight runs, and at 25-foot (7.6-m) maximum intervals in congested areas.
- G. Color-Coding for Phase and Voltage Level Identification, 600 V and Less: Use the colors listed below for ungrounded conductors.
 - 1. Colors for 208/120-V Circuits:
 - a. Phase A: Black.
 - b. Phase B: Red.
 - c. Phase C: Blue.
 - d. Neutral: White.
 - e. Ground: Green.
 - 2. Colors for 480/277-V Circuits:
 - a. Phase A: Brown.
 - b. Phase B: Orange.
 - c. Phase C: Yellow.
 - d. Neutral: Gray.
 - e. Ground: Green.
 - 3. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.
- H. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench exceeds 16 inches (400 mm) overall.
- I. Painted Identification: Prepare surface and apply paint according to Division 09 painting Sections.

END OF SECTION 26 05 53

SECTION 26 09 23

LIGHTING CONTROL DEVICES

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 lighting control devices:
 - 1. Time switches.
 - 2. Outdoor and indoor photoelectric switches.
 - 3. Indoor occupancy sensors.
 - 4. Standalone indoor lighting control systems
 - 5. Lighting contactors.
 - 6. Emergency shunt relays.
- B. Related Sections include the following:
 - 1. Division 26 Section "Network Lighting Controls" for low-voltage, manual and programmable lighting control systems.

1.03 DEFINITIONS

- A. LED: Light-emitting diode.
- B. PIR: Passive infrared.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: Show installation details for occupancy and light-level sensors.
 - 1. Interconnection diagrams showing field-installed wiring.
- C. Operation and Maintenance Data: For each type of product 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.

1.06 COORDINATION

- A. Coordinate layout and installation of ceiling-mounted devices with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, smoke detectors, fire-suppression system, and partition assemblies.

PART 2: PRODUCTS

2.01 TIME SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Leviton Mfg. Company Inc.
 - 2. Lightolier Controls; a Genlyte Company.
 - 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 4. Paragon Electric Co.; Invensys Climate Controls.
 - 5. Square D; Schneider Electric.
 - 6. TORK.
 - 7. Watt Stopper (The).
- B. Electronic Time Switches: Electronic, solid-state programmable units with alphanumeric display; complying with UL 917.
 - 1. Contact Configuration: as indicated on drawings.
 - 2. Contact Rating: 20-A ballast load, 120/240-V ac.
 - 3. Program: 8 on-off set points on a 24-hour schedule unless noted otherwise on the drawings and an annual holiday schedule that overrides the weekly operation on holidays.
 - 4. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 - 5. Astronomic Time: All channels.
 - 6. Battery Backup: For schedules and time clock.
- C. Electromechanical-Dial Time Switches: Type complying with UL 917.
 - 1. Contact Configuration: as indicated on the drawings.
 - 2. Contact Rating: 20-A ballast load, 120/240-V ac.
 - 3. Circuitry: Allow connection of a photoelectric relay as substitute for on-off function of a program.
 - 4. Astronomic time dial.
 - 5. Eight-Day Program: Uniquely programmable for each weekday and holidays.
 - 6. Skip-a-day mode.
 - 7. Wound-spring reserve carryover mechanism to keep time during power failures, minimum of 16 hours.

2.02 OUTDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, compatible for connection to the network lighting control panel and products by one of the following:
 - 1. Grasslin Controls Corporation; a GE Industrial Systems Company.
 - 2. Intermatic, Inc.
 - 3. Lithonia Lighting; Acuity Lighting Group, Inc.
 - 4. Paragon Electric Co.; Invensys Climate Controls.

5. Square D; Schneider Electric.
 6. TORK.
 7. Watt Stopper (The).
- B. Description: Solid state, with SPST dry contacts rated for 1800-VA, to operate connected relay, contactor coils, or microprocessor input; complying with UL 773A.
1. Light-Level Monitoring Range: 2.0 to 10 fc, with an adjustment for turn-on and turn-off levels within that range, and a directional lens in front of photocell to prevent fixed light sources from causing turn-off.
 2. Time Delay: 15-second minimum, to prevent false operation.
 3. Surge Protection: Metal-oxide varistor, complying with IEEE C62.41.1, IEEE C62.41.2, and IEEE 62.45 for Category A1 locations.
 4. Mounting: Twist lock complying with IEEE C136.10, with base-and-stem mounting or stem-and-swivel mounting accessories as required to direct sensor to the north sky exposure.

2.03 INDOOR PHOTOELECTRIC SWITCHES

- A. Manufacturers: Subject to compliance with requirements, compatible for connection to the network lighting control panel and provide products by one of the following:
1. Allen-Bradley/Rockwell Automation.
 2. Eaton Electrical Inc; Cutler-Hammer Products.
 3. Intermatic, Inc.
 4. Lithonia Lighting; Acuity Lighting Group, Inc.
 5. MicroLite Lighting Control Systems.
 6. Novitas, Inc.
 7. Paragon Electric Co.; Invensys Climate Controls.
 8. Square D; Schneider Electric.
 9. TORK.
 10. Touch-Plate, Inc.
 11. Watt Stopper (The).
- B. Ceiling-Mounted Photoelectric Switch: Solid-state, light-level sensor unit, with separate relay unit, to detect changes in lighting levels that are perceived by the eye. Cadmium sulfide photo-resistors are not acceptable.
1. Sensor Output: Contacts rated to operate the associated relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 2. Retain second option in first subparagraph below for lighting control of interior spaces with large window areas, including atriums and corridors; otherwise, retain first option.
 3. Light-Level Monitoring Range: 10 to 200 fc (108 to 2152 lx), with an adjustment for turn-on and turn-off levels within that range.
 4. Time Delay: Adjustable from 5 to 300 seconds to prevent cycling, with deadband adjustment.
 5. Indicator: Two LEDs to indicate the beginning of on-off cycles.

2.04 INDOOR OCCUPANCY SENSORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Hubbell Lighting.
 2. Lutron
 3. nLight; Acuity Lighting Group, Inc.
 4. Sensor Switch, Inc.
 5. Watt Stopper (The).
 6. or approved equal
- B. General Description: Wall- or ceiling-mounting, solid-state units with a separate relay unit.
1. Operation: Unless otherwise indicated, turn lights on when covered area is occupied and off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
 2. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor shall be powered from the relay unit.
 3. Relay Unit: Dry contacts rated for 20-A ballast load at 120- and 277-V ac, for 13-A tungsten at 120-V ac, and for 1 hp at 120-V ac. Power supply to sensor shall be 24-V dc, 150-mA, Class 2 power source as defined by NFPA 70.
 4. Mounting:
 - a. Sensor: Suitable for mounting in any position on a standard outlet box.
 - b. Relay: Externally mounted through a 1/2-inch (13-mm) knockout in a standard electrical enclosure.
 - c. Time-Delay and Sensitivity Adjustments: Recessed and concealed behind hinged door.
 5. Indicator: LED, to show when motion is being detected during testing and normal operation of the sensor.
 6. Bypass Switch: Override the on function in case of sensor failure.
 7. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lx); keep lighting off when selected lighting level is present.
- C. PIR Type: Ceiling mounting; detect occupancy by sensing a combination of heat and movement in area of coverage.
1. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm).
 2. Detection Coverage (Room): Detect occupancy anywhere in a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 3. Detection Coverage (Corridor): Detect occupancy within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling.
- D. Ultrasonic Type: Ceiling mounting; detect occupancy by sensing a change in pattern of reflected ultrasonic energy in area of coverage.
1. Detector Sensitivity: Detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 2. Detection Coverage (Small Room): Detect occupancy anywhere within a circular area of 600 sq. ft. (56 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 4. Detection Coverage (Large Room): Detect occupancy anywhere within a circular area of 2000 sq. ft. (186 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.
 5. Detection Coverage (Corridor): Detect occupancy anywhere within 90 feet (27.4 m) when mounted on a 10-foot- (3-m-) high ceiling in a corridor not wider than 14 feet (4.3 m).
- E. Dual-Technology Type: Ceiling mounting; detect occupancy by using a combination of PIR and ultrasonic detection methods in area of coverage. Particular technology or combination of technologies that controls on-off functions shall be selectable in the field by operating controls on unit.
1. Sensitivity Adjustment: Separate for each sensing technology.
 2. Detector Sensitivity: Detect occurrences of 6-inch- (150-mm-) minimum movement of any portion of a human body that presents a target of not less than 36 sq. in. (232 sq. cm), and detect a person of average size and weight moving not less than 12 inches (305 mm) in either a horizontal or a vertical manner at an approximate speed of 12 inches/s (305 mm/s).
 3. Detection Coverage (Standard Room): Detect occupancy anywhere within a circular area of 1000 sq. ft. (93 sq. m) when mounted on a 96-inch- (2440-mm-) high ceiling.

2.05 STANDALONE INDOOR LIGHTING CONTROL SYSTEMS

A. Manufacturers

1. Available Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. nLight; Acuity Lighting
 - b. Douglas Lighting
 - c. Leviton Mfg. Company Inc.
 - d. Lutron Electronics Company, Inc.
 - e. Hubbell
 - f. Watt Stopper
 - g. or approved equal
2. The manufacturer shown on the drawings is the basis of design. All other manufacturers are required to provide all pieces, parts, wiring and programming required by their system to meet the intent. This shall include all additional work required in the field.

B. Manual Switches

1. Push-Button Switches: Modular, processor based, low-voltage type
 - a. Match color specified in Division 26 Section "Wiring Devices."
 - b. Integral LED pilot light to indicate when circuit is on.
 - c. Provide multiple button devices as indicated in the contract documents.
2. Wall Plates: Single and multi-gang plates as specified in Division 26 Section "Wiring Devices."
3. Legend: Engraved or permanently silk-screened on face for all devices.
 - a. Use labeling designations indicated in drawings.
 - b. Where no labeling is indicated on drawings, provide standard on/off & up/down.

C. Sensors

1. Ceiling-mounted sensors, including daylight and occupancy sensors, shall be Dual-Technology type, fully compatible with the local control system, and have appropriate coverage types for the mounting height, as determined by the general space type and design.
2. Wall-mounted sensors integrated into push button switches shall meet all requirements for manual switches and have the appropriate buttons for dimming control and legends as indicated on drawings
3. Wall-mounted sensors not physically combined with other controls shall meet Indoor Occupancy Sensor requirements and shall be mounted at a height appropriate to provide full coverage
4. Sensor quantities and locations shown on plans indicate design intent. The contractor is responsible for providing sensor quantities and layouts as necessary given the capabilities of the manufacturer's equipment.

D. Controllers

1. Controllers must be fully compatible with both the room control system and all control technologies specified in the light fixtures.
2. Where a fixture is indicated as "Legally Required Life Safety", the controller serving the fixture must be UL924 listed, be provided with a non-switched branch circuit conductor to monitor for loss of power, and default to ON when a loss of power is detected
3. Controller locations
 - a. The drawings may indicate zone-level or fixture-level control. Either technology may be applied (unless specifically called out in an area on plans), but the contractor is responsible for providing all necessary components to make the selected method meet design intent.
 - b. All controllers installed in exposed ceilings must be mounted inside junction boxes painted to match the ceiling.
 - c. Fixture-level controllers must be installed inside the fixture or solidly affixed to the exterior. Fixture-level controllers may not be affixed in such a way to interfere with vertical clearances or any other disciplines.

2.06 EMERGENCY SWITCH BYPASS DEVICE

- 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. Bodine
 2. Leviton
 3. Wattstopper
 4. Nine 24
 5. or approve equal
- C. Description: Normally closed, electrically held relay, arranged for wiring in parallel with manual and automatic switching contacts; complying with UL 924.
- D. Devices that bypass automatic relays shall be connected such that upon loss of power, the automatic relay is bypassed and lighting branch circuits are energized.

2.07 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

- B. Classes 2 and 3 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 18 AWG. Comply with requirements in Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."

PART 3: EXECUTION

3.01 SENSOR INSTALLATION

- A. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.02 CONTACTOR INSTALLATION

- A. Mount electrically held lighting contactors with elastomeric isolator pads, to eliminate structure-borne vibration, unless contactors are installed in an enclosure with factory-installed vibration isolators.

3.03 WIRING INSTALLATION

- A. Wiring Method: Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and non-power-limited conductors according to conductor manufacturer's written instructions.
- C. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- D. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 IDENTIFICATION

- A. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits or luminaries controlled by photoelectric and occupancy sensors at each sensor.
- B. Label time switches and contactors with a unique designation.

3.05 FIELD QUALITY CONTROL

- A. Perform the following field tests and inspections and prepare test reports:

1. After installing time switches and sensors, and after electrical circuitry has been energized, adjust and test for compliance with requirements.
 2. Operational Test: Verify operation of each lighting control device, and adjust time delays.
- B. Lighting control devices that fail tests and inspections are defective work.

3.06 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors to suit occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.07 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control system specified in Division 26 Section "Network Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices. Refer to Division 01 Section "Demonstration and Training."

END OF SECTION 26 09 23

SECTION 26 09 43

NETWORK LIGHTING 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.

1.02 SUMMARY

- A. This Section includes manually operated lighting controls with relays and control module.
- B. This Section includes manually operated, computer controlled, programmable, digital lighting controls with external signal source relays and control modules.
- C. Related Sections include the following:
 - 1. Division 26 Section "Lighting Control Devices" for time switches, photoelectric switches, occupancy sensors, and multipole contactors.

1.03 DEFINITIONS

- A. BACnet: A networking communication protocol that complies with ASHRAE 135.
- B. BAS: Building automation system.
- C. DALI: Digital addressable lighting interface.
- D. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- E. 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.
- F. Monitoring: Acquisition, processing, communication, and display of equipment status data, metered electrical parameter values, power quality evaluation data, event and alarm signals, tabulated reports, and event logs.
- G. PC: Personal computer; sometimes plural as "PCs."
- H. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
- I. RS-485: A serial network protocol, similar to RS-232, complying with TIA/EIA-485-A.

1.04 SUBMITTALS

- A. Product Data: For control modules, power distribution components, manual switches and plates, and conductors and cables.
- B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on this Project.
 - 1. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - 2. Block Diagram: Show interconnections between components specified in this Section and devices furnished with power distribution system components. Indicate data communication paths and identify networks, data buses, data gateways, concentrators, and other devices to be used. Describe characteristics of network and other data communication lines.
 - 3. Wiring Diagrams: Power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.
- C. Coordination Drawings: Submit evidence that lighting controls are compatible with connected monitoring and control devices and systems specified in other Sections.
 - 1. Show interconnecting signal and control wiring and interfacing devices that prove compatibility of inputs and outputs.
 - 2. For networked controls, list network protocols and provide statements from manufacturers that input and output devices meet interoperability requirements of the network protocol.
- D. Software and Firmware Operational Documentation:
 - 1. Software operating and upgrade manuals.
 - 2. Program Software Backup: On a magnetic media or compact disc, complete with data files.
 - 3. Device address list.
 - 4. Printout of software application and graphic screens.
- E. Field quality-control test reports.
- F. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- G. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- H. Warranty: Special warranty specified in this Section.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain lighting control module and power distribution components through one source from a single manufacturer.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with protocol described in IEC 60929, Annex E, for DALI lighting control devices, wiring, and computer hardware and software.
- E. Comply with NFPA 70.

1.06 COORDINATION

- A. Coordinate lighting control components to form an integrated interconnection of compatible components.
 - 1. Match components and interconnections for optimum performance of lighting control functions.
 - 2. Coordinate lighting controls with Owner requirements.
 - 3.
- B. Coordinate lighting control components specified in this Section with components specified in Division 26 Section "Panelboards."

1.07 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of lighting controls that fail in materials or workmanship or from transient voltage surges within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Failure of software input/output to execute switching or dimming commands.
 - b. Failure of modular relays to operate under manual or software commands.
 - c. Damage of electronic components due to transient voltage surges.
 - 2. Warranty Period: Two years from date of Substantial Completion.

1.08 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. 8 system connected occupancy sensors.
 - 2. 2 System connected 3 button manual control switches.

1.09 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two (2) years.
- B. Software shall accessible through a web browser and shall be programmed with user names and passwords as directed by owner.

- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two (2) years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.
 - 1. Provide 30-day notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment, if necessary.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. 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:
 - 1. nLight; Acuity Lighting
 - 2. Douglas Lighting
 - 3. Leviton Mfg. Company Inc.
 - 4. Lutron Electronics Company, Inc.
 - 5. Hubbell
 - 6. Watt Stopper
- B. The manufacturer shown on the drawings is the basis of design. All other manufacturers are required to provide all pieces, parts, wiring and programming required by their system to meet the intent. This shall include all additional work required in the field.

2.02 SYSTEM REQUIREMENTS

- A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.
- B. Installations with multiple relay cabinets shall be capable of communication such that activation a switch or control device terminated in one panel can activate and control relay, control functions or relay groups in all other panels within the system
- C. Performance Requirements: Manual switch operation sends a signal to programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays in the power-supply circuits to groups of lighting fixtures or other loads.
- D. Performance Requirements: Manual switches, an internal timing and control unit, and external sensors or other control signal sources send a signal to a PC-based programmable-system control module that processes the signal according to its programming and routes an open or close command to one or more relays in the power-supply circuits, or routes variable commands to one or more dimmers, for groups of lighting fixtures or other loads.
- E. System Description:
 - 1. Network Lighting control system shall have 1 relay panel in location shown on drawings.
 - 2. Provide panel each with 16 relays for control of loads indicated in the relay schedule.

3. Provide 1 multi zone control buttons in Building engineers office at the panel for on/off sweep of all corridors.
4. Provide system connected Occupancy sensors throughout build as indicated.
5. Panel shall control all exterior lighting, corridors, and other indicated areas.
 - a. Exterior fixtures: Initial programming shall be photo cell on/off and modified to owner's timed on/off schedule in the field.
 - b. Corridors and common areas: Initial programming shall be timed on/off schedule 6am to 6pm with 2 hours occupancy sensor override after hours. Schedule shall be modified to the owner's schedule in the field.
6. System shall be capable of being accessed from an office PC with the individual zones able to be modified.

2.03 CONTROL MODULE

- A. Control Module Description: Comply with UL 916 (CSA C22.2, No. 205); microprocessor-based, solid-state, 365-day timing and control unit. Output circuits shall be switched on or off by internally programmed time signals or by program-controlled analog or digital signals from external sources. Output circuits shall be pilot-duty relays compatible with power switching devices.
1. System Memory: Nonvolatile. System shall reboot program and reset time automatically without errors after power outages up to 90 days' duration.
 2. Software: Lighting control software shall be capable of linking switch inputs to relay outputs, retrieving links, viewing relay output status, controlling relay outputs, simulating switch inputs, setting device addresses, and assigning switch input and relay output modes.
 3. Automatic Time Adjustment: System shall automatically adjust for leap year and daylight saving time and shall provide weekly routine and annual holiday scheduling.
 4. Astronomic Control: Automatic adjustment of dawn and dusk switching.
 5. Local Override Capability: Manual, low-voltage control devices shall override programmed shutdown of lighting and shall override other programmed control for intervals that may be duration programmed.
 6. Automatic Control of Local Override: Automatic control shall switch lighting off if lighting has been switched on by local override after 2 hours.
 7. Automatic battery backup shall provide power to maintain program and system clock operation for 90 days' minimum duration when power is off.
 8. Daylight Compensating Control: Control module shall interpret a preset threshold illumination-level signal from photoelectric relays and shall dim connected lighting fixtures to maintain adjustable minimum illumination level as daylight contribution varies.
 9. Diagnostics: When system operates improperly, software shall initiate factory-programmed diagnosis of failure and display messages identifying problem and possible causes.

2.04 POWER DISTRIBUTION COMPONENTS

- A. Modular Relay Panel: Comply with UL 508 (CSA C22.2, No. 14) and UL 916 (CSA C22.2, No. 205); factory assembled with modular single-pole relays, power supplies, and accessory components required for specified performance.
1. Cabinet: Steel with hinged, locking door.
 - a. Barriers separate low-voltage and line-voltage components.
 - b. Directory: Mounted on back of door. Identifies each relay as to load groups controlled and each programmed pilot device if any.
 - c. Control Power Supply: Transformer and full-wave rectifier with filtered dc output.
 2. Single-Pole Relays: Mechanically held unless otherwise indicated; split-coil, momentary-pulsed type.
 - a. Low-Voltage Leads: Plug connector to the connector strip in cabinet and pilot light power where indicated.
 - b. Rated Capacity (Mounted in Relay Panel): 20 A, 125-V ac for tungsten filaments; 20 A, 277-V ac for ballasts.
 - c. Endurance: 50,000 cycles at rated capacity.
 - d. Mounting: Provision for easy removal and installation in relay cabinet.
- B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state control panels.

2.05 CONTROL OF EMERGENCY CIRCUITS

- A. Control of lighting branch circuit that are designated for “Legally Required Life Safety Lighting” shall be controlled by a system that is listed to do so by UL924 using one of the following:
1. Control panel with programming listed to control emergency loads.
 2. A factory installed relay listed to bypass the normal control relay.
 3. An “Emergency Switch Bypass Device” separately mounted and connected to bypass the control relay is allowed.
 4. Upon “loss of power” all emergency circuit control devices shall default to “closed”.
- B. All devices shall be connected to a non switched lighting branch circuit conductor to monitor for “Loss of Power” that will activate all lighting by bypassing all control devices.

2.06 MANUAL SWITCHES AND PLATES

- A. Push-Button Switches: Modular, processor based, low-voltage type.

1. Match color specified in Division 26 Section "Wiring Devices."
 2. Integral LED pilot light to indicate when circuit is on.
 3. Provide multiple button devices as indicated in the contract documents.
- B. Wall Plates: Single and multi-gang plates as specified in Division 26 Section "Wiring Devices."
- C. Legend: Engraved or permanently silk-screened on face for all devices.
1. Use labeling designations indicated in drawings.
 2. Where no labeling is indicated on drawings, provide standard on/off & up/down.

2.07 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- D. Digital and Multiplexed Signal Cables: Unshielded, twisted-pair cable with copper conductors, complying with TIA/EIA-568-B.2, Category 6 for horizontal copper cable and with Division 27 Section "Communications Horizontal Cabling."
- E. As required by manufacturer

PART 3: EXECUTION

3.01 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install wiring in raceways. Comply with Division 26 Section "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size shall be 1/2 inch (13 mm).
- C. 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.
- D. Size conductors according to lighting control device manufacturer's written instructions, unless otherwise indicated.
- E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
- F. Identify components and power and control wiring according to Division 26 Section "Identification for Electrical Systems."

3.02 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 assist in field testing. Report results in writing.
- B. Perform the following field tests and inspections and prepare test reports:
 - 1. Test for circuit continuity.
 - 2. Verify that the control module features are operational.
 - 3. Check operation of local override controls.
 - 4. Test system diagnostics by simulating improper operation of several components selected by Architect.

3.03 ADJUSTING

- A. System shall be programmed and operational prior to owner/engineer's walk through. Provide all programming modifications as required.
- B. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting sensors and to assist Owner's personnel in making program changes to suit actual occupied conditions. Provide up to two visits to Project site outside normal occupancy hours for this purpose.

3.04 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls. Refer to Division 01 Section "Demonstration and Training."
 - 1. This training session shall be a minimum of 2 hours.
 - 2. Training shall include a one hour recorded presentation which shall include operation, adjustment of time schedules, viewing of time schedules and basic troubleshooting. Recorded session shall also include contact information. Session may be recorded in advance (on or off site) but shall be available and used at the time of training.
 - 3. Training must be scheduled in advance thru the construction manager with notification to Owner, Engineer and Architect.

END OF SECTION 26 09 43

SECTION 26 24 13

SWITCHBOARDS

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 SCOPE

- A. The existing 1200A switchboard shall be replaced with a new 1200A switchboard.
 - 1. The existing utility transformer shall be reused.
 - 2. Provide a new CT cabinet and metering on the exterior of the building.
 - 3. The new switchboard shall be free standing and can be installed in the electrical room's space as shown on the drawings prior to any demolition of the existing service. There is an existing 4" curb at the new location (from equipment previously removed) that shall be modified by this contractor to accommodate the new switchboard.
 - 4. The new switch board shall have 3 sections: Main Section, (1) distribution section for City Hall load & (1) distribution section for Police Station Loads. These sections shall not be combined.
 - 5. All existing connection to the existing switchboard shall be extended to the new service and reconnected.
 - 6. Due to the Police Station function associated with this building, service downtime shall be scheduled with the owner in advance and limited to 4 hours and done outside normal business hours.
 - a. The generator may be operated to facilitate the new connections. All fuel used during construction is the responsibility of this contractor.
 - 7. After the installation of the new equipment, all existing used panels, conduits and the existing switchboard shall be removed in a neat and workmanlike manor.

1.03 SUMMARY

- A. Section Includes:
 - 1. Service and distribution switchboards rated 600 V and less.
 - 2. Transient voltage suppression devices.
 - 3. Disconnecting and overcurrent protective devices.
 - 4. Control power.
 - 5. Accessory components and features.
 - 6. Identification.

1.04 SUBMITTALS

- A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

- B. Shop Drawings: For each switchboard and related equipment.
1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
 2. Detail enclosure types for types other than NEMA 250, Type 1.
 3. Detail bus configuration, current, and voltage ratings.
 4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
 5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.
 6. Detail utility company's metering provisions with indication of approval by utility company.
 7. Include evidence of NRTL listing for series rating of installed devices.
 8. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 9. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
 10. Include diagram and details of proposed mimic bus.
 11. Include schematic and wiring diagrams for power, signal, and control wiring.
- C. Samples: Representative portion of mimic bus with specified material and finish, for color selection.
- D. Qualification Data: For qualified Installer.
- E. Field Quality-Control Reports:
1. Test procedures used.
 2. Test results that comply with requirements.
 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Routine maintenance requirements for switchboards and all installed components.
 2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.

3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

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.
- B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 2.
- F. Comply with NFPA 70.
- G. Comply with UL 891.

1.06 DELIVERY, STORAGE, AND HANDLING

- A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.
- B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.
- C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.07 PROJECT CONDITIONS

- A. Installation Pathway: Remove and replace access fencing, doors, lift-out panels, and structures to provide pathway for moving switchboards into place.
- B. Environmental Limitations:
 1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

1.08 COORDINATION

- A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03.

1.09 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
 - 1. Warranty Period: Two (2) years from date of Substantial Completion.

1.10 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
 - 3. Fuses and Fusible Devices for Fused Circuit Breakers: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

PART 2: PRODUCTS

2.01 MANUFACTURED UNITS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Nominal System Voltage: 120/208 V.
- D. Main-Bus Continuous: As indicated on drawings.
- E. Indoor Enclosures: Steel, NEMA 250, Type 1.

- F. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.
- G. Barriers: Between adjacent switchboard sections.
- H. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.
- I. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.
- J. Removable, Hinged Rear Doors and Compartment Covers: Secured by standard bolts, for access to rear interior of switchboard.
- K. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.
- L. Buses and Connections: Three phase, four wire unless otherwise indicated.
 - 1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity, with tin-plated aluminum or copper feeder circuit-breaker line connections.
 - 2. Phase- and Neutral-Bus Material: Tin-plated, high-strength, electrical-grade aluminum alloy with tin-plated aluminum circuit-breaker line connections.
 - 3. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
 - 4. Load Terminals: Insulated, rigidly braced, runback bus extensions, of same material as through buses, equipped with compression connectors for outgoing circuit conductors. Provide load terminals for future circuit-breaker positions at full-ampere rating of circuit-breaker position.
 - 5. Ground Bus: 1/4-by-1-inch - Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with compression connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
 - 6. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from both ends.
 - 7. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with compression connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
 - 8. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.
- M. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.
- N. Bus-Bar Insulation: Factory-applied, flame-retardant, tape wrapping of individual bus bars or flame-retardant, spray-applied insulation. Minimum insulation temperature rating of 105 deg C.

2.02 TRANSIENT VOLTAGE SUPPRESSION DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:
 - 1. Fuses, rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Integral disconnect switch.
 - 4. Redundant suppression circuits.
 - 5. Redundant replaceable modules.
 - 6. Arrangement with wire connections to phase buses, neutral bus, and ground bus.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.
 - 9. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
 - 10. Four-digit, transient-event counter set to totalize transient surges.
- D. Peak Single-Impulse Surge Current Rating: 120 kA per mode/240 kA per phase].
- E. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.
- F. Protection modes and UL 1449 SVR for 240/120-V, three-phase, four-wire circuits with high leg shall be as follows:
 - 1. Line to Neutral: 400 V, 800 V from high leg.
 - 2. Line to Ground: 400 V.
 - 3. Neutral to Ground: 400 V.
- G. Protection modes and UL 1449 SVR for 240-, 480-, or 600-V, three-phase, three-wire, delta circuits shall be as follows:
 - 1. Line to Line: 2000 V for 480 V.
 - 2. Line to Ground: 1500 V for 480 V.

2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 2. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable electronic trip; and the following field-adjustable settings:
 3. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
 - e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.
 - f. Communication Capability: Integral communication module with functions and features compatible with power monitoring and control system specified in Division 26 Section "Electrical Power Monitoring and Control."
 - g. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at [55] [75] percent of rated voltage.
 - h. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - i. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
 - j. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
- B. Fused Switch: NEMA KS 1, Type HD; clips to accommodate specified fuses; lockable handle.
- C. Fuses are specified in Division 26 Section "Fuses."

2.04 INSTRUMENTATION

- A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
 - 1. Potential Transformers: IEEE C57.13; 120 V, 60 Hz, tapped secondary; disconnecting type with integral fuse mountings. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 2. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; double secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.
 - 3. Control-Power Transformers: Dry type, mounted in separate compartments for units larger than 3 kVA.
 - 4. Current Transformers for Neutral and Ground-Fault Current Sensing: Connect secondary wiring to ground overcurrent relays, via shorting terminals, to provide selective tripping of main and tie circuit breaker. Coordinate with feeder circuit-breaker, ground-fault protection.

2.05 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.
- B. Retain first paragraph below for circuit breakers with solid-state trip devices.
- C. Spare-Fuse Cabinet: Suitably identified, wall-mounted, lockable, compartmented steel box or cabinet. Arrange for wall mounting.

2.06 IDENTIFICATION

- A. Presentation Media: Painted graphics in color contrasting with background color to represent bus and components, complete with lettered designations.
- B. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Receive, inspect, handle, and store switchboards according to NEMA PB 2.1.
- B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.
- C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install the Main Switch and switchboards and accessories according to NEMA PB 2.1.
- B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified 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 (450-mm) centers around the full perimeter of concrete base.
 - 2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
 - 3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
 - 4. Install anchor bolts to elevations required for proper attachment to switchboards.
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.
- D. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.
- E. Install filler plates in unused spaces of panel-mounted sections.
- F. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.
 - 1. Set field-adjustable switches and circuit-breaker trip ranges.
- G. Install spare-fuse cabinet.
- H. Comply with NECA 1.

3.03 CONNECTIONS

- A. Comply with requirements for terminating feeder bus specified in Division 26 Section "Enclosed Bus Assemblies." Drawings indicate general arrangement of bus, fittings, and specialties.
- B. Comply with requirements for terminating cable trays specified in Division 26 Section "Cable Trays for Electrical Systems." Drawings indicate general arrangement of cable trays, fittings, and specialties.

3.04 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

- B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.05 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. 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.
- C. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each switchboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- D. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Switchboard will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.06 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges as indicated.

3.07 PROTECTION

- A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.08 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories and to use monitoring and communication units.

END OF SECTION 26 24 13

SECTION 26 24 16

PANELBOARDS

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. Distribution panelboards.
 - 2. Lighting and appliance branch-circuit panelboards.

1.03 SUBMITTALS

- A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each panelboard and related equipment.
 - 1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
 - 2. Detail enclosure types and details for types other than NEMA 250, Type 1.
 - 3. Detail bus configuration, current, and voltage ratings.
 - 4. Short-circuit current rating of panelboards and overcurrent protective devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 6. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.
- C. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- D. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
 - 2. Time-current curves, including selectable ranges for each type of overcurrent protective device that allows adjustments.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NEMA PB 1.
- E. Comply with NFPA 70.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Remove loose packing and flammable materials from inside panelboards; install temporary electric heating (250 W per panelboard) to prevent condensation.
- B. Handle and prepare panelboards for installation according to NEMA PB 1.

1.06 PROJECT CONDITIONS

- A. Environmental Limitations:
 - 1. Do not deliver or install panelboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above panelboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
 - 2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Not exceeding minus 22 deg F to plus 104 deg F.
- B. Service Conditions: NEMA PB 1, usual service conditions, as follows:
 - 1. Ambient temperatures within limits specified.

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, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.8 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. All Branch Circuit Panels shall be provided with an additional 50% spare 20/1 breakers (or until 42 space panel is full)
2. Keys: Two spares for each type of panelboard cabinet lock.
3. Circuit Breakers Including GFCI and Ground Fault Equipment Protection (GFEP) Types: Two spares for each panelboard.

PART 2: PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Enclosures: Flush- and surface-mounted cabinets.

1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Kitchen Areas: NEMA 250, Type 4, stainless steel, heavy duty, double hinged.
 - c. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - d. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 5.
2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
3. Gutter Extension and Barrier: Same gage and finish as panelboard enclosure; integral with enclosure body. Arrange to isolate individual panel sections.
4. Finishes:
 - a. Panels and Trim: Factory finished immediately after cleaning and pre-treating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Same finish as panels and trim.
5. Directory Card: Inside panelboard door, mounted in transparent card holder.

B. Incoming Mains Location: Top and bottom.

C. Phase, Neutral, and Ground Buses:

1. Material: Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

3. Isolated Ground Bus: Adequate for branch-circuit isolated ground conductors; insulated from box, where noted on drawings.
 4. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads, where noted on drawings.
- D. Conductor Connectors: Suitable for use with conductor material and sizes.
1. Material: Hard-drawn copper, 98 percent conductivity.
 2. Main and Neutral Lugs: Compression type.
 3. Ground Lugs and Bus-Configured Terminators: Compression type.
 4. Feed-Through Lugs: Compression type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device, where noted on the drawings.
 5. Subfeed (Double) Lugs: Compression type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device, where noted on the drawings.
 6. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus, where noted on the drawings.
- E. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- F. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.02 DISTRIBUTION PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, power and feeder distribution type.
- C. Doors: Secured with vault-type latch with tumbler lock; keyed alike.
1. For doors more than 36 inches high, provide two latches, keyed alike.
- D. Mains: Circuit breaker.
- E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.
- F. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

2.03 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Panelboards: NEMA PB 1, lighting and appliance branch-circuit type.
- C. Mains: Circuit breaker.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

2.04 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.
 - 1. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads, and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
 - 2. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 - 3. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
 - 4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:
 - a. Standard frame sizes, trip ratings, and number of poles.
 - b. Lugs: Compression style, suitable for number, size, trip ratings, and conductor materials.
 - c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
 - d. Ground-Fault Protection: Remote-mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.

- e. Shunt Trip: 120 -V trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
- f. Under-voltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
- g. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
- h. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
- i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on or off position.
- j. Handle Clamp: Loose attachment, for holding circuit-breaker handles in on position.

2.05 SURGE PROTECTIVE DEVICE

- A. Provide a SPD in electronic grade panelboards (those feeding computer receptacles) As indicated on the riser.
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Eaton Electrical Inc
 - 2. Leibert
 - 3. Current Technologies
 - 4. Prior Approval
- C. Surge Protection Device Description: IEEE C62.41 Compliant, externally mounted, solid-state. Parallel connected modular (with field replaceable modules) type, with sine-wave tracking suppression and filtering modules, UL1449, third edition, short circuit current rating matching or exceeding the panelboard short-circuit rating. And with the following features and accessories:
 - 1. Fused rated at 200-kA interrupting capacity.
 - 2. Fabrication using bolted compression lugs for internal wiring.
 - 3. Integral disconnect switch.
 - 4. Redundant suppression circuits.
 - 5. Redundant replaceable modules.
 - 6. Arrangement with wire connections to phase buses, neutral, and ground bus.
 - 7. LED indicator lights for power and protection status.
 - 8. Audible alarm, with silencing switch, to indicate when protection has failed.

2.06 ACCESSORY COMPONENTS AND FEATURES

- A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3: EXECUTION

3.02 INSTALLATION

- B. Install panelboards and accessories according to NEMA PB 1.1.
- C. Mount top of trim 90 inches above finished floor unless otherwise indicated.
- D. Mount panelboard cabinet plumb and rigid without distortion of box. Mount recessed panelboards with fronts uniformly flush with wall finish and mating with back box.
- E. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- F. Install filler plates in unused spaces.
- G. Stub four 1-inch empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch empty conduits into raised floor space or below slab not on grade.
- H. Arrange conductors in gutters into groups and bundle and wrap with wire ties after completing load balancing.
- I. Comply with NECA 1.

3.03 IDENTIFICATION

- J. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- K. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- L. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- M. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

- N. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each panelboard bus, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- O. Tests and Inspections:

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

P. Panelboards will be considered defective if they do not pass tests and inspections.

3.05 ADJUSTING

- Q. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- R. Set field-adjustable circuit-breaker trip ranges as specified in Division 26 Section "Overcurrent Protective Device Coordination Study."
- S. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.
1. Measure as directed during period of normal system loading.
 2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
 3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.
 4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

3.06 PROTECTION

- A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions.

END OF SECTION 26 24 16

SECTION 26 27 26

WIRING DEVICES

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. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Receptacles with integral surge suppression units.
 - 3. Snap switches.
 - 4. Communications outlets.
 - 5. Pendant cord-connector devices.
- B. Related Sections include the following:
 - 1. Division 27 Section "Communications Horizontal Cabling" for workstation outlets.

1.03 DEFINITIONS

- A. EMI: Electromagnetic interference.
- B. GFCI: Ground-fault circuit interrupter.
- C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.
- D. RFI: Radio-frequency interference.
- E. UTP: Unshielded twisted pair.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials and process used for pre-marking wall plates.
- C. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.05 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type of wiring device and associated wall plate through one source from a single manufacturer. Insofar as they are available, obtain all wiring devices and associated wall plates from a single manufacturer and one source.
- 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 NFPA 70.

1.06 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers' Names: Shortened versions (shown in parentheses) of the following manufacturers' names are used in other Part 2 articles:
 - 1. Cooper Wiring Devices; a division of Cooper Industries, Inc. (Cooper).
 - 2. Hubbell Incorporated; Wiring Device-Kellems (Hubbell).
 - 3. Leviton Mfg. Company Inc. (Leviton).
 - 4. Pass & Seymour/Legrand; Wiring Devices & Accessories (Pass & Seymour).

2.02 STRAIGHT BLADE RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 5351 (single), 5352 (duplex).
 - b. Hubbell; HBL5351 (single), CR5352 (duplex).
 - c. Leviton; 5891 (single), 5352 (duplex).
 - d. Pass & Seymour; 5381 (single), 5352 (duplex).
 - 2. Tamper-resistant (TR) models Shall have dual mechanical shutter system to help prevent insertion of foreign objects.
 - a. Install these devices in all lobbies and general public spaces.

2.03 GFCI RECEPTACLES

- A. General Description: Straight blade, feed through type. Comply with NEMA WD 1, NEMA WD 6, UL 498, and UL 943, Class A, and include indicator light that is lighted when device is tripped.
- B. Duplex GFCI Convenience Receptacles, 125 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:

- a. Cooper; GF20.
- b. Pass & Seymour; 2084

2.04 USB RECEPTACLES

- A. Convenience Receptacles, 125 V, 20 A with (1) USB-A & (1) USB-C ports: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R/USB, and UL 498.
- B. Duplex USB Convenience Receptacles, 125 V, 20 A / 5v, 5.0a:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Hubbell; USB20AC5
 - b. Pass & Seymour; PTTR20ACUSBW.

2.05 SNAP SWITCHES

- A. Comply with NEMA WD 1 and UL 20.
- B. Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221 (single pole), 2222 (two pole), 2223 (three way), 2224 (four way).
 - b. Hubbell; CS1221 (single pole), CS1222 (two pole), CS1223 (three way), CS1224 (four way).
 - c. Leviton; 1221-2 (single pole), 1222-2 (two pole), 1223-2 (three way), 1224-2 (four way).
 - d. Pass & Seymour; 20AC1 (single pole), 20AC2 (two pole), 20AC3 (three way), 20AC4 (four way).
- C. Pilot Light Switches, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; 2221PL for 120 V and 277 V.
 - b. Hubbell; HPL1221PL for 120 V and 277 V.
 - c. Leviton; 1221-PLR for 120 V, 1221-7PLR for 277 V.
 - d. Pass & Seymour; PS20AC1-PLR for 120 V.
 - 2. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- D. Key-Operated Switches, 120/277 V, 20 A:
 - 1. Products: Subject to compliance with requirements, provide one of the following:
 - a. Cooper; AH1191N.
 - b. Leviton; 1221-2KL.
 - c. Pass & Seymour; PS20AC1-KL.
 - 2. Description: Single pole, with factory-supplied key in lieu of switch handle.

- E. Single-Pole, Double-Throw, Momentary Contact, Center-Off Switches, 120/277 V, 20 A; for use with mechanically held lighting contactors.

2.06 OCCUPANCY SENSORS

A. Long-Range Sensors:

1. Available Products: Subject to compliance with requirements, products that may be incorporated into the Work include, but are not limited to, the following:
2. Products: Subject to compliance with requirements, provide one of the following:
 - a. Mytech-DT-Series.
 - b. Watt Stopper (The); DT-Series.
 - c. Approved equal.
3. Description: Dual technology, with both passive-infrared- and ultrasonic-type sensing, 120/277 V, adjustable time delay up to 30 minutes, 110-degree field of view, and a minimum coverage area as indicated on the drawings.

2.07 WALL PLATES

A. Single and combination types to match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Material for Finished Spaces: 0.035-inch-thick, satin-finished stainless steel.
3. Material for Unfinished Spaces: Satin-finished stainless steel.
4. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with type 3R weather-resistant thermoplastic with lockable cover.

2.08 MULTIOUTLET ASSEMBLIES

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

1. Hubbell Incorporated; Wiring Device-Kellems.
2. Wiremold Company (The).

B. Components of Assemblies: Products from a single manufacturer designed for use as a complete, matching assembly of raceways and receptacles.

C. Raceway Material: Metal, with manufacturer's standard ivory.

D. Wire: No. 12 AWG or as noted.

2.9 FINISHES

- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 - 1. Wiring Devices Connected to Normal Power System: Gray, unless otherwise indicated or required by NFPA 70 or device listing.

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. Take steps to insure that devices and their boxes are protected. 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 the 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.
 - 4. Existing Conductors:
 - a. Cut back and pigtail, or replace all damaged conductors.
 - b. Straighten conductors that remain and remove corrosion and foreign matter.
 - c. Pigtailing existing conductors is permitted provided the outlet box is large enough.
- D. Device Installation:
 - 1. 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.
 - 2. Keep each wiring device in its package or otherwise protected until it is time to connect conductors.
 - 3. Do not remove surface protection, such as plastic film and smudge covers, until the last possible moment.

4. Connect devices to branch circuits using pigtails that are not less than 6 inches in length.
 5. When there is a choice, use side wiring with binding-head screw terminals. Wrap solid conductor tightly clockwise, 2/3 to 3/4 of the way around terminal screw.
 6. Use a torque screwdriver when a torque is recommended or required by the manufacturer.
 7. When conductors larger than No. 12 AWG are installed on 15- or 20-A circuits, splice No. 12 AWG pigtails for device connections.
 8. Tighten unused terminal screws on the device.
 9. When mounting into metal boxes, remove the fiber or plastic washers used to hold device mounting screws in yokes, allowing metal-to-metal contact.
- E. Receptacle Orientation:
1. Install ground pin of vertically mounted receptacles down, and on horizontally mounted receptacles to the right.
 2. Install hospital-grade receptacles in patient-care areas with the ground pin or neutral blade at the top.
- F. 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.
- G. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical and with grounding terminal of receptacles on top. Group adjacent switches under single, multi-gang wall plates.
- H. Adjust locations of floor service outlets to suit arrangement of partitions and furnishings.

3.02 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
1. Receptacles: Identify panelboard and circuit number from which served. Use hot, stamped or engraved machine printing with black-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.03 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
1. In healthcare facilities, prepare reports that comply with recommendations in NFPA 99.
 2. Test Instruments: Use instruments that comply with UL 1436.
 3. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated LED indicators of measurement.

B. Tests for Convenience Receptacles:

1. Line Voltage: Acceptable range is 105 to 132 V.
2. Percent Voltage Drop under 15-A Load: A value of 6 percent or higher is not acceptable.
3. Ground Impedance: Values of up to 2 ohms are acceptable.
4. GFCI Trip: Test for tripping values specified in UL 1436 and UL 943.
5. Using the test plug, verify that the device and its outlet box are securely mounted.
6. The tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

- C. Test straight blade for the retention force of the grounding blade according to NFPA 99. Retention force shall be not less than 4 oz.

END OF SECTION 26 27 26

SECTION 26 28 13

FUSES

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. Cartridge fuses rated 600-V ac and less.
 - 2. Plug fuses rated 125-V ac and less.
 - 3. Plug-fuse adapters for use in Edison-base, plug-fuse sockets.
 - 4. Spare-fuse cabinets.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:
 - 1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.
 - a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
 - b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.
 - 2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
- B. Operation and Maintenance Data: For fuses 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. Ambient temperature adjustment information.
 - 2. Current-limitation curves for fuses with current-limiting characteristics.

1.04 QUALITY ASSURANCE

- A. Source Limitations: Obtain fuses, for use within a specific product or circuit, from single source from single manufacturer.

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. Comply with NEMA FU 1 for cartridge fuses.
- D. Comply with NFPA 70.
- E. Comply with UL 248-11 for plug fuses.

1.05 PROJECT CONDITIONS

- A. Where ambient temperature to which fuses are directly exposed is less than 40 deg F (5 deg C) or more than 100 deg F (38 deg C) , apply manufacturer's ambient temperature adjustment factors to fuse ratings.

1.06 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.07 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.

PART 2: PRODUCTS

2.01 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Fuses in switchboards, 600 amperes and less:
 - a. Bussman Class L, Limitron KTU (or Hi Cap KRP-C).
 - b. Gould Shawmut Class L, Amp Trap A4BY.
 - c. Littlefuse Class L, KLP-C.
 - 2. Fuses for feeder circuits:
 - a. Bussman Low Peak, LPN-RK (250V) and LPS-RK (600V).
 - b. Gould Shawmut Amp Trap II, A2D-R (250V) and A6D-R (600V).
 - c. Littlefuse, Little Peak, LLN-RK (250V) and LLS-RK (600V).
 - 3. Fuses for Motor circuits:
 - a. Bussman Fusetron, FRN-R (250V) and FRS-R (600V).
 - b. Gould Shawmut Trionic, TR-R (250V) and FLS-R (600V).
 - c. Littlefuse Slo-Blo, FLN-RL (250V) and FLS-R (600V).

4. Special Applications:
 - a. For in-line fuses and weatherproof assembly, provide Bussman Tron Type HEB fuse holder and type KTK fuse with 1A0513 boot or equal.
 - b. For protection of control circuit transformers, provide Bussman type FNQ time delay fuses or equal.

2.02 FUSE MATERIALS

- A. All fuses shall be from one manufacturer.
- B. Fuses in main switchboard, 601 amperes and larger:
 1. U.L. listed, Class L current limiting, 600 volt with interrupting ratings of 200,000 amperes.
 2. Fuse links shall be pure silver plated copper construction..
- C. Fuses for feeder circuits, 600 amperes and less:
 1. U.L. listed, Class RK1, current limiting, time delay with interrupting rating of 200,000 amperes.
 2. Shall also be provided to protect motor loads served from main switchboard.
 3. Shall be rejection type fuses.
- D. Fuses for motor circuits, 600 amperes and less:
 1. U.L. listed, Class RK5, time delay with interrupting rating of 200,000 amperes.
 2. Shall also serve remote disconnect switches.
 3. Shall be rejection type.

2.03 SPARE-FUSE CABINE

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
 1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 2. Finish: Gray, baked enamel.
 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.
- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.
- B. Install plug-fuse adapters in Edison-base fuseholders and sockets. Ensure that adapters are irremovable once installed.
- C. Install spare-fuse cabinet(s) where directed by Owner.

3.03 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 26 28 13

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1: GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

- A. Section Includes:
 - 1. Fusible switches.
 - 2. Nonfusible switches.
 - 3. Receptacle switches.
 - 4. Shunt trip switches.
 - 5. Molded-case circuit breakers (MCCBs).
 - 6. Molded-case switches.
 - 7. Enclosures.

1.03 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.04 SUBMITTALS

- A. Product Data: For each type of enclosed switch, circuit breaker, accessory, and component indicated. Include dimensioned elevations, sections, weights, and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.
 - 1. Enclosure types and details for types other than NEMA 250, Type 1.
 - 2. Current and voltage ratings.
 - 3. Short-circuit current ratings (interrupting and withstand, as appropriate).
 - 4. Include evidence of NRTL listing for series rating of installed devices.
 - 5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
 - 6. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

- B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.
 - 1. Wiring Diagrams: For power, signal, and control wiring.
- C. Qualification Data: For qualified testing agency.
- D. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.
 - 1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
 - 2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
 - 3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- E. Field quality-control reports.
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Results of failed tests and corrective action taken to achieve test results that comply with requirements.
- F. Manufacturer's field service report.
- G. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 - 1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
 - 2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.05 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Member company of NETA or an NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by NETA to supervise on-site testing.
- B. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.
- C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed switches and circuit breakers, including clearances between enclosures, and adjacent surfaces and other items. Comply with indicated maximum dimensions.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NFPA 70.

1.06 COORDINATION

- A. Coordinate layout and installation of switches, circuit breakers, and components with equipment served and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

1.07 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. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 - 2. Fuse Pullers: One for each size and type.

PART 2: PRODUCTS

2.01 FUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- B. Type GD, General Duty, Single Throw, 240-V ac, 800 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with cartridge fuse interiors to accommodate indicated fuses, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Double Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Accessories:
 - 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 - 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 - 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.

4. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
5. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
6. Hookstick Handle: Allows use of a hookstick to operate the handle.
7. Lugs: Mechanical type, suitable for number, size, and conductor material.
8. Service-Rated Switches: Labeled for use as service equipment.

2.02 NONFUSIBLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. Type GD, General Duty, Single Throw, 600 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept two padlocks, and interlocked with cover in closed position.
- C. Type HD, Heavy Duty, Single Throw, 600-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- D. Type HD, Heavy Duty, Six Pole, Single Throw, 600-V ac, 200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- E. Type HD, Heavy Duty, Double Throw, 600-Vac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- F. Accessories:
 1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Isolated Ground Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 5. Hookstick Handle: Allows use of a hookstick to operate the handle.
 6. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.03 RECEPTACLE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
- B. Basis-of-Design Product: Subject to compliance with requirements, provide product indicated on Drawings or comparable product by one of the following:
 - 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 - 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 - 3. Siemens Energy & Automation, Inc.
 - 4. Square D; a brand of Schneider Electric.
- C. Type HD, Heavy-Duty, Single-Throw Fusible Switch 600-V ac, 100 A; UL 98 and NEMA KS 1; horsepower rated, with clips or bolt pads to accommodate indicated fuses; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Type HD, Heavy-Duty, Single-Throw Nonfusible Switch: 600-V ac, 100 A; UL 98 and NEMA KS 1; horsepower rated, lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- E. Interlocking Linkage: Provided between the receptacle and switch mechanism to prevent inserting or removing plug while switch is in the on position, inserting any plug other than specified, and turning switch on if an incorrect plug is inserted or correct plug has not been fully inserted into the receptacle.
- F. Receptacle: Polarized, three-phase, four-wire receptacle (fourth wire connected to enclosure ground lug).

2.04 SHUNT TRIP SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 - 1. Cooper Bussmann, Inc.
 - 2. Ferraz Shawmut, Inc.
 - 3. Littelfuse, Inc.
- B. General Requirements: Comply with, UL 50, and UL 98, with 200-kA interrupting and short-circuit current rating when fitted with Class J fuses.
- C. Switches: Three-pole, horsepower rated, with integral shunt trip mechanism and Class J fuse block; lockable handle with capability to accept three padlocks; interlocked with cover in closed position.
- D. Control Circuit: 120-V ac; obtained from integral control power transformer, with primary and secondary **fuses**, with a control power transformer of enough capacity to operate shunt trip, connected pilot, and indicating and control devices.
- E. Accessories:
 - 1. Oiltight key switch for key-to-test function.
 - 2. Oiltight red ON pilot light.
 - 3. Isolated neutral lug; 100 percent rating.
 - 4. Retain first subparagraph below if using switch for hydraulic elevators with automatic recall. Show required interface wiring on Drawings.
 - 5. Mechanically interlocked auxiliary contacts that change state when switch is opened and closed.
 - 6. Form C alarm contacts that change state when switch is tripped.
 - 7. Retain two subparagraphs below when interfacing elevators with the facility fire-alarm system is required. In first subparagraph, if retaining 24-V dc coil option, a separate 24-V dc source and an initiating contact must be provided by the facility fire-alarm system.

8. Three-pole, double-throw, fire-safety and alarm relay; [120-V ac] [24-V dc] coil voltage.
9. Three-pole, double-throw, fire-alarm voltage monitoring relay complying with NFPA 72.

2.05 MOLDED-CASE CIRCUIT BREAKERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.
- C. Thermal-Magnetic Circuit Breakers: Inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits. Adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
- D. Adjustable, Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
- E. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:
 1. Instantaneous trip.
 2. Long- and short-time pickup levels.
 3. Long- and short-time time adjustments.
 4. Ground-fault pickup level, time delay, and I^2t response.
- F. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.
- G. Integrally Fused Circuit Breakers: Thermal-magnetic trip element with integral limiter-style fuse listed for use with circuit breaker and trip activation on fuse opening or on opening of fuse compartment door.
- H. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
- I. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).
- J. Features and Accessories:
 1. Standard frame sizes, trip ratings, and number of poles.
 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
 4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.

6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Alarm Switch: One contact that operates only when circuit breaker has tripped.
9. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.
10. Zone-Selective Interlocking: Integral with ground-fault trip unit; for interlocking ground-fault protection function.
11. Electrical Operator: Provide remote control for on, off, and reset operations.

2.06 MOLDED-CASE SWITCHES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following
 1. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 3. Siemens Energy & Automation, Inc.
 4. Square D; a brand of Schneider Electric.
- B. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.
- C. Features and Accessories:
 1. Standard frame sizes and number of poles.
 2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
 3. Ground-Fault Protection: Comply with UL 1053; remote-mounted and powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
 4. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
 5. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 6. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.
 7. Alarm Switch: One [NO] [NC] contact that operates only when switch has tripped.
 8. Key Interlock Kit: Externally mounted to prohibit switch operation; key shall be removable only when switch is in off position.
 9. Zone-Selective Interlocking: Integral with ground-fault shunt trip unit; for interlocking ground-fault protection function.
 10. Electrical Operator: Provide remote control for on, off, and reset operations.

2.07 ENCLOSURES

- A. Enclosed Switches and Circuit Breakers: NEMA AB 1, NEMA KS 1, NEMA 250, and UL 50, to comply with environmental conditions at installed location.
 - 1. Indoor, Dry and Clean Locations: NEMA 250, Type 1
 - 2. Outdoor Locations: NEMA 250, Type 3R
 - 3. Other Wet or Damp, Indoor Locations: NEMA 250, Type 4
 - 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.
 - 5. Retain one of two options in subparagraph below to comply with the division and group listing of the environment. Frequently, one enclosure type will accommodate more than one hazardous environment rating. Consult manufacturers for availability of, and limitations on, hazardous environment enclosures. These enclosures do not apply to shunt trip or receptacle switches as specified in the Section Text.

PART 3: EXECUTION

3.01 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from enclosures and components.
- D. Install fuses in fusible devices.
- E. Comply with NECA 1.

3.03 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.04 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. 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.
- C. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
- D. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- E. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- F. Prepare test and inspection reports, including a certified report that identifies enclosed switches and circuit breakers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 26 28 16

SECTION 26 29 13

ENCLOSED CONTROLLERS

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 ac, enclosed controllers rated 600 V and less, of the following types:
 - 1. Across-the-line, manual and magnetic controllers.
 - 2. Reduced-voltage controllers.
 - 3. Multispeed controllers.
 - 4. Variable frequency controllers for small motor applications.
- B. Related Sections include the following:
 - 1. Division 26 Section "Electrical Power Monitoring and Control" for interfacing communication and metering requirements.
 - 2. Division 26 Section "Variable-Frequency Motor Controllers" for general-purpose, ac, adjustable-frequency, pulse-width-modulated controllers for use on constant torque loads in ranges up to 200 hp.
 - 3. Division 26 Section "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for low-voltage power, control, and communication surge suppressors.

1.03 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include dimensions and manufacturer's technical data on features, performance, electrical characteristics, ratings, and finishes.
- B. Shop Drawings: For each enclosed controller.
 - 1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings. 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.
- 2. Wiring Diagrams: Power, signal, and control wiring.
- C. Coordination Drawings: Floor plans, drawn to scale, showing dimensioned layout, required working clearances, and required area above and around enclosed controllers where pipe and ducts are prohibited. Show enclosed controller layout and relationships between electrical components and adjacent structural and mechanical elements. Show support locations, type of support, and weight on each support. Indicate field measurements.
- D. Field quality-control test reports.
- E. 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.
- F. Load-Current and Overload-Relay Heater List: Compile after motors have been installed and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.
- G. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed and arrange to demonstrate that dip switch settings for motor running overload protection suit actual motor to be protected.

1.04 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles (160 km) of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Source Limitations: Obtain enclosed controllers 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, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. Comply with NFPA 70.
- E. Product Selection for Restricted Space: Drawings indicate maximum dimensions for enclosed controllers, minimum clearances between enclosed controllers, and for adjacent surfaces and other items. Comply with indicated maximum dimensions and clearances.

1.05 DELIVERY, STORAGE, AND HANDLING

- A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

- B. If stored in areas subject to weather, cover enclosed controllers to protect them from weather, dirt, dust, corrosive substances, and physical damage. Remove loose packing and flammable materials from inside controllers; install electric heating of sufficient wattage to prevent condensation.

1.06 PROJECT CONDITIONS

- A. Interruption of Existing Electrical Service: Do not interrupt electrical service to facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary electrical service according to requirements indicated:
 - 1. Notify Construction Manager no fewer than two days in advance of proposed interruption of electrical service.
 - 2. Indicate method of providing temporary utilities.
 - 3. Do not proceed with interruption of electrical service without Construction Manager's written permission.

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 size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified in Division 03 Section "Cast-in-Place Concrete."
- C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07 Section "Roof Accessories."
- D. Coordinate features of enclosed controllers and accessory devices with pilot devices and control circuits to which they connect.
- E. 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.

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 following:
- B. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. ABB Power Distribution, Inc.; ABB Control, Inc. Subsidiary.
 - 2. Danfoss Inc.; Danfoss Electronic Drives Div.
 - 3. Eaton Corporation; Cutler-Hammer Products.
 - 4. General Electrical Company; GE Industrial Systems.
 - 5. Rockwell Automation; Allen-Bradley Co.; Industrial Control Group.
 - 6. Siemens/Furnas Controls.
 - 7. Square D.

2.02 ACROSS-THE-LINE ENCLOSED CONTROLLERS

- A. Manual Controller: NEMA ICS 2, general purpose, Class A, with "quick-make, quick-break" toggle or pushbutton action, and marked to show whether unit is "OFF," "ON," or "TRIPPED."
 - 1. Overload Relay: Ambient-compensated type with inverse-time-current characteristics and NEMA ICS 2, Class 10 tripping characteristics. Relays shall have heaters and sensors in each phase, matched to nameplate, full-load current of specific motor to which they connect and shall have appropriate adjustment for duty cycle.

- B. Magnetic Controller: NEMA ICS 2, Class A, full voltage, nonreversing, across the line, unless otherwise indicated.
 - 1. Control Circuit: 120 V; obtained from integral control power transformer with a control power source of sufficient capacity to operate connected pilot, indicating and control devices, plus 100 percent spare capacity.
 - 2. Overload Relay: Ambient-compensated type with inverse-time-current 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. Adjustable Overload Relay: Dip switch selectable for motor running overload protection, and selected to protect motor against voltage and current unbalance and single phasing. Provide relay with Class II ground-fault protection, with start and run delays to prevent nuisance trip on starting.

- C. Combination Magnetic Controller: Factory-assembled combination controller and disconnect switch.
 - 1. 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.
 - 2. Nonfusible Disconnecting Means: NEMA KS 1, heavy-duty, nonfusible switch.
 - 3. Circuit-Breaker Disconnecting Means: NEMA AB 1, motor-circuit protector with field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.

2.03 MULTISPEED ENCLOSED CONTROLLERS

- A. Multispeed Enclosed Controller: Match controller to motor type, application, and number of speeds; include the following accessories:
 - 1. Compelling relay to ensure that motor will start only at low speed.
 - 2. Accelerating relay to ensure properly timed acceleration through speeds lower than that selected.
 - 3. Decelerating relay to ensure automatically timed deceleration through each speed.

2.04 VARIABLE FREQUENCY CONTROLLERS

- A. All VFD are provided by the Mechanical contractor. This contractor is responsible for mounting and provide connection from the power source/panelboard to the VFD and from the VFD to the motor. Coordinate installation with the mechanical contractor and VFD supplier.

2.05 ENCLOSURES

- A. Description: Flush- or surface-mounting cabinets as indicated. NEMA 250, Type 1, unless otherwise indicated to comply with environmental conditions at installed location.
 - 1. Outdoor Locations: NEMA 250, Type 3R.
 - 2. Kitchen Areas: NEMA 250, Type 4X, stainless steel.
 - 3. Other Wet or Damp Indoor Locations: NEMA 250, Type 4.
 - 4. Hazardous Areas Indicated on Drawings: NEMA 250, Type 7C.

2.06 ACCESSORIES

- A. Devices shall be factory installed in controller enclosure, unless otherwise indicated.
- B. Push-Button Stations, Pilot Lights, and Selector Switches: NEMA ICS 2, heavy-duty type.
- C. Stop and Lockout Push-Button Station: Momentary-break, push-button station with a factory-applied hasp arranged so padlock can be used to lock push button in depressed position with control circuit open.
- D. Control Relays: Auxiliary and adjustable time-delay relays.
- E. Elapsed Time Meters: Heavy duty with digital readout in hours.
- F. Phase-Failure and Undervoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connection. Provide adjustable undervoltage setting.

2.07 FACTORY FINISHES

- A. Finish: Manufacturer's standard Grey paint applied to factory-assembled and -tested enclosed controllers before shipping.

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 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.

3.03 INSTALLATION

- A. For control equipment at walls, bolt units to wall or mount on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."

- B. Install freestanding equipment on concrete bases.
- C. Enclosed Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26 Section "Fuses."

3.04 IDENTIFICATION

- A. Identify enclosed controller, components, and control wiring according to Division 26 Section "Identification for Electrical Systems."
- B.

3.05 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables."
- 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- and automatic-control devices that have no safety functions when switch is in hand position.
 - 2. Connect selector switches with enclosed controller circuit 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.

3.06 CONNECTIONS

- A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.
- B. Ground equipment according to Division 26 Section "Grounding and Bonding for Electrical Systems."

3.07 FIELD QUALITY CONTROL

- A. Prepare for acceptance tests as follows:
 - 1. Test insulation resistance for each enclosed 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 controllers, wiring, components, connections, and equipment installation.
 - 2. Assist in field testing of equipment.
 - 3. Report results in writing.

C. Perform the following field tests and inspections and prepare test reports:

1. Perform each electrical test and visual and mechanical inspection, except optional tests, stated in NETA ATS, 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.

3.08 ADJUSTING

A. Set field-adjustable switches and circuit-breaker trip ranges.

3.9 DEMONSTRATION

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

END OF SECTION 26 29 13

SECTION 265119

INTERIOR LIGHTING

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. Interior solid-state luminaires that use LED technology.
 - 2. Lighting fixture supports.
- B. Related Requirements:
 - 1. Section 260943 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls" for manual or programmable control systems with low-voltage control wiring or data communication circuits.

1.3 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.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product.
 - 1. Arrange in order of luminaire designation.
 - 2. Include data on features, accessories, and finishes.
 - 3. Include physical description and dimensions of luminaires.

4. Include emergency lighting units, including batteries and chargers.
 5. Include life, output (lumens, CCT, and CRI), and energy efficiency data.
 6. Photometric data and adjustment factors based on laboratory tests IES LM-79 and IES LM-80.
 - 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. Testing Agency Certified Data: For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
- B. Shop Drawings: For nonstandard or custom luminaires.
1. Include plans indicating all luminaire supports, tubes, pendants or cables that hang down below ceiling and submittal shall be approved by the architect prior to ordering.
 2. Include plans, elevations, sections, and mounting and attachment details.
 3. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 4. Include diagrams for power, signal, and control wiring.
- C. Product Schedule: For luminaires and lamps.

1.5 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Reflected ceiling plan(s) 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. Lighting luminaires.
 2. Support length
 3. Mounting Heights
 4. Suspended ceiling components.
 5. Partitions and millwork that penetrate the ceiling or extend to within 12 inches of the plane of the luminaires.
 6. Structural members to which equipment or luminaires will be attached.
 7. Initial access modules for acoustical tile, including size and locations.
 8. Fixture mounting and supports for ceiling type, or without ceiling.
 9. Items penetrating finished ceiling, including the following:
 - a. Other luminaires.
 - b. Air outlets and inlets.
 - c. Technology equipment
 - d. Speakers.
 - e. Sprinklers.
 - f. Duct Work.
 - g. Cranes
- B. Qualification Data: For testing laboratory providing photometric data for luminaires.

- C. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.
- D. Product Certificates: For each type of luminaire.
- E. Sample warranty.

1.6 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1.7 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.
- B. Lamps: Furnish attic stock (replacement) lamps in the amount of 15%, but no fewer than four of each type of lamp supplied.
- C. In addition to the fixtures indicated on the drawings, provide extra light fixtures as described below. Retain in original factory container/packaging. Fixture locations will be determined during construction.
 - 1. Provide ten (10) exit (Type E1) light fixtures. **A credit of \$300.00 will be required for each unused fixture at project close-out.**
 - 2. Provide 5 (5) Emergency lighting packs (Type E3) light fixtures. **A credit of \$300.00 will be required for each unused fixture at project close-out.**
 - 3. Provide 5 (5) troffer plaster ceiling flange kits for all light fixtures. **A credit of \$50.00 will be required for each unused fixture at project close-out.**

1.8 QUALITY ASSURANCE

- A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.
- B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.
- C. Provide luminaires from a single manufacturer for each luminaire type.
- D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
- B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE 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. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. Bulb shape complying with ANSI C79.1.
- F. Lamp base complying with ANSI C81.61.
- G. CRI of minimum 80. CCT of 4100 K.
- H. Minimum Rated lamp life of 50,000 hours.
- I. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- J. Internal driver.
- K. Nominal Operating Voltage: 120 V ac.
 - 1. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

2.2 EXIT SIGNS

- A. Description: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:

1. Lamps for AC Operation: LEDs, 70,000 hours minimum rated lamp life.

2.3 MATERIALS

A. Metal Parts:

1. Free of burrs and sharp corners and edges.
2. Sheet metal components shall be steel unless otherwise indicated.
3. Form and support to prevent warping and sagging.

B. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

C. Diffusers and Globes:

1. Acrylic Diffusers: One hundred percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
2. Glass: Annealed crystal glass unless otherwise indicated.
3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.

D. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Locate labels where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

1. Label shall include the following lamp characteristics:

- a. "USE ONLY" and include specific lamp type.
- b. Lamp diameter, shape, size, wattage, and coating.
- c. CCT and CRI for all luminaires.

2.4 METAL FINISHES

A. Variations in finishes are unacceptable in the same piece. Variations in finishes of adjoining components are acceptable if they are within the range of approved Samples and if they can be and are assembled or installed to minimize contrast.

2.5 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. All Luminaire supports, tubes, pendants or cables shall have their length coordinated with the architectural plans

B. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

C. Single-Stem Hangers: 1/2-inch steel tubing with swivel ball fittings and ceiling canopy. Finish same as luminaire.

D. Wires: ASTM A 641/A 641 M, Class 3, soft temper, zinc-coated steel, 12 gage.

- E. Rod Hangers: 3/16-inch minimum diameter, cadmium-plated, threaded steel rod.
- F. Hook Hangers: Integrated assembly matched to luminaire, line voltage, and equipment with threaded attachment, cord, and locking-type plug.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, 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 luminaire to verify actual locations of luminaire and electrical connections before fixture installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 TEMPORARY LIGHTING

- A. If approved by the Architect, use selected permanent luminaires for temporary lighting. When construction is sufficiently complete, clean luminaires used for temporary lighting and install new lamps.

3.3 INSTALLATION

- A. Comply with NECA 1.
- B. Install luminaires level, plumb, and square with ceilings and walls unless otherwise indicated.
- C. Install lamps in each luminaire.
- D. Supports:
 - 1. Sized and rated for luminaire weight.
 - 2. Able to maintain luminaire position after cleaning and relamping.
 - 3. Provide support for luminaire without causing deflection of ceiling or wall.
 - 4. Luminaire mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and vertical force of 400 percent of luminaire weight.
- E. Flush-Mounted Luminaire Support:
 - 1. Secured to outlet box.
 - 2. Attached to ceiling structural members at four points equally spaced around circumference of luminaire.
 - 3. Trim ring flush with finished surface.
- F. Wall-Mounted Luminaire Support:
 - 1. Attached to a minimum 20 gauge backing plate attached to wall structural members.

2. Do not attach luminaires directly to gypsum board.

G. Suspended Luminaire Support:

1. Pendants and Rods: Where longer than 48 inches, brace to limit swinging.
2. Stem-Mounted, Single-Unit Luminaires: Suspend with twin-stem hangers. Support with approved outlet box and accessories that hold stem and provide damping of luminaire oscillations. Support outlet box vertically to building structure using approved devices.
3. Continuous Rows of Luminaires: Use tubing or stem for wiring at one point and tubing or rod for suspension for each unit length of luminaire chassis, including one at each end.
4. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.

H. Ceiling-Grid-Mounted Luminaires:

1. Secure to any required outlet box.
2. Secure luminaire to the luminaire opening using approved fasteners in a minimum of four locations, spaced near corners of luminaire.
3. Use approved devices and support components to connect luminaire to ceiling grid and building structure in a minimum of four locations, spaced near corners of luminaire.

I. Remote Power Supplies:

1. Locate and install remote power supplies, drivers and transformers.
2. Provide all wiring and connections.
3. Provide remote power supplies, drivers and transformers for all fixtures listed in the light fixture schedule all specialty low voltage lighting shown to be connected on the lighting plans.
 - a. Verify and provide the proper voltage for all lighting show to be connected.

- J. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.4 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.5 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:

1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
2. Test for Emergency Lighting: Interrupt power supply to demonstrate proper operation. Verify transfer from normal power to battery power and retransfer to normal.

- B. Luminaire will be considered defective if it does not pass operation tests and inspections.

- C. Prepare test and inspection reports.

3.6 STARTUP SERVICE

- A. Comply with requirements for startup specified in Section 260943.16 "Addressable-Fixture Lighting Controls."
- B. Comply with requirements for startup specified in Section 260943.23 "Relay-Based Lighting Controls."

3.7 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 26 51 19

SECTION 265619 - EXTERIOR LIGHTING

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. Exterior solid-state luminaires that are designed for and exclusively use LED lamp technology.
 - 2. Luminaire supports.
 - 3. Luminaire-mounted photoelectric relays.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color rendering index.
- C. Fixture: See "Luminaire."
- D. IP: International Protection or Ingress Protection Rating.
- E. Lumen: Measured output of lamp and luminaire, or both.
- F. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of luminaire.
 - 1. Provide civil plan with exterior pole location for approval by the architect.
 - 2. Arrange in order of luminaire designation.
 - 3. Include data on features, accessories, and finishes.
 - 4. Include physical description and dimensions of luminaire.
 - 5. Lamps, include life, output (lumens, CCT, and CRI), and energy-efficiency data.
 - 6. Photometric data and adjustment factors based on laboratory tests, complying with IES LM-79 & IES LM-80.

- a. **Manufacturer's Certified Data:** Photometric data certified by manufacturer's laboratory with a current accreditation under the NVLAP for Energy Efficient Lighting Products.
 - b. **Testing Agency Certified Data:** For indicated luminaires, photometric data certified by a qualified independent testing agency. Photometric data for remaining luminaires shall be certified by manufacturer.
7. Wiring diagrams for power, control, and signal wiring.
 8. Photoelectric relays.
 9. Means of attaching luminaires to supports and indication that the attachment is suitable for components involved.
- B. **Shop Drawings:** For nonstandard or custom luminaires.
1. Include plans, elevations, sections, and mounting and attachment details.
 2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 3. Include diagrams for power, signal, and control wiring.
- C. **Product Certificates:** For each type of the following:
1. Luminaire.
 2. Photoelectric relay.
- D. Source quality-control reports.
- E. Sample warranty.

1.5 CLOSEOUT SUBMITTALS

- A. **Operation and Maintenance Data:** For luminaires to include in operation and maintenance manuals.
1. Provide a list of all lamp types used on Project. Use ANSI and manufacturers' codes.
 2. Provide a list of all photoelectric relay types used on Project; use manufacturers' codes.

1.6 QUALITY ASSURANCE

- A. **Luminaire Photometric Data Testing Laboratory Qualifications:** Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products and complying with applicable IES testing standards.
- B. Provide luminaires from a single manufacturer for each luminaire type.
- C. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

- D. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering prior to shipping.

1.8 FIELD CONDITIONS

- A. Verify existing and proposed utility structures prior to the start of work associated with luminaire installation.
- B. Coordinate the location of all new exterior luminaires with the mechanical and civil plans to avoid underground utilities and to verify the pole base location is not in sidewalks. Mark locations of exterior luminaires on survey or civil plan for approval by Architect prior to the start of luminaire installation.

1.9 WARRANTY

- A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Structural failures, including luminaire support components.
 - b. Faulty operation of luminaires and accessories.
 - c. Deterioration of metals, metal finishes, and other materials beyond normal Verify available warranties and warranty periods.
 - 2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.1 LUMINAIRE 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. NRTL Compliance: Luminaires shall be listed and labeled for indicated class and division of hazard by an NRTL.
- C. FM Global Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by FM Global.
- D. UL Compliance: Comply with UL 1598 and listed for wet location.

- E. Bulb shape complying with ANSI C79.1.
- F. CRI of minimum 80. CCT of 4100 K.
- G. L70 lamp life of 50,000 hours.
- H. Lamps dimmable from 100 percent to 0 percent of maximum light output.
- I. Internal driver.
- J. Nominal Operating Voltage: 120 V ac.
- K. Lamp Rating: Lamp marked for outdoor use.
- L. Source Limitations: Obtain luminaires from single source from a single manufacturer.
- M. Source Limitations: For luminaires, obtain each color, grade, finish, type, and variety of luminaire from single source with resources to provide products of consistent quality in appearance and physical properties.

2.2 MATERIALS

- A. Metal Parts: Free of burrs and sharp corners and edges.
- B. Sheet Metal Components: Corrosion-resistant aluminum. Form and support to prevent warping and sagging.
- C. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses.
- D. Diffusers and Globes:
 - 1. Acrylic Diffusers: 100 percent virgin acrylic plastic, with high resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.
 - 2. Glass: Annealed crystal glass unless otherwise indicated.
 - 3. Lens Thickness: At least 0.125 inch minimum unless otherwise indicated.
- E. Lens and Refractor Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.
- F. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:
 - 1. White Surfaces: 85 percent.
 - 2. Specular Surfaces: 83 percent.
 - 3. Diffusing Specular Surfaces: 75 percent.
- G. Housings:

1. Rigidly formed, weather- and light-tight enclosure that will not warp, sag, or deform in use.
 2. Provide filter/breather for enclosed luminaires.
- H. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.
1. Label shall include the following lamp characteristics:
 - a. "USE ONLY" and include specific lamp type.
 - b. Lamp diameter, shape, size, wattage and coating.
 - c. CCT and CRI for all luminaires.

2.3 FINISHES

- A. Variations in Finishes: Noticeable variations in same piece are unacceptable. Variations in appearance of adjoining components are acceptable if they are within the range of approved Samples and are assembled or installed to minimize contrast.
- B. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.
- C. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
 2. Natural Satin Finish: Provide fine, directional, medium satin polish (AA-M32); buff complying with AA-M20 requirements; and seal aluminum surfaces with clear, hard-coat wax.
 3. Class I, Clear-Anodic Finish: AA-M32C22A41 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, clear coating 0.018 mm or thicker) complying with AAMA 611.
 4. Class I, Color-Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: Medium satin; Chemical Finish: Etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker), complying with AAMA 611.
 - a. Color: Dark bronze.
- D. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.
1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish

surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1 or SSPC-SP 8.

2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.
 - a. Color: As selected from manufacturer's standard catalog of colors.
 - b. Color: As selected by Architect from manufacturer's full range.

2.4 LUMINAIRE SUPPORT COMPONENTS

- A. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for channel and angle iron supports and nonmetallic channel and angle supports.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine substrates, areas, 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 luminaire electrical conduit to verify actual locations of conduit connections before luminaire installation.
- C. Examine walls, roofs, and canopy ceilings and overhang ceilings for suitable conditions where luminaires will be installed.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 GENERAL INSTALLATION REQUIREMENTS

- A. Comply with NECA 1.
- B. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.
- C. Install lamps in each luminaire.
- D. Fasten luminaire to structural support.
- E. Supports:
 1. Sized and rated for luminaire weight.
 2. Able to maintain luminaire position after cleaning and relamping.
 3. Support luminaires without causing deflection of finished surface.
 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire weight and a vertical force of 400 percent of luminaire weight.
- F. Wall-Mounted Luminaire Support:

1. Attached to a minimum 1/8 inch backing plate attached to wall structural members.
- G. Wiring Method: Install cables in raceways. Conceal raceways and cables.
- H. Install luminaires level, plumb, and square with finished grade unless otherwise indicated. Install luminaires at height and aiming angle as indicated on Architectural Drawings.
- I. Coordinate layout and installation of luminaires with other construction.
- J. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.
- K. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables" and 260533 "Raceways and Boxes for Electrical Systems" for wiring connections and wiring methods.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Inspect each installed luminaire for damage. Replace damaged luminaires and components.
- B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:
 1. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
 2. Verify operation of photoelectric controls.
- C. Illumination Tests:
 1. Measure light intensities at night. Use photometers with calibration referenced to NIST standards. Comply with the following IES testing guide(s):
 - a. IES LM-5.
 - b. IES LM-50.
 - c. IES LM-52.
 - d. IES LM-64.
 - e. IES LM-72.
 2. Operational Test: After installing luminaires, switches, and accessories, and after electrical circuitry has been energized, test units to confirm proper operation.
- D. Luminaire will be considered defective if it does not pass tests and inspections.

- E. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

3.5 DEMONSTRATION

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

3.6 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.
 - 1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
 - 2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
 - 3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION 265619

SECTION 26 72 00

DEMOLITION FOR ELECTRICAL SYSTEMS

PART 1 GENERAL

1.1 APPLICABLE DOCUMENTS

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

1.2 SCOPE OF WORK

- A. Provide the disconnection and removal of electrical materials and equipment for relocation, salvage and proper disposition of items in accordance with the Contract Documents.
- B. Provide the disconnection, removal and protection of light fixtures that are to be relocated. Refer to the lighting plans for additional information.
- C. Disconnection of all electrical connections to mechanical equipment shown on the Mechanical Demolition Plans. This shall also include removal of all associated conduit, wire, disconnects and other electrical equipment.

1.3 RELATED WORK

- A. This is part of General Provisions.

PART 2 PRODUCTS

(Not Applicable)

PART 3 - EXECUTION

3.1 PREPARATION

- A. Prior to submitting a bid, contractor shall inspect existing conditions affecting his work and review the Contract Document requirements. Refer any unclear details or conflicts to the Engineer for clarification prior to commencing the Work. Perform preliminary on-site investigation(s) as required to ascertain extent of Work. Existing conditions which would have become apparent by such investigation(s) will not be allowed as cause for claims for extra cost. Beginning of demolition means Contractor accepts existing conditions.
- B. Plan and coordinate the electrical work with that of other trades/contractors, existing building systems (required to be maintained) and the Owner's occupancy requirements.
- C. Identify any existing damage or non-working fixtures, circuits or systems that are being relocated or extended and notify the Architect and Engineer in writing. Upon completion of construction, it is the contractor responsibility to have all the lighting, branch circuitry, Fire Alarm, PA sound system and other similar systems in good working order.
- D. Identify and provide new supporting means for existing electrical equipment such as low voltage cabling, conduits, boxes, pullboxes, conduit bodies, and conduit racks that will need additional support due to the demolition of the existing supports, including ceilings, walls and structure above. Provide temporary shoring and supports if no existing structural members are available.

- E. Maintain proper exit and egress paths through the building. Provide temporary emergency lighting and illuminated exit signage as required by the Building Official or AHJ.
- F. Conduct demolition to minimize interference with adjacent and occupied building areas.
- G. Perform noisy work before or after the Owner's working hours to minimum disruption.
- H. Coordinate and sequence demolition so as not to cause shutdown of operation of surrounding areas.
- I. Any cutting method, which may create sparks, must include "Fire Watch" and portable fire-suppression devices as required by the Fire Code and/or the Owners Fire Insurance Carrier. Submit fire watch procedures for approval.

3.2 DEMOLITION AND/OR REMODELING

- A. This Contractor shall coordinate, schedule and remove all unused branch circuiting and electrical devices such as light fixtures, receptacles, switches, floor outlets, etc., not indicated to remain.
 - 1. Typically all light fixtures, light switches and duplex receptacles through-out the designated construction area of shall be remove to accommodate the new addition.
 - 2. All exposed unused branch circuiting shall be coordinated, scheduled and removed back to source.
 - 3. When conduits are stubbed out of a surface not being removed for new construction, such as a floor slab, or a poured concrete column or wall that is to remain, these conduits shall be cut back to a point where patching can adequately be performed.
- B. All devices that are to be relocated shall be disconnected, removed, cleaned and stored by this Contractor for reinstallation at a later time.
- C. All devices that are to be removed shall be first offered to Owner for use as salvage or spare parts.
 - 1. All items not wanted by Owner, shall be become the property of this Contractor, removed from the site and legally disposed of. Equipment, devices, etc., removed from the site prior to offering back to the Owner, shall be restored or compensation shall be required, with the amount as determined by the Engineer.
- D. Install blank stainless steel cover plates on all abandoned outlets.
- E. Disposal of all light fixture lamps and ballasts are the responsibility of the Contractor. The Contractor shall carefully remove all such equipment and place in containers and deliver to a certified hazardous waste disposal service and/or a certified hazardous lamp recycling service. Also, Contractor shall provide the Owner with the certification documentation proving that the work has been performed.
- F. Maintain circuit continuity of any electrical devices downstream that are to remain.
 - 1. Provide temporary and permanent service, including branch circuiting, and all necessary components required to maintain proper operation of such devices.
- G. Refer to the architectural and mechanical documents and remove electrical devices, light fixtures, conduits, and wires from walls, ceilings, or equipment items being removed whether or not shown on the electrical drawings at no additional cost to the Owner.
- J. Remove abandoned wiring to source of supply. Remove fuses and turn circuit breakers OFF and provide new, updated panelboard directory for new and existing panelboards that have circuits deleted or added.

3.3 INTERRUPTING SERVICES

- A. Plan, coordinate and obtain permission, in writing, from General Contractor, Architect/Engineer and Owner's site representative prior to any interruption of services.
- B. Perform work that will interrupt electrical service at a time which will cause the least interference with the normal operation of the building and that will minimize the impact to the General Contractor and Owner's Scheduled Events.
- C. Provide 72 hours written notice prior to any required outage and include in Bid, premium time to facilitate such shut-downs. Work shall be performed at times that will minimize the impact to the Owner's Scheduled use of the building.
- D. Should any portion of the fire sprinkler and/or alarm system require removal or relocation, this Contractor shall contact the fire alarm monitoring company and the Owner before such a move is attempted.
- E. Existing sound, call, fire alarm, fire sprinkler, voice/data and other systems must remain intact and operating at all times. Should any portion of the system require removal, interruption or relocation due to demolition work, this Contractor shall coordinate that work with the Owner's Building Contractors performing this work and with the Architect/Engineer and Owner before disconnection. Provide all necessary components to provide and maintain the building systems in a complete and operating system condition.

3.4 EXISTING CONDITIONS

- A. Electrical devices shown on the drawings as existing have been based on existing plans and/or sight observations; however, they may not be installed as originally shown. Although a site survey has been conducted to discover some of these differences, no attempt has been made to find changes made in hidden areas such as above ceilings and in walls. It shall be the Contractor's responsibility to verify the accuracy of the "Existing Conditions" as shown on the drawings. The Contractor shall perform all modifications and additions as necessary to correct for hidden conditions and allow for the completion of the new work.

END OF SECTION

SECTION 27 05 00

COMMON WORK RESULTS FOR COMMUNICATIONS

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. Communications equipment coordination and installation.
 - 2. Sleeves for pathways and cables.
 - 3. Pillow seals for sleeves.
 - 4. Common communications installation requirements.

1.03 COORDINATION

- A. Coordinate arrangement, mounting, and support of communications equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting pathways, cables, wireways, and busways will be clear of obstructions and of the working and access space of other equipment.
- B. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- C. Coordinate location of access panels and doors for communications items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Steel Doors and Frames."
- D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Firestopping."

PART 2: PRODUCTS

2.01 SLEEVES FOR PATHWAYS AND CABLES

- A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

2.02 SLEEVE SEALS

- A. Description: Modular sealing pillows, designed for field assembly, to fill annular space between sleeve and pathway or cable. Provide pillows to seal all sleeves in fire-rated walls and all sleeves over 1" in diameter.
 - 1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.

PART 3: EXECUTION

3.01 COMMON REQUIREMENTS FOR COMMUNICATIONS INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both communications equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR COMMUNICATIONS PENETRATIONS

- A. Communications penetrations occur when pathways, cables, penetrate concrete slabs, concrete or masonry walls, gypsum walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 4 inches above finished floor level.
- G. Size pipe sleeves to provide a minimum of 1/4-inch annular clear space between sleeve and pathway or cable, unless larger size is indicated.

- H. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and pathway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- I. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pathway and cable penetrations. Install sleeves and seal pathway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."
- J. Roof-Penetration Sleeves: Seal penetration of individual pathways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- K. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.

3.03 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for communications installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Firestopping."

END OF SECTION 27 05 00

**SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS**

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. Telecommunications mounting elements.
 2. Backboards.
 3. Telecommunications equipment racks and cabinets.
 4. Telecommunications service entrance pathways.
 5. Grounding.

1.03 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. LAN: Local area network.
- C. RCDD: Registered Communications Distribution Designer.

1.04 SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Shop Drawings: For communications equipment room fittings. 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. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
 3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.

1.05 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

1. Layout Responsibility: Preparation of Shop Drawings shall be under the direct supervision of RCDD.
 2. 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.
 3. Field Inspector: Currently registered by BICSI as RCDD to perform the on-site inspection.
- 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- D. Grounding: Comply with ANSI-J-STD-607-A.

1.06 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install equipment frames until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.07 COORDINATION

- A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service 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 them to other participants.
 3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of 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 locations of communications equipment requiring electrical power to operate.

PART 2: PRODUCTS

2.01 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

- B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
 - 2. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 3. Lacing bars, spools, J-hooks, and D-rings.
 - 4. Straps and other devices.
- C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."
 - 1. Outlet boxes shall be no smaller than 4 inches wide, 4 inches high, and 2-1/4 inches deep.

2.02 BACKBOARDS

- A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches mounted on all wall in data/server rooms. Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry." Paint with (2) coats white paint per architectural specification.

2.03 EQUIPMENT FRAMES

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Cooper B-Line, Inc.
 - 2. Hubbell Premise Wiring.
 - 3. Leviton Voice & Data Division.
 - 4. Middle Atlantic Products, Inc.
 - 5. Ortronics, Inc.
 - 6. Panduit Corp.
 - 7. Siemon Co. (The).
 - 8. Belden
 - 9. Hoffman
- B. General Frame Requirements:
 - 1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
 - 2. Module Dimension: Width compatible with EIA 310 standard, 19-inch panel mounting.
 - 3. Finish: Manufacturer's standard, baked-polyester powder coat.
- C. Floor-Mounted Racks: Modular-type, steel construction.
 - 1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug, and a power strip.
 - 2. Baked-polyester powder coat finish.

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

D. Modular Freestanding Cabinets:

1. Removable and lockable side panels.
2. Hinged and lockable front and rear doors.
3. Adjustable feet for leveling.
4. Screened ventilation openings in the roof and rear door.
5. Cable access provisions in the roof and base.
6. Grounding bus bar.
7. Rack mounted, 550-cfm fan with filter.
8. Power strip.
9. Baked-polyester powder coat finish.
10. All cabinets keyed alike.

E. Modular Wall Cabinets:

1. Wall mounting.
2. Steel construction.
3. Treated to resist corrosion.
4. Lockable front and rear doors.
5. Louvered side panels.
6. Cable access provisions top and bottom.
7. Grounding lug.
8. Rack-mounted, 250-cfm fan.
9. Power strip.
10. All cabinets keyed alike.

F. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.04 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Rack mounting.
2. Six, 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
3. LED indicator lights for power and protection status.
4. LED indicator lights for reverse polarity and open outlet ground.
5. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

6. Close-coupled, direct plug-in line cord.
7. Rocker-type on-off switch, illuminated when in on position.
8. Peak Single-Impulse Surge Current Rating: 13 kA per phase.
9. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

2.05 GROUNDING

- A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- B. Provide a telecommunications Ground Bus Bar in each Telecommunications (Voice and/or Data) Room:
 1. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
 2. Ground Bus Bar: Copper, minimum 1/4"T x 2"W x 12"L with 3/8-inch holes spaced 1-1/8 inches apart.
 3. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.
- C. Comply with ANSI-J-STD-607-A.

2.06 LABELING

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers

PART 3: EXECUTION

3.01 INSTALLATION

- A. Comply with NECA 1.
- B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.
- C. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.
- D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.02 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping." Comply with TIA/EIA-569-A, Annex A, "Firestopping."

SECTION 27 11 00
COMMUNICATIONS EQUIPMENT ROOM FITTINGS

- B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.03 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 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.

3.04 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems." Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.
- B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.
- C. Labels shall be preprinted or computer-printed type.

END OF SECTION 27 11 00

**SECTION 27 13 00
COMMUNICATIONS BACKBONE 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.

1.02 SCOPE

- A. Install new Backbone cabling for the new Data Room.
- B. Pull back, re-route and reconnect the 144 pair city owned fiber.
1. The existing fiber enters the building 3' above grade in the front of the building. Is connected in the room where it enters and has approx. 15' of coiled slack.
 2. The existing entrance enter the building where a new window is to be installed
 3. Pull back outside the building, create a new entrance that does not interfere with construction (within 5' of original location) and reroute.
 - a. New location shall be near grade or below and properly water sealed/protected.
 4. Reconnect fiber and test as required.
 5. Existing fiber is live and shall be coordinated with the owner.
 - a. Downtime shall be done outside normal business hours and limited to 4-5 or as coordinated with owner I.T.

1.03 SUMMARY

- A. Section Includes:

1. Pathways.
2. Single Mode armored optical fiber cabling.
3. Cable connecting hardware, patch panels, and cross-connects.
4. Cabling identification products.

- B. Related Sections:

1. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices

1.04 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- C. EMI: Electromagnetic interference.
- D. IDC: Insulation displacement connector.
- E. LAN: Local area network.
- F. RCDD: Registered Communications Distribution Designer.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

G. UTP: Unshielded twisted pair.

1.05 BACKBONE CABLING DESCRIPTION

- A. The existing Data/server room on the main level internally and externally will be required to remain operational. Down time will be limited and requires advanced scheduling with the owner.
- B. This contractor shall identify the existing connections within the building on a plan that includes internal fiber, room to room and all fiber that enters and/or leaves the building.
- C. Backbone cabling system shall provide interconnections between the server room and the data room #A220B. Cabling system consists of backbone cables, intermediate and main cross-connects mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.
- D. Provide 6pr (12 strand) armored single mode fiber optic cable, with connectors matching existing, from the main server room to the Data room #A220B. Provide Fiber distribution enclosure in each rack or telecommunications enclosure. Provide patch cords to switches.
- E. Backbone cabling cross-connects may be located in communications equipment rooms or at entrance facilities. Bridged taps and splitters shall not be used as part of backbone cabling.
- F. Provide 25pair UTP cable from the Server room to the data room. UTP shall be terminated on 110 wall mounted blocks and labeled.

1.06 PERFORMANCE REQUIREMENTS

- A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-C.3, when tested according to test procedures of this standard.

1.07 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings:
 - 1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 - 2. Cabling administration drawings and printouts.
 - 3. Wiring diagrams to show typical wiring schematics including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

- 4. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
- C. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- D. Source quality-control reports.
- E. Field quality-control reports.
- F. Maintenance Data: For splices and connectors to include in maintenance manuals.

1.08 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
 - 1. Layout Responsibility: Preparation of Shop Drawings by an RCDD or pre-approve county vendor.
 - 2. 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.
- B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- E. Grounding: Comply with ANSI-J-STD-607-A.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
 - 1. Test optical fiber cable to determine the continuity of the strand end to end. Use optical fiber flashlight or optical loss test set.
 - 2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.

1.010 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until 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.

**SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING**

1.11 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

PART 2: PRODUCTS

2.01 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.

2.02 OPTICAL FIBER CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Berk-Tek; a Nexans company.
 2. CommScope, Inc.
 3. Corning Cable Systems.
 4. Mohawk; a division of Belden CDT.
 5. Siemon
- B. Description: Provide 12 strand-fiber single mode, Armored, tight buffer, optical fiber cable.
1. Comply with ICEA S-83-596 for mechanical properties.
 2. Comply with TIA/EIA-568 for performance specifications.
 3. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:
 - a. Plenum-Rated: Type OFCP, complying with NFPA 262.
- C. Jacket:
1. Cable cordage jacket, fiber, unit, and group color shall be according to TIA/EIA-598-B.
 2. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches.

2.03 OPTICAL FIBER CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
1. Berk-Tek; a Nexans company.
 2. Corning Cable Systems.
 3. Hubbell Premise Wiring.
 4. Siemon Co. (The).
 5. Leviton
- B. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.
- C. Patch Cords: Factory-made, Connectors matching existing, dual-fiber cables in 36-inch lengths.
- D. Cable Connecting Hardware:
 1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
 2. Quick-connect, duplex connectors.

2.04 GROUNDING

- A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.
- B. Comply with ANSI-J-STD-607-A.

2.05 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.06 SOURCE QUALITY CONTROL

- A. Testing Agency: Engage a qualified testing agency to evaluate cab
- B. Factory test cables on reels according to TIA/EIA-568-B.1.
- C. Factory test single mode optical fiber cables according to TIA/EIA-526 and TIA/EIA-568.
- 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 WIRING METHODS

- A. Wiring Method: Utilize appropriate J-Hooks for distribution between data rooms.
 1. Install armored plenum cable only.
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors.
- C. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

3.02 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.
- B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- E. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Secure conduits to backboard when entering room from overhead.
 - 3. Extend conduits 4 inches above finished floor.
 - 4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- F. Backboards: Install backboards with 96-inch dimension vertical. Butt adjacent sheets tightly, and form smooth gap-free corners and joints.

3.03 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Comply with TIA/EIA-568-B.1.
 - 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 - 3. Cables may not be spliced. 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.
 - 4. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 - 5. 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. Use lacing bars and distribution spools.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

6. 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.
 7. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
 8. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
 9. Pulling Cable: Comply with manufactures requirements. Monitor cable pull tensions.
- C. Optical Fiber Cable Installation:
1. Comply with TIA/EIA-568-C.3.
 2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.
- D. Group connecting hardware for cables into separate logical fields.

3.04 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Firestopping. "Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- B. Comply with BICSI TDMM, "Firestopping Systems" Article.
- C. Use firestopping modular pillows. Do not use fire caulking.

3.05 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 No. 2/0 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 TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 1. Administration Class: 2.
 2. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

- B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA/EIA standard as it applies to this Section. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.
- C. Cable Schedule: Install in a 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.
- D. 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, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.
- E. 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. 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.
- F. 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 TIA/EIA 606-A, for the following:
 - 1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.07 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
 - 2. Optical Fiber Cable Tests:
 - a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
 - b. Link End-to-End Attenuation Tests:
 - 1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.

SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING

- 2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.
- C. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted in accordance with BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. Remove and replace cabling where test results indicate that they do not comply with specified requirements.
- E. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports and submit to Engineer for review and approval.

END OF SECTION 27 13 00

**SECTION 27 13 00
COMMUNICATIONS BACKBONE CABLING**

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL 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.

1.02 SUMMARY

- A. Section Includes:
1. Pathways.
 2. UTP cabling.
 3. Cable connecting hardware, patch panels, and cross-connects.
 4. Telecommunications outlet/connectors.
 5. Cabling system identification products.

1.03 SCOPE

- A. Existing
1. All existing cables for removed data devices and old telephone systems in in areas of construction shall be removed.
- B. New
1. Provide new cabling, equipment and devices as indicated on drawings and in the spec.

1.04 DEFINITIONS

- A. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. LAN: Local area network.
- E. WAP: Wireless Access Point
- F. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.
- G. UTP: Unshielded twisted pair.

1.05 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

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. Bridged taps and splices shall not be installed in the horizontal cabling.
- B. Each voice/data outlet (1/2 shaded triangle) shall have three (3) data jacks and cables (unless noted otherwise).
- C. Each multi Data outlet (open triangle) shown on the plans shall have 2 data jacks and cables (unless noted otherwise).
- D. Each single Data outlet (fully shaded triangle) shown on the plans shall have 1 data jacks and cable (unless noted otherwise).
- E. Each TV outlet shown on the plans shall have HDMI jacks and cable routed to the server room (unless noted otherwise).
- F. Each WAP (Wireless Access Point) Data outlet (open triangle w/ "WAP") shown on the plans shall have (2) Cat 6A data jacks and cables (unless noted otherwise).
- G. Provide additional Cat 6 cables to the following locations:
 1. (2) fire alarm control panel
 2. Gas Meter
 3. Elevator control room
 4. Elevator communication panels on each floor
 5. Clock System
 6. Walk-in refrig/freezer
 7. Building automation system
- H. Each outlet box shall be a minimum of 4" x 4" x 2¼" with a single gang mud ring and faceplate. All devices shall be modular. Each outlet box shall have 1" conduit stubbed to above accessible ceiling space with a nylon bushing, unless indicated otherwise.
- I. 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. The maximum allowable length does not include an allowance for the length of 16 feet in the horizontal cross-connect.

1.06 PERFORMANCE REQUIREMENTS

- A. General Performance: Horizontal cabling system shall comply with Category 6 transmission standards in TIA/EIA-568-C.2, when tested according to test procedures of this standard.
- B. WAP Performance: Horizontal cabling system for WAP locations shall comply with Category 6A transmission standards in TIA/EIA-568-C.2, when tested according to test procedures of this standard.

1.07 SUBMITTALS

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

**SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING**

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
 2. Wiring diagrams to show typical wiring schematics, including the following:
 - a. Cross-connects.
 - b. Patch panels.
 - c. Patch cords.
 3. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
- C. Samples: For workstation outlets, jacks, jack assemblies, in specified finish, one for each size and outlet configuration.
- D. Qualification Data: For Installer, qualified layout technician, installation supervisor, and field inspector.
- E. Source quality-control reports.
- F. Field quality-control reports.
- G. Maintenance Data: For splices and connectors to include in maintenance manuals.
- H. As-Built: Provide complete electronic and hard copies of as-built drawings (floor plans) indicating all horizontal cabling, devices, labeling, and backbone cabling.

1.08 QUALITY ASSURANCE

- A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.
1. Layout Responsibility: Preparation of Shop Drawings and Cabling Administration Drawings, by an RCDD or pre-approved county vendor.
 2. 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.
- 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. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.
- D. Grounding: Comply with ANSI-J-STD-607-A.

1.09 DELIVERY, STORAGE, AND HANDLING

- A. Test cables upon receipt at Project site.
1. Test each pair of UTP cable for open and short circuits.

**SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING**

1.010 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until 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.

1.11 COORDINATION

- A. Coordinate layout and installation of telecommunications pathways and 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.

1.12 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. Provide (6) complete voice/data outlets locations to be installed during construction. Exact locations to be determined in the field, estimate 200' from telecom room. Each outlet shall have two data. **A credit of \$300.00/outlet shall be required at Project Close-Out for any unused outlets.**

PART 2: PRODUCTS

2.01 PATHWAYS

- A. General Requirements: Comply with TIA/EIA-569-A.
- B. Provide 1" metal conduit sleeves from main corridors to every room requiring voice/data devices. Sleeves shall be located above accessible ceiling and bushed on both ends. Low-voltage installer shall determine exact locations and quantities.
- C. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support for cabling between the Cross-Connect the work area outlet shall be accomplished with metal j-hooks. Plenum rated plastic Velcro straps, zip-ties, etc... will **not be allowed.**

2.02 UTP CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Mohawk
 - 2. Superior Essex
 - 3. Berk-Tek
 - 4. General Cable
 - 5. Signamax
 - 6. Seimon

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

- B. Description: Enhanced Category 6, 100-ohm, 23 AWG 4-pair UTP, with a blue thermoplastic jacket.
1. Comply with ICEA S-90-661 for mechanical properties.
 2. Comply with TIA/EIA-568-C.2 for performance specifications.
 3. Comply with TIA/EIA-568-C.2, Category 6.
 4. Shall meet IEEE 802.af and IEEE 802at for PoE applications
 5. 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. Description: Augmented Category 6, 500-ohm, 23 AWG 4-pair UTP, with an orange thermoplastic jacket and non-continuous shielding wire and rated for 10GBASE-T.
1. Comply with ICEA Sfor mechanical properties.
 2. Comply with TIA/EIA-568-C.1 for performance specifications.

2.03 UTP CABLE HARDWARE

- A. Manufacturers: Subject to compliance with requirements, provide products by the following:
1. Panduit Corp. - TX6000 series
 2. Belden
 3. Signamax
 4. Hitachi
- B. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.
- C. Terminate all cables in rack-mounted patch panels. Do not install wall-mounted blocks.
- D. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.
1. Number of Terminals per Field: One for each conductor in assigned cables.
- E. Patch Panel: Provide separate patch panel for general cabling (Cat 6E) and WAP (Cat 6A) Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables. Provide (48) port panels with 25% spare capacity.
1. Number of Jacks per Field: One for each four-pair plus 25% spare capacity.
- F. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

- G. Patch Cords: Factory-made, four-pair cables in lengths as required; terminated with eight-position modular plug at each end.
1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6E performance. Patch cords shall have latch guards to protect against snagging.
 2. Patch cords shall have color-coded boots for circuit identification.

2.04 TELECOMMUNICATIONS OUTLET/CONNECTORS

- A. Jacks: 100-ohm, balanced, twisted-pair connector; four-pair, eight-position modular. Comply with TIA/EIA-568-B.1.
- B. Outlets: Each voice/data outlet & TV outlet shall have Cat 6e cables and devices, quantity as above. Data outlets for WAP Wireless access points shall have (2) Cat 6A cable and device terminated in separate patch panels.
1. Metal Faceplate: Satin Stainless Steel. Coordinate with Division 26 Section "Wiring Devices."
 2. For use with snap-in jacks accommodating any combination of UTP, optical fiber, and coaxial work area cords.
 - a. Flush mounting jacks, ~~positioning the cord at a 45-degree angle.~~
 3. Legend: Snap-in, clear-label covers and machine-printed paper inserts.

2.05 GROUNDING

- A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.
- B. Comply with ANSI-J-STD-607-A.

2.06 IDENTIFICATION PRODUCTS

- A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.07 SOURCE QUALITY CONTROL

- A. Factory test UTP cables according to TIA/EIA-568-C.2.
- B. Cable will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

PART 3: EXECUTION

3.01 WIRING METHODS

- A. Wiring Method: Install cables in 1" minimum, metal raceways except above accessible ceiling spaces. Conceal raceway and cables except in unfinished spaces.
 - 1. Install plenum cable only.
 - 2. Comply with requirements for raceways and boxes specified in Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors.
- C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.02 INSTALLATION OF PATHWAYS

- A. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings."
- B. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- C. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.
- D. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- E. Pathway Installation in Communications Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room. Where applicable, conduits shall enter room at a location to correspond with ladder racking in room.
 - 2. Secure conduits to backboard when entering room from overhead.
 - 3. Extend conduits 4 inches above finished floor.
 - 4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.03 INSTALLATION OF CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

1. Comply with TIA/EIA-568-B.1.
 2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
 3. Terminate conductors; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
 4. Cables may not be spliced. 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.
 5. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
 6. 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.
 7. 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.
 8. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
 9. In the communications equipment room, install a 10-foot-long service loop on each end of cable.
 10. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.
- C. UTP Cable Installation:
1. Comply with TIA/EIA-568-B.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 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 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:

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
3. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.04 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Penetration Firestopping."
- B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.
- D. Use firestopping pillows only. Do not use fire caulk.

3.05 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 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 TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 1. Administration Class: 2.
 2. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
- B. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.
- C. 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.

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

- D. 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, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors. Follow convention of TIA/EIA-606-A. Furnish electronic record of all drawings, in software and format selected by Owner.
- E. 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. 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.
- F. 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 TIA/EIA-606-A.
1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.07 FIELD QUALITY CONTROL

- A. Perform tests and inspection
- B. Tests and Inspections:
1. Visually inspect UTP and 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 TIA/EIA-568-B.1.
 2. Visually confirm Category 6, 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 TIA/EIA-568-B.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 TIA/EIA-568-B and TIA/EIA-568-C.2:

SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING

- 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.
- C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted in accordance with the BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. 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 15 00

**SECTION 27 15 00
COMMUNICATIONS HORIZONTAL CABLING**

PART 1 GENERAL

1.1 SECTION INCLUDES

- A. Specifications for Council Chambers Audio, Video Presentation, Broadcast and Control Systems.
- B. Submittal Requirements
- C. Quality Assurance
- D. Warranty
- E. Equipment List

1.2 RELATED SECTIONS

- A. 02 00 00 Existing Conditions
- B. 06 40 00 Architectural Woodwork
- C. 09 50 00 Ceilings
- D. 09 80 00 Acoustic Treatment
- E. 11 52 00 Audio-Visual Equipment – refer to this section
- F. 12 30 00 Casework
- G. 26 00 00 Electrical
- H. 27 00 00 Communications

1.3 REFERENCES

- A. NFPA 70 - National Electric Code
- B. NEC 2017 – National Electric Code

1.4 DEFINITIONS

- A. Owner: City of Hopkins
- B. Owner's Technical Contact: Alex Hepp
- C. Architect: Wold Architects and Engineers
- D. Electrical Engineer: Karl Bohnsack, Paulson & Clark Engineering
- E. Technology Consultant: Kyle Moorhead, MoreCom
- F. For Abbreviations, Reference Sheet T0.00

1.5 SYSTEM DESCRIPTION

- A. General
 1. Provide and Install architecturally integrated audio-visual systems in council chambers and lobby which includes: audio, video, presentation, control, broadcast and automated playback systems.
 2. Contractor shall coordinate with owner, consultant and other trades as necessary to achieve a complete and operational system.
 3. Owner Furnished Equipment (OFE) is equipment that is presently installed and in use. Contractor shall remove all audio-visual equipment from council chambers and related control room and re-use components identified as OFE.
 4. The drawings and specifications represent a conceptual system. It is the sole responsibility of the contractor to engineer and build a complete and operational system that meets owner and consultants' expectations without seeking additional compensation.
 5. Reference Sheet T0.00 for cable types and specifications.
 6. Note: Contractor shall remove all equipment and cabling from all control room equipment racks, clean up the control room cabling, reuse existing racks to house new system. Contractor shall provide shop drawings of rack details.

- B Audio (Sheet T4.41)
1. Microphones
 - a. Shure, MX412/s and MX418/s, Gooseneck Microphones
 1. Contractor shall remove and reuse OFE designated microphones.
 2. Contractor shall provide and install new microphones as required.
 2. Contractor shall coordinate with Owner on desired locations of microphones.
 3. Contractor shall drill holes into furniture and mount microphones with non-shock-mount per manufactures directions.
 4. Contractor shall conceal connectors and cables from view.
 - b. Shure, ULXS series, Wireless Microphones
 1. Contractor shall remove and reuse OFE designated wireless microphones.
 - c. Winegard, SS-2200, Square Shooter Antenna
 1. Contractor shall remove and reuse OFE designated wireless microphone antennas (2).
 2. Contractor shall note the relocation of the antennas in the new council chambers layout.
 3. Contractor shall coordinate with owner on exact locations desired for antennas.
 2. Audio Mixers
 - a. Lectrosonics, DM1612, matrix audio mixers (2)
 1. Contractor shall remove and reuse two (2) OFE audio mixers.
 2. Contractor shall re-program audio mixers for optimum reinforced sound and broadcast audio performance.
 3. Contractor shall meet Owner and Consultants desired operational performance. Reference sheet T4.31 Tag Notes for more information.
 3. Equalizers
 - a. Contractor shall remove existing Sabine equalizers and provide to Owner's technical contact. These equalizers shall not be reused in the new system.
 - b. Ashly, MQX-2310 equalizers
 1. Contractor shall provide and install five (5) Ashly graphic equalizers.
 2. Contractor shall adjust equalizers for optimum reinforced sound performance.
 3. Contractor shall meet Owner and Consultants desired operational performance.

4. Audio Amplifiers

- a. Crown Audio, CTS-4200, four channel audio amplifier
 1. Contractor shall remove and reuse one (1) OFE, audio amplifier.
 2. Contractor shall configure audio amplifier for optimum reinforced sound performance.
 3. Contractor shall meet Owner and Consultants desired operational performance.
- b. Crown Audio, 8|300, eight channel audio amplifier
 1. Contractor shall provide and install one (1) eight channel audio amplifier.
 2. Contractor shall configure audio amplifier for optimum reinforced sound performance.
 3. Contractor shall meet Owner and Consultants desired operational performance.

5. Ceiling Speakers

- a. Existing Speakers
 1. Contractor shall remove and dispose existing ceiling speakers in the council chambers and lobby areas as they shall not be reused in this project.
- b. JBL, 47HC, Narrow Beam, Ceiling Speaker, 70Volt
 1. Contractor shall provide and install fourteen (14), ceiling speakers into council chambers finished ceiling.
 2. Contractor shall position and configure (tap) speakers for optimum reinforced sound performance while maintaining optimum gain before feedback.
 3. Contractor shall meet Owner and Consultants desired operational performance.
- c. JBL, 47LP, Low Profile, Ceiling Speaker, 70Volt
 1. Contractor shall provide and install four (4), ceiling speakers into lobby's finished ceiling.
 2. Contractor shall position and configure (tap) speakers for optimum reinforced sound performance while maintaining optimum gain before feedback.
 3. Contractor shall meet Owner and Consultants desired operational performance.

6. Volume Control

- a. Primary sound/volume control shall be accomplished via the control system additionally, in the lobby, contractor shall provide a manual wall mounted volume control for additional volume control of the lobby speaker zone.
- b. OSD Audio, MVC-100, White
 1. Contractor shall provide and install one (1), volume control into lobby.
 2. Contractor shall coordinate with owner and consultant as well as with other trades on the exact location of volume control.
 3. Contractor shall meet Owner and Consultants desired operational performance.

C. Council Chambers Presentation Video (Sheet T4.41)

1. Lectern Computer

a. Logitech MK270, Keyboard and Mouse

1. Contractor shall remove and reuse existing (OFE) wireless keyboard and mouse for the lectern computer.

b. Logic Supply, CL100 Fanless Computer

1. Contractor shall provide and install a (1), Logic supply CL100 fanless computer configured with an Intel Braswell Pentium N3710 processor; 8GB SO-DIMM DDR3L 1600 Memory; 512 GB mSATA SSD hard drive; Wireless, Wi-Fi/BT, Realtek Dual-Band 1x1 802.11a/b/g/n/ac, (AW-CB161H) wireless option; Wi-Fi dual band terminal antenna, 108mm; DC 12V, 36W, power adapter with interchangeable plug; Auto Power On option; Wall Mounting Brackets; Computer Port & Dust Blocking Kit; Windows 10 Pro 64Bit operating system; 5-year extended manufacture's warranty.

2. Contractor shall provide and install a custom, permanent mounting solution for computer. Contractor shall coordinate with owner and consultant on location.

c. Network Cable, CAT5e

1. Contractor shall provide and install a CAT5e network cable with RJ45 connectors between Lectern computer and terminating to the network switch in the control room.

2. Cable is identified as D13

d. Cables to Go, 56783, HDMI Cable

1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.

e. Blackmagic Design, CONVBCD/SDIHDWPSU, HDMI to SDI Micro Converter

1. Contractor shall provide and install one (1) HDMI to SDI converter.

2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.

3. Contractor shall configure converter for optimum system performance. Contractor shall coordinate with consultant and owner on locations and performance expectations.

2. Lectern Bring Your Own Device (BYOD)
 - a. Network Cable
 1. Contractor shall provide and install a CAT5e stranded network cable with RJ45 connectors between the BYOD, passing through the table box and terminating to the network switch in the control room.
 2. Reference Tag Notes on Sheet T4.41
 - b. Cables to Go, 50612, HDMI cable
 1. Contractor shall provide and install a (1) fifteen foot (15') high speed HDMI cable with ethernet.
 2. Reference Tag Notes on Sheet T4.41
 - c. Cables to Go, 54403, Display Port Cable
 1. Contractor shall provide and install a (1) fifteen foot (15') DisplayPort cable with Latches 8K UHD M/M Black.
 2. Reference Tag Notes on Sheet T4.41
 - d. Cables to Go 50227, VGA Cable with Audio
 1. Contractor shall provide and install a (1) fifteen foot (15') VGA with 3.5mm Stereo Audio A/V cable M/M.
 2. Reference Tag Notes on Sheet T4.41
 - e. Extron Electronics, 60-1405-02 Cable Cubby 700
 1. Contractor shall remove and reuse existing Extron Cable Cubby 700 and its accessory items.
 2. Contractor shall install into the face of the new lectern concealing all cables when lid is closed.
 3. Contractor shall coordinate with owner and consultant on exact location in new lectern.
 4. Reference Tag Notes on Sheet T4.41
 - f. Kramer Electronics, SID-X3N, Switcher
 1. Contractor shall provide and install a Kramer Electronics SID-X3N switcher.
 2. Contractor shall conceal switcher into framing of lectern behind access panels.
 3. Contractor shall update firmware of new device.
 4. Contractor shall set the DIP-switches per the following:
 - 1 = Off in general use, on when updating firmware.
 - 2 = Off, use analog audio
 - 3 = On, use analog audio in the DVI signal
 - 4 = On, set video mode to Last Connected
 - 5 = Off, automatic EDID
 - 6 = On, Switching Delay set to .5 seconds
 - 7 = Off, output disable delay set to 15 minutes
 - 8 = ON, power is always on
 5. Contractor shall coordinate with owner and consultant on exact location in new lectern.
 6. Reference Tag Notes on Sheet T4.41
 - g. Cables to Go, 56783 (V21)
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V21 on Sheet T4.41 but is lacking a unique project identifier.
 3. Cable shall be concealed from view and installed behind the lectern access panels into the framing of the lectern.
 4. Coordinate exact location with owner and consultant on exact location in new lectern.

- h. Blackmagic Design, CONVBC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.
- 3. North Staff Table Computer
 - a. Logitech MK270, Keyboard and Mouse
 - 1. Contractor shall remove and reuse existing (OFE) wireless keyboard and mouse for the lectern computer.
 - b. Logic Supply, CL100 Fanless Computer
 - 1. Contractor shall provide and install a (1), Logic supply CL100 fanless computer configured with an Intel Braswell Pentium N3710 processor; 8GB SO-DIMM DDR3L 1600 Memory; 512 GB mSATA SSD hard drive; Wireless, Wi-Fi/BT, Realtek Dual-Band 1x1 802.11a/b/g/n/ac, (AW-CB161H) wireless option; Wi-Fi dual band terminal antenna, 108mm; DC 12V, 36W, power adapter with interchangeable plug; Auto Power On option; Wall Mounting Brackets; Computer Port & Dust Blocking Kit; Windows 10 Pro 64Bit operating system; 5-year extended manufacturer's warranty.
 - 2. Contractor shall provide and install a custom, permanent mounting solution for computer. Contractor shall coordinate with owner and consultant on location.
 - c. Network Cable, CAT5e
 - 1. Contractor shall provide and install a CAT5e network cable with RJ45 connectors between Lectern computer and terminating to the network switch in the control room.
 - 2. Cable is identified as D15
 - d. Cables to Go, 56783, HDMI Cable
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - e. Blackmagic Design, CONVBC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.

4. North Staff Table Bring Your Own Device (BYOD)
 - a. Network Cable
 1. Contractor shall provide and install a CAT5e stranded network cable with RJ45 connectors between the BYOD, passing through the table box and terminating to the network switch in the control room.
 2. Reference Tag Notes on Sheet T4.41
 - b. Cables to Go, 50612, HDMI cable
 1. Contractor shall provide and install a (1) fifteen-foot (15') high speed HDMI cable with ethernet.
 2. Reference Tag Notes on Sheet T4.41
 - c. Cables to Go, 54403, Display Port Cable
 1. Contractor shall provide and install a (1) fifteen-foot (15') DisplayPort cable with Latches 8K UHD M/M Black.
 2. Reference Tag Notes on Sheet T4.41
 - d. Cables to Go 50227, VGA Cable with Audio
 1. Contractor shall provide and install a (1) fifteen-foot (15') VGA with 3.5mm Stereo Audio A/V cable M/M.
 2. Reference Tag Notes on Sheet T4.41
 - e. Extron Electronics, 60-1405-02 Cable Cubby 700
 1. Contractor shall provide and install Extron Cable Cubby 700 and its accessory items.
 2. Contractor shall install into the face of the new North Staff Table concealing all cables when lid is closed.
 3. Contractor shall coordinate with owner and consultant on exact location in new lectern.
 4. Reference Tag Notes on Sheet T4.41
 - f. Kramer Electronics, SID-X3N, Switcher
 1. Contractor shall provide and install a Kramer Electronics SID-X3N switcher.
 2. Contractor shall conceal switcher into framing of North Staff Table behind access panels.
 3. Contractor shall update firmware of new device.
 4. Contractor shall set the DIP-switches per the following:
 - 1 = Off in general use, on when updating firmware.
 - 2 = Off, use analog audio
 - 3 = On, use analog audio in the DVI signal
 - 4 = On, set video mode to Last Connected
 - 5 = Off, automatic EDID
 - 6 = On, Switching Delay set to .5 seconds
 - 7 = Off, output disable delay set to 15 minutes
 - 8 = ON, power is always on
 5. Contractor shall coordinate with owner and consultant on exact location in new lectern.
 6. Reference Tag Notes on Sheet T4.41

- g. Cables to Go, 56783, HDMI cable
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - 2. Cable is identified as V41 on Sheet T4.41 but is lacking a unique project identifier.
 - 3. Cable shall be concealed from view and installed behind the lectern access panels into the framing of the furniture.
 - 4. Coordinate exact location with owner and consultant on exact location.
 - h. Blackmagic Design, CONVBDC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.
5. South Staff Table Computer
- a. Logitech MK270, Keyboard and Mouse
 - 1. Contractor shall provide and install (OFE) wireless keyboard and mouse for the lectern computer.
 - b. Logic Supply, CL100 Fanless Computer
 - 1. Contractor shall provide and install a (1), Logic supply CL100 fanless computer configured with an Intel Braswell Pentium N3710 processor; 8GB SO-DIMM DDR3L 1600 Memory; 512 GB mSATA SSD hard drive; Wireless, Wi-Fi/BT, Realtek Dual-Band 1x1 802.11a/b/g/n/ac, (AW-CB161H) wireless option; Wi-Fi dual band terminal antenna, 108mm; DC 12V, 36W, power adapter with interchangeable plug; Auto Power On option; Wall Mounting Brackets; Computer Port & Dust Blocking Kit; Windows 10 Pro 64Bit operating system; 5-year extended manufacturer's warranty.
 - 2. Contractor shall provide and install a custom, permanent mounting solution for computer. Contractor shall coordinate with owner and consultant on location.
 - c. Network Cable, CAT5e
 - 1. Contractor shall provide and install a CAT5e network cable with RJ45 connectors between computer and terminating to the network switch in the control room.
 - 2. Cable is identified as D17
 - d. Cables to Go, 56783, HDMI Cable
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - e. Blackmagic Design, CONVBDC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.

6. South Staff Table Bring Your Own Device (BYOD)
 - a. Network Cable
 1. Contractor shall provide and install a CAT5e stranded network cable with RJ45 connectors between the BYOD, passing through the table box and terminating to the network switch in the control room.
 2. Reference Tag Notes on Sheet T4.41
 - b. Cables to Go, 50612, HDMI cable
 1. Contractor shall provide and install a (1) fifteen-foot (15') high speed HDMI cable with ethernet.
 2. Reference Tag Notes on Sheet T4.41
 - c. Cables to Go, 54403, Display Port Cable
 1. Contractor shall provide and install a (1) fifteen-foot (15') DisplayPort cable with Latches 8K UHD M/M Black.
 2. Reference Tag Notes on Sheet T4.41
 - d. Cables to Go 50227, VGA Cable with Audio
 1. Contractor shall provide and install a (1) fifteen-foot (15') VGA with 3.5mm Stereo Audio A/V cable M/M.
 2. Reference Tag Notes on Sheet T4.41
 - e. Extron Electronics, 60-1405-02 Cable Cubby 700
 1. Contractor shall provide and install Extron Cable Cubby 700 and its accessory items.
 2. Contractor shall install into the face of furniture concealing all cables when lid is closed.
 3. Contractor shall coordinate with owner and consultant on exact location.
 4. Reference Tag Notes on Sheet T4.41
 - f. Kramer Electronics, SID-X3N, Switcher
 1. Contractor shall provide and install a Kramer Electronics SID-X3N switcher.
 2. Contractor shall conceal switcher into framing of North Staff Table behind access panels.
 3. Contractor shall update firmware of new device.
 4. Contractor shall set the DIP-switches per the following:
 - 1 = Off in general use, on when updating firmware.
 - 2 = Off, use analog audio
 - 3 = On, use analog audio in the DVI signal
 - 4 = On, set video mode to Last Connected
 - 5 = Off, automatic EDID
 - 6 = On, Switching Delay set to .5 seconds
 - 7 = Off, output disable delay set to 15 minutes
 - 8 = ON, power is always on
 5. Contractor shall coordinate with owner and consultant on exact location.
 6. Reference Tag Notes on Sheet T4.41

- g. Cables to Go, 56783, HDMI cable
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - 2. Cable is identified as V61 on Sheet T4.41 but is lacking a unique project identifier.
 - 3. Cable shall be concealed from view and installed behind the lectern access panels into the framing of the furniture.
 - 4. Coordinate exact location with owner and consultant on exact location.
 - h. Blackmagic Design, CONVBDC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.
7. Control Room Computer
- a. Logitech MK270, Keyboard and Mouse
 - 1. Contractor shall remove, reuse, and install (OFE) wireless keyboard and mouse for the lectern computer.
 - b. Owner Furnished Computer
 - 1. Contractor shall remove, reuse, and install (OFE) control room computer.
 - c. Network Cable, CAT5e
 - 1. Contractor shall provide and install a CAT5e network cable with RJ45 connectors between computer and terminating to the network switch in the control room.
 - 2. Cable is identified as D19
 - d. Cables to Go, 56783, HDMI Cable
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - e. Blackmagic Design, CONVBDC/SDIHDWPSU, HDMI to SDI Micro Converter
 - 1. Contractor shall provide and install one (1) HDMI to SDI converter.
 - 2. Contractor shall conceal converter from view by mounting within the framing of the furniture and behind access panels.
 - 3. Contractor shall configure converter for optimum system performance.
 - 4. Contractor shall coordinate with consultant and owner on locations and performance expectations.
8. Portable Document Camera
- a. HoverCam Ultra 8 document camera
 - 1. Contractor shall provide and install a portable document camera.
 - 2. Contractor shall connect and test document camera at the lectern BYOD location using the HDMI input.
 - 3. Contractor shall coordinate with owner on location desired for stowing portable document camera when not in use.

9. Presentation Switcher
 - a. Blackmagic Design, VHUBSMTCS6G1212, Smart Video Hub Clean Switch 12x12
 1. Contractor shall remove, reuse, and reinstall the existing presentation switcher.
 2. Contractor shall connect all presentation sources into the inputs and presentation destinations as shown on T4.41.
 3. Contractor shall provide and install network cabling between switcher and control system network switch. Unique identifier is D30.
 4. Control of presentation switcher shall be front panel as well as Crestron control.
 5. Once an input is selected, route to all outputs.
 6. Coordinate with consultant and owner as required.
10. Lectern Recessed Monitor
 - a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind the lectern access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. AOC, e2270swhn, Monitor
 1. Contractor shall provide and install a (1) AOC, e2270swhn, monitor.
 2. Contractor shall install in recessed monitor cavity within lectern.
 3. Contractor shall conceal cabling from view and make appearance of lectern recessed monitor as neat and professional as possible.
 4. Coordinate exact location with owner and consultant
 - d. Custom Mounting Solution
 1. Contractor shall provide and install a custom monitor mounting solution within the lectern recessed cavity that offers adequate support for the monitor at the optimum viewing angle to the seated lectern users.

11. North Staff Table Monitor

- a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
- b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
- c. Lilliput, A12, Monitor
 1. Contractor shall provide and install a Lilliput, A12 monitor in the furniture's recessed cavity.
 2. Contractor shall recess monitor into cavity and conceal cabling and mount from camera/audience view.
 3. Power and communication cabling shall be routed out of the recessed cavity and connected within furniture, behind access panels.
- d. CAMVATE, 4332014124, monitor mount
 1. Contractor shall provide and install a CAMVATE, 4332014124 monitor mount.
 2. Contractor shall fasten mount to recessed monitor cavity in furniture.
 3. Contractor shall fasten monitor to mount and adjust for optimum view.
 4. Coordinate with owner and consultant on exact locations.

12. North Dais Monitors (2)
 - a. Blackmagic Design, CONVBDC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. Lilliput, A12, Monitors (2)
 1. Contractor shall provide and install two (2) Lilliput, A12 monitors in the furniture's recessed cavities.
 2. Contractor shall recess monitors into cavities and conceal cabling and mounts from camera/audience views.
 3. Power and communication cabling shall be routed out of the recessed cavities and connected within furniture, behind access panels.
 - d. CAMVATE, 4332014124, monitor mounts (2)
 1. Contractor shall provide and install two (2) CAMVATE, 4332014124 monitor mounts.
 2. Contractor shall fasten mounts to recessed monitor cavities in furniture.
 3. Contractor shall fasten monitors to mounts and adjust for optimum view.
 4. Coordinate with owner and consultant on exact locations.

13. Center Dais Monitors (2)
 - a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. Lilliput, A12, Monitors (2)
 1. Contractor shall provide and install two (2) Lilliput, A12 monitors in the furniture's recessed cavities.
 2. Contractor shall recess monitors into cavities and conceal cabling and mounts from camera/audience views.
 3. Power and communication cabling shall be routed out of the recessed cavities and connected within furniture, behind access panels.
 - d. CAMVATE, 4332014124, monitor mounts (2)
 1. Contractor shall provide and install two (2) CAMVATE, 4332014124 monitor mounts.
 2. Contractor shall fasten mounts to recessed monitor cavities in furniture.
 3. Contractor shall fasten monitors to mounts and adjust for optimum view.
 4. Coordinate with owner and consultant on exact locations.

14. South Dais Monitors (2)
 - a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. Lilliput, A12, Monitors (2)
 1. Contractor shall provide and install two (2) Lilliput, A12 monitors in the furniture's recessed cavities.
 2. Contractor shall recess monitors into cavities and conceal cabling and mounts from camera/audience views.
 3. Power and communication cabling shall be routed out of the recessed cavities and connected within furniture, behind access panels.
 - d. CAMVATE, 4332014124, monitor mounts (2)
 1. Contractor shall provide and install two (2) CAMVATE, 4332014124 monitor mounts.
 2. Contractor shall fasten mounts to recessed monitor cavities in furniture.
 3. Contractor shall fasten monitors to mounts and adjust for optimum view.
 4. Coordinate with owner and consultant on exact locations.

15. South Staff Table Monitor
 - a. Blackmagic Design, CONVBDC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. Lilliput, A12, Monitor
 1. Contractor shall provide and install a Lilliput, A12 monitor in the furniture's recessed cavity.
 2. Contractor shall recess monitor into cavity and conceal cabling and mount from camera/audience view.
 3. Power and communication cabling shall be routed out of the recessed cavity and connected within furniture, behind access panels.
 - d. CAMVATE, 4332014124, monitor mount
 1. Contractor shall provide and install a CAMVATE, 4332014124 monitor mount.
 2. Contractor shall fasten mount to recessed monitor cavity in furniture.
 3. Contractor shall fasten monitor to mount and adjust for optimum view.
 4. Coordinate with owner and consultant on exact locations.

16. North Audience Monitor

- a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
- b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V2111 on Sheet T4.41.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
- c. Sony, XBR75X850F, 75" monitor
 1. Contractor shall provide and install a Sony, XBR75X850F, 75" Monitor into architectural cavity/build-out provided.
 2. Contractor shall fasten monitor to wall mount specified.
 3. Contractor shall conceal and cable manage all devices, power and low-voltage cabling required.
 4. Contractor shall coordinate exact location/elevation with consultant and owner.
- d. Legrand AV/Chief, TS525TU, Large Thinstall Dual Swing Arm Wall Mount.
 1. Contractor shall provide and install articulating wall mount into architectural buildout/nook.
 2. Contractor shall securely fasten monitor mount into wall framing with adequate fastening solution to support the entire load at most extended position of mount while in motion.
 3. Contractor shall fasten all devices and cables to monitor mount in a neat and professional manner as to conceal from audience view while extended. Cable management shall not impede motion of monitor mount.
 4. Contractor shall securely fasten monitor to mount and mount to wall.
 5. Coordinate exact location/elevation with consultant and owner to achieve a recessed mounting solution when stowed.

17. South Audience Monitor
- a. Blackmagic Design, CONVBC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 - 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.41.
 - 2. Conceal converter from view into furniture
 - 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 - 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 - 2. Cable is identified as V2111 on Sheet T4.41.
 - 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 - 4. Coordinate exact location with owner and consultant.
 - c. Sony, XBR75X850F, 75" monitor
 - 1. Contractor shall provide and install a Sony, XBR75X850F, 75" Monitor into architectural cavity/build-out provided.
 - 2. Contractor shall fasten monitor to wall mount specified.
 - 3. Contractor shall conceal and cable manage all devices, power and low-voltage cabling required.
 - 4. Contractor shall coordinate exact location/elevation with consultant and owner.
 - d. Legrand AV/Chief, TS525TU, Large Thinstall Dual Swing Arm Wall Mount.
 - 1. Contractor shall provide and install articulating wall mount into architectural buildout/nook.
 - 2. Contractor shall securely fasten monitor mount into wall framing with adequate fastening solution to support the entire load at most extended position of mount while in motion.
 - 3. Contractor shall fasten all devices and cables to monitor mount in a neat and professional manner as to conceal from audience view while extended. Cable management shall not impede motion of monitor mount.
 - 4. Contractor shall securely fasten monitor to mount and mount to wall.
 - 5. Coordinate exact location/elevation with consultant and owner to achieve a recessed mounting solution when stowed.

- D. Council Chambers Broadcast Video (Sheet T4.42)
1. Camera One (South Wall) Vaddio, Roboshot 30HDBT, Black
 - a. Contractor shall provide and install a Vaddio, 999-9963-200, Roboshot 30, HDBT, Black camera system.
 1. Install camera into the recessed camera cavity in the South Wall of the council chambers. Conceal all cabling from audience view and provide custom vibration isolation solution if image vibrates while camera is completely zoomed in onto furthest council/staff member seating position.
 2. Install one-link bridge into a control room rack and connect to camera controller via CAT5e cabling as indicated on T4.42.
 - b. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet. Cable shall connect output of one-link bridge to Tricaster video production platform.
 - c. Contractor shall paint the camera cavity flat black if necessary.
 2. Camera two (Below Soffit, Room Center Line) Vaddio, Roboshot 30HDBT, White
 - a. Contractor shall provide and install a Vaddio, 999-2225-150 in-ceiling half-recessed enclosure.
 1. Recessed enclosure shall be installed on the room center line within the rear chambers (West) soffit.
 2. Recessed enclosure shall be connected to 1" EMT conduit that connects this location to the control room.
 - b. Contractor shall provide and install a Vaddio, 999-9963-200W, Roboshot 30, HDBT, White camera system.
 1. Install camera into the Vaddio ceiling mount half recessed enclosure located on the room centerline below soffit in rear of chambers.
 2. Conceal all cabling from audience view and provide custom vibration isolation solution if image vibrates while camera is completely zoomed in onto furthest council/staff member seating position.
 3. Install one-link bridge into a control room rack and connect to camera controller via CAT5e cabling as indicated on T4.42.
 - c. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet. Cable shall connect output of one-link bridge to Tricaster video production platform.
 3. Camera Three (North Wall) Vaddio, Roboshot 30HDBT, Black
 - a. Contractor shall provide and install a Vaddio, 999-9963-200, Roboshot 30, HDBT, Black camera system.
 1. Install camera into the recessed camera cavity in the North Wall of the council chambers. Conceal all cabling from audience view and provide custom vibration isolation solution if image vibrates while camera is completely zoomed in onto furthest council/staff member seating position.
 2. Install one-link bridge into a control room rack and connect to camera controller via CAT5e cabling as indicated on T4.42.
 - b. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet. Cable shall connect output of one-link bridge to Tricaster video production platform.
 - c. Contractor shall paint the camera cavity flat black if necessary.

4. Camera Four (East Wall) Vaddio, Roboshot 30HDBT, Black
 - a. Contractor shall provide and install a Vaddio, 999-9963-200, Roboshot 30, HDBT, Black camera system.
 1. Install camera into the recessed camera cavity in the East Wall of the council chambers. Located above logo and below finished ceiling. Conceal all cabling from audience view and provide custom vibration isolation solution if image vibrates while camera is completely zoomed in onto furthest lectern/staff member seating position.
 2. Install one-link bridge into a control room rack and connect to camera controller via CAT5e cabling as indicated on T4.42.
 - b. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet. Cable shall connect output of one-link bridge to Tricaster video production platform.
 - c. Contractor shall paint the camera cavity flat black if necessary.
5. ADD ALTERNATE 03: Camera Five (Integrated into Dais)
 - a. Contractor shall provide and install a Marshall Electronics CV350-10XB into the face of the dais on furniture/room center line.
 - b. Contractor shall provide and install a custom mounting solution for camera free of vibration and concealing camera from view of council members.
 - c. Only the camera lens shall appear visible through the finished face of the dais. The camera body shall remain concealed below the backplash.
 - d. Contractor shall provide and install into the control room a SDI to NDI converter such as the NewTek, FG-001776-R001.
 1. NDI converter shall connect via CAT5e cabling to the AV network switch as indicated on T4.42 cable ID D5.
 2. Contractor shall program Tricaster and NDI converter for usable, reliable, high-quality video signal.
6. Presentation System Output
 - a. Contractor shall connect the presentation switcher output to the Tricaster broadcast system via an NDI converter.
 - b. Contractor shall provide and install a Blackmagic Design, CONVMSA mini converter SDI to analog.
 1. Converter shall loop SDI into an SDI to NDI converter.
 2. Converter shall provide stereo, balanced, line-level audio outputs to the audio mixers.
 3. Contractor shall configure converter for optimum audio output to mixers.
 - c. Contractor shall provide and install into the control room a SDI to NDI converter such as the NewTek, FG-001776-R001.
 1. NDI converter shall connect via CAT5e cabling to the AV network switch as indicated on T4.42 cable ID D6.
 2. Contractor shall program Tricaster and NDI converter for usable, reliable, high-quality video signal.
7. Camera(s) Controller
 - a. Contractor shall provide and install a Vaddio, 999-5700-00, Production View Camera Controller into the control room.
 - b. Contractor shall coordinate exact location with owner and consultant.
 - c. Contractor shall program camera controller so upon power up, all cameras are identified and controllable. Owner shall program camera presets.

8. Tricaster Mini Advanced HD-4
 - a. Contractor shall provide, install, and configure a NewTek, FG-001989-R001, Tricaster Mini Advanced HD-4.
 - b. Tricaster shall be located in the control room. Exact location shall be coordinated with consultant and owner.
 - c. Contractor shall provide and install a Logitech, MK120 wired keyboard and mouse for Tricaster Operations.
 - d. Contractor shall provide and install audio connections from the audio mixer to the audio inputs of the Tricaster. Contractor shall calibrate and configure audio mixer and Tricaster for optimal operation of entire system and to the satisfaction of the owner and consultant.
9. Tricaster Monitors
 - a. Contractor shall provide and install two (2) AOC, e2270swhn 22" monitors into the control room for end user interface to the Tricaster System.
 - b. Contractor shall provide custom mounting solutions (2) for each of the AOC monitors securing the monitors to the rack system. Coordinate locations and mounting solution with owner and consultant.
 - c. Contractor shall provide and install two (2) Cables to Go 56783 HDMI cables between the Tricaster HDMI outputs and the AOC monitor inputs.
10. AIR Switcher
 - a. Contractor shall provide and install a Blackmagic Design, SWATEMTVSTU/HD, ATEM Studio HD switcher.
 - b. Contractor shall install switcher into control room rack system. Coordinate exact location with owner and consultant.
 - c. Contractor shall configure switcher for audio follow video and optimal use by owner.
11. Air Distribution Amplifier
 - a. Contractor shall provide and install a (1) SDI distribution amplifier such as Blackmagic Design, CONVMSIDIDA, mini converter SDI Distribution.
 - b. Distribution Amplifier shall be installed into the control room rack system. Contractor to provide custom mounting solution. Coordinate location with consultant and owner.

12. Broadcast Distribution

a. Comcast

1. Contractor shall remove and reuse Comcast equipment.
2. Contractor shall coordinate with Consultant, Owner and Comcast to provide calibrated, reliable audio and video signals for broadcast on their system.
3. Contractor shall provide any necessary converters, adapters or processing required to match modulator/media converter requirements.
4. Contractor shall coordinate with Comcast, Owner and other trades to ensure all fiber optic links are established for broadcast to Comcast.
5. Coordinate exact location of equipment with Consultant and Owner.

b. CenturyLink

1. Contractor shall remove and reuse CenturyLink equipment.
2. Contractor shall coordinate with Consultant, Owner and CenturyLink to provide calibrated, reliable audio and video signals for broadcast on their system.
3. Contractor shall provide any necessary converters, adapters or processing required to match modulator/media converter requirements.
4. Contractor shall coordinate with CenturyLink, Owner and other trades to ensure all fiber optic links are established for broadcast to CenturyLink.
5. Coordinate exact location with Consultant and Owner.

c. Granicus

1. Contractor shall remove and reuse Granicus equipment.
2. Contractor shall coordinate with Consultant, Owner and Granicus to provide calibrated, reliable audio and video signals for broadcast on their system.
3. Contractor shall provide any necessary converters, adapters or processing required to match modulator/media converter requirements.
4. Contractor shall coordinate with Granicus, Owner and other trades to ensure all network links are established for broadcast to Granicus.
5. Coordinate exact location of Granicus equipment with Owner and Consultant.

13. Lobby Monitor
 - a. Blackmagic Design, CONVBDC/SDIHDWPSU, micro converter, bi-directional SDI/HDMI
 1. Contractor shall provide and install a bi-directional micro-converter converting SDI to HDMI as shown on T4.42.
 2. Conceal converter from view into furniture
 3. Coordinate exact location with owner and consultant.
 - b. HDMI Cable, Cables to Go 56783
 1. Contractor shall provide and install a (1) Cables to Go, 56783, six foot (6') high speed HDMI cable with ethernet.
 2. Cable is identified as V741 on Sheet T4.42.
 3. Cable shall be concealed from view and installed behind access panels into the framing of the furniture.
 4. Coordinate exact location with owner and consultant.
 - c. Sony, XBR65X850F, 75" monitor
 1. Contractor shall provide and install a Sony, XBR65X850F, 65" Monitor into architectural cavity/build-out provided.
 2. Contractor shall fasten monitor to wall mount specified.
 3. Contractor shall conceal and cable manage all devices, power and low-voltage cabling required.
 4. Contractor shall coordinate exact location/elevation with consultant and owner.
 - d. Legrand AV/Chief, TS525TU, Large Thinstall Dual Swing Arm Wall Mount.
 1. Contractor shall provide and install articulating wall mount into architectural buildout/nook.
 2. Contractor shall securely fasten monitor mount into wall framing with adequate fastening solution to support the entire load at most extended position of mount while in motion.
 3. Contractor shall fasten all devices and cables to monitor mount in a neat and professional manner as to conceal from audience view while extended. Cable management shall not impede motion of monitor mount.
 4. Contractor shall securely fasten monitor to mount and mount to wall.
 5. Coordinate exact location/elevation with consultant and owner to achieve a recessed mounting solution when stowed.
14. Network Switch – Audio Visual Local Area Network
 - a. Contractor shall remove, reuse and install the existing Audio-Visual Local Area Network switch.
 - b. Contractor shall coordinate switch location with Owner and Consultant.
 - c. Contractor shall coordinate with Owner's technical contact on cabling and configuration required for link to City Core Switch.
 - d. Network requires internet access, network security, a dedicated subnet with DHCP and DNS services provided by City router(s).
15. ADD ALTERNATE TWO: AUTOMATIC PLAYBACK SYSTEM
 - a. Contractor shall remove existing playback system
 - b. Contractor shall remove, reuse and reinstall the FM receiver.
 - c. Contractor shall leave in position and reuse the FM antenna in the stairwell.
 - d. Contractor shall provide, install and configure a Tight Rope Media Systems Cable Cast system.
 - e. Contractor shall coordinate with Owner and Consultant on location and configuration.

E. AV Control System (Sheet T5.11)

1. Crestron Control System
 - a. Contractor shall provide and install a new Crestron Control System such as a Crestron CP3N, 6505417.
 - b. Contractor shall provide and install all custom programming necessary to reliably control the AV and lighting systems in a manner satisfactory to the Owner and Consultant.
2. Crestron Touch Panels (3)
 - a. Contractor shall provide and install three new Crestron touch panels such as Crestron, TSW-760-NC-B-S.
 - b. Contractor shall provide and install three new Crestron touch panel table mounts such as TSW-760-TTK-BS.
 - c. Coordinate exact locations of touch panels with Owner and Consultant.
 - d. Contractor shall issue as shop drawings to consultant all touch panel page layouts for control and user interfaces.
3. Network Switch – Control Network
 - a. Contractor shall remove, reuse and install a network switch for the Control Network.
 - b. Contractor shall connect all controlled AV devices to the Control Network.
 - c. Contractor shall coordinate switch location with Owner and Consultant.
 - d. Contractor shall coordinate with Owner's technical contact on cabling and configuration required for link to City Core Switch.
 - e. Network requires internet access, network security, a dedicated subnet with DHCP and DNS services provided by City router(s).
4. SOHO Router
 - a. Contractor shall remove, reuse, and install a network router for the Control Network.
 - b. Contractor shall coordinate with Owner's technical contact on cabling and configuration required for Control System Router.
 - c. Contractor shall re-establish control system wireless access point.

1.6 SUBMITTALS

A. Shop Drawings

1. Rack Details

- a. Contractor shall submit to the consultant prior to construction shop drawings showing control room rack layouts and details.
- b. Consultant must sign off and agree to contractor's plans prior to construction.

2. Furniture Details

- a. Contractor shall submit to the consultant prior to construction shop drawings showing details for integrating AV systems into furniture showing both visible and hidden components.
- b. Consultant must sign off and agree to contractor's plans prior to construction.

3. Control System Touch Panel Layouts

- a. Contractor shall submit to the consultant prior to construction shop drawings showing touch panel pages and code details for each button push.
- b. Consultant must sign off and agree to contractor's plans prior to construction.

B. As-Built Documents

1. Schematics

- a. Within 30-days of substantial completion, Contractor shall submit to Consultant as-built schematic drawings.
- b. Consultant must sign-off on as-built drawings before final payment will be issued to contractor.

2. OEM Manual Binders

- a. Within 30-days of substantial completion, Contractor shall submit to Consultant three ring binders containing printed manuals of all original equipment manufacturer equipment. Binder shall be organized by alphabetically by manufacturer name.
Consultant must sign-off on OEM Manual Binders before final payment will be issued to contractor.

1.7 EVIDENCE OF QUALIFICATIONS

- A. To demonstrate qualification for performing the Work of this Contract, bidders and/or subcontractors may be requested by the Consultant and/or Owner to submit AIA Form 305.
- B. The bidder shall bear any and all costs to obtain the requested AIA documents and information.

1.71 SUBCONTRACTORS/SUPPLIERS/OTHERS

- A. The Contractor shall be entirely responsible to the Owner for the competency and standard of work of Subcontractors used.
- B. The Contractor shall be entirely responsible to the Owner for the acts and omissions of the Contractor's subcontractor(s) and/or persons directly or indirectly employed by the Contractor.
- C. Owner reserves the right to reject a proposed subcontractor.

1.8 LIST OF SHEETS

- T0.00 Title Sheet
- T4.31 Audio Schematics
- T4.41 Presentation Video
- T4.42 Broadcast Video
- T5.11 AV Control System Schematic

1.9 EQUIPMENT LISTS

Drawing ID	Make	Model	Description	Unit
MON.441.21	AOC	E2270SWHN	21.5" TN MONITOR	
MON.442.41	AOC	E2270SWHN	21.5" TN MONITOR	
MON.442.42	AOC	E2270SWHN	21.5" TN MONITOR	
OFF.TAB.511.01	APPLE	IPAD AIR 2	WIFI, 16Gb	
GEQ.431.01	ASHLY	MQX-2310	GRAPHIC EQUALIZER, 31-BAND, 25MM SLIDERS	
GEQ.431.02	ASHLY	MQX-2310	GRAPHIC EQUALIZER, 31-BAND, 25MM SLIDERS	
GEQ.431.03	ASHLY	MQX-2310	GRAPHIC EQUALIZER, 31-BAND, 25MM SLIDERS	
GEQ.431.04	ASHLY	MQX-2310	GRAPHIC EQUALIZER, 31-BAND, 25MM SLIDERS	
GEQ.431.05	ASHLY	MQX-2310	GRAPHIC EQUALIZER, 31-BAND, 25MM SLIDERS	
CNV.441.01	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.02	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.03	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.04	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.05	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.06	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.07	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.21	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.30	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.441.31	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
CNV.442.74	BLACKMAGIC DESIGN	CONVBDC/SDIHDWPSU	MICRO CONVERTER BIDIRECTIONAL SDI/HDMI	
VDA.442.71	BLACKMAGIC DESIGN	CONVMSDIDA	MINI CONVERTER SDI DISTRIBUTION	
SWT.442.61	BLACKMAGIC DESIGN	SWATEMTVSTU/HD	ATEM TELEVISION STUDIO HD	
SWT.441.01	BLACKMAGIC DESIGN	VHUBSMTCS6G1212	SMART VIDEOHUB CLEANSWITCH 12X12	
SPL.431.01	BLONDER TONGUE	DGS-2	SPLITTER, 2 WAY	
SPL.431.02	BLONDER TONGUE	DGS-2	SPLITTER, 2 WAY	
CBL.441.02c	CABLES TO GO	50227	15 FT SELECT VGA + 3.5mm STEREO AUDIO A/V CABLE M/M	
CBL.441.04c	CABLES TO GO	50227	15 FT SELECT VGA + 3.5mm STEREO AUDIO A/V CABLE M/M	
CBL.441.06c	CABLES TO GO	50227	15 FT SELECT VGA + 3.5mm STEREO AUDIO A/V CABLE M/M	
CBL.441.02a	CABLES TO GO	50612	15 FT HIGH SPEED HDMI WITH ETHERNET	
CBL.441.04a	CABLES TO GO	50612	15 FT HIGH SPEED HDMI WITH ETHERNET	
CBL.441.06a	CABLES TO GO	50612	15 FT HIGH SPEED HDMI WITH ETHERNET	
CBL.441.02b	CABLES TO GO	54403	15 FT DISPLAYPORT CABLE WITH LATCHES 8K UHD M/M	
CBL.441.04b	CABLES TO GO	54403	15 FT DISPLAYPORT CABLE WITH LATCHES 8K UHD M/M	
CBL.441.06b	CABLES TO GO	54403	15 FT DISPLAYPORT CABLE WITH LATCHES 8K UHD M/M	
CBL.441.01	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.03	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.05	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.07	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.21	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.30	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.441.31	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.01	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.02	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.03	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.04	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.41	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.42	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
CBL.442.74	CABLES TO GO	56783	6 FT HIGH SPEED HDMI CABLE WITH ETHERNET	
MNT.441.22	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.23	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.24	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.25	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.26	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.27	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.28	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
MNT.441.29	CAMVATE	4332014124	VIDEO WALL/CEILING MOUNT 1/4" - 20 THREAD	
OFF.SVR.442.72	CENTURYLINK	MODULATOR	MODULATOR	
OFF.SVR.442.71	COMCAST	MODULATOR	MODULATOR	
CTL.511.01	CRESTRON	CP3N	3-SERIES CONTROL SYSTEM	
TPL.511.01	CRESTRON	TSW-760-NC-B-S	7" TOUCH SCREEN	

Drawing ID	Make	Model	Description	Unit
TPL.511.02	CRESTRON	TSW-760-NC-B-S	7" TOUCH SCREEN	
TPL.511.03	CRESTRON	TSW-760-NC-B-S	7" TOUCH SCREEN	
MNT.511.01	CRESTRON	TSW-760-TTK-B-S	TABLETOP KIT FOR TOUCH SCREEN	
MNT.511.02	CRESTRON	TSW-760-TTK-B-S	TABLETOP KIT FOR TOUCH SCREEN	
MNT.511.03	CRESTRON	TSW-760-TTK-B-S	TABLETOP KIT FOR TOUCH SCREEN	
OFE.AMP.431.02	CROWN AUDIO	CTS-4200	POWER AMPLIFIER, 4 CHANNEL, 260W	
AMP.431.01	CROWN AUDIO	DCi 8 300	POWER AMPLIFIER, 8 CHANNEL, 300W, 70V/100V	
MNT.442.01	CUSTOM MOUNT		CAMERA MOUNT	
MNT.442.03	CUSTOM MOUNT		CAMERA MOUNT	
MNT.442.04	CUSTOM MOUNT		CAMERA MOUNT	
BYOD.441.02	END-USER DEVICE		LAPTOP	
BYOD.441.04	END-USER DEVICE		LAPTOP	
BYOD.441.06	END-USER DEVICE		LAPTOP	
OFE.TTB.441.02	EXTRON ELECTRONICS	60-1405-02	SERIES/2 CABLE ACCESS ENCLOSURE FOR AV CONN AND AC POWER	
TTB.441.04	EXTRON ELECTRONICS	60-1405-02	SERIES/2 CABLE ACCESS ENCLOSURE FOR AV CONN AND AC POWER	
TTB.441.06	EXTRON ELECTRONICS	60-1405-02	SERIES/2 CABLE ACCESS ENCLOSURE FOR AV CONN AND AC POWER	
OFE.SVR.442.73	GRANICUS	SERVER	SERVER	
OFE.PC.441.07	HEWLETT PACKARD	Z SERIES	PC	
DOC.441.01	HOVERCAM	ULTRA 8	DOCUMENT CAMERA, HDMI, USB 3.0	
OFE.NSW.511.01	HP	JH019A	NETWORK SWITCH	
OFE.NSW.442.01	HP ENTERPRISE	JH019A	OFFICECONNECT 1420 24-PORT GIGABIT POE+ UNMANAGED SWITCH	
SPK.431.01	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.02	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.03	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.04	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.05	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.06	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.07	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.08	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.09	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.10	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.11	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.12	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.13	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.14	JBL	47HC	HIGH CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.15	JBL	47LP	LOW PROFILE CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.16	JBL	47LP	LOW PROFILE CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.17	JBL	47LP	LOW PROFILE CEILING LOUDSPEAKER, 70V, 7.5W	
SPK.431.18	JBL	47LP	LOW PROFILE CEILING LOUDSPEAKER, 70V, 7.5W	
ASW.441.02	KRAMER ELECTRONICS	SID-X3N	DISPLAYPORT, HDMI, VGA, & DVI AUTOSWITCHER	
ASW.441.04	KRAMER ELECTRONICS	SID-X3N	DISPLAYPORT, HDMI, VGA, & DVI AUTOSWITCHER	
ASW.441.06	KRAMER ELECTRONICS	SID-X3N	DISPLAYPORT, HDMI, VGA, & DVI AUTOSWITCHER	
OFE.MIX.431.01	LECTROSONICS	DM1612	DIGITAL AUTOMATIC MATRIX MIXER DSP	
OFE.MIX.431.02	LECTROSONICS	DM1612	DIGITAL AUTOMATIC MATRIX MIXER DSP	
MNT.441.30	LEGRAND AV	CHIEF TS525TU	LARGE THINSTALL DUAL SWING ARM WALL DISPLAY MOUNT	
MNT.441.31	LEGRAND AV	CHIEF TS525TU	LARGE THINSTALL DUAL SWING ARM WALL DISPLAY MOUNT	
MNT.442.74	LEGRAND AV	CHIEF TS525TU	LARGE THINSTALL DUAL SWING ARM WALL DISPLAY MOUNT	
MON.441.22	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.23	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.24	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.25	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.26	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.27	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.28	LILLIPUT	A12	12.5" BROADCAST MONITOR	
MON.441.29	LILLIPUT	A12	12.5" BROADCAST MONITOR	
OFE.RTR.511.01	LINKSYS	WRT 1200AC	DUAL-BAND WIRELESS GIGABIT ROUTER	
CPU.441.01	LOGIC SUPPLY	CL100	INDUSTRIAL FANLESS MINI PC	
CPU.441.03	LOGIC SUPPLY	CL100	INDUSTRIAL FANLESS MINI PC	
CPU.441.05	LOGIC SUPPLY	CL100	INDUSTRIAL FANLESS MINI PC	
KEY.451.01	LOGITECH	MK120	WIRED MOUSE, WIRED KEYBOARD	

Drawing ID	Make	Model	Description	Unit
OFE.KEY.441.01	LOGITECH	MK270	KEYBOARD AND MOUSE COMBO	
OFE.KEY.441.03	LOGITECH	MK270	KEYBOARD AND MOUSE COMBO	
OFE.KEY.441.07	LOGITECH	MK270	KEYBOARD AND MOUSE COMBO	
NDI.442.05	NEWTEK	FG-001776-R001	CONNECT SPARK SDI	
SEG.442.01	NEWTEK	FG-001989-R001	TRICASTER MINI ADVANCED HD-4	
VOL.431.01	OSD AUDIO	MVC-100 WHITE	DECORA® STYLE 70V, VOLUME CONTROLS/ATTENUATOR	
OFE.MIC.431.01	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.02	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.03	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.04	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.05	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.06	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.07	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.08	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.09	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.10	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.11	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.12	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.13	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.14	SHURE	MX412S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.15	SHURE	MX418S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.16	SHURE	MX418S	MICROPHONE, GOOSENECK, MUTE SWITCH AND LED INDICATOR	
OFE.MIC.431.20	SHURE	ULXS124/58	COMBO MIC/LAVALIER WIRELESS SYSTEM	
OFE.MIC.431.19	SHURE	ULXS124/85	COMBO MIC/LAVALIER WIRELESS SYSTEM	
MON.442.74	SONY	XBR65X850F	65" HDR UHD SMART LED TV	
MON.441.30	SONY	XBR75X850F	75" SMART 4K UHD TV	
MON.441.31	SONY	XBR75X850F	75" SMART 4K UHD TV	
MNT.442.02	VADDIO	999-2225-150	IN-CEILING HALF-RECESSED ENCLASURE FOR ROBOSHOT CAMERA	
PCC.442.01	VADDIO	999-5700-0000	PRODUCTIONVIEW PRECISION CAMERA CONTROL	
CAM.442.01	VADDIO	999-9963-200	ROBOSHOT 30 HDBT CAMERA, ONELINK BRIDGE, BLACK	
CAM.442.03	VADDIO	999-9963-200	ROBOSHOT 30 HDBT CAMERA, ONELINK BRIDGE, BLACK	
CAM.442.04	VADDIO	999-9963-200	ROBOSHOT 30 HDBT CAMERA, ONELINK BRIDGE, BLACK	
CAM.442.02	VADDIO	999-9963-200W	ROBOSHOT 30 HDBT CAMERA, ONELINK BRIDGE, WHITE	
OFE.ANT.431.01	WINEGARD	SS-2000	AMPLIFIED DIRECTIONAL ANTENNA, HDTV2 AND POWER SUPPLY	
OFE.ANT.431.02	WINEGARD	SS-2000	AMPLIFIED DIRECTIONAL ANTENNA, HDTV2 AND POWER SUPPLY	

1.91 ADD ALTERNATE ONE: ROOM SCHEDULING TOUCH PANELS

A. Equipment List Forthcoming in Addendum

1.92 ADD ALTERNATE TWO: AUTOMATED PLAYBACK SYSTEM

Drawing ID	Make	Model	Description	Unit
APB.442.01	TIGHTROPE MEDIA SYSTEMS	CBL-FLEXLITE-340	CABLECAST VIDEO SERVER	

1.93 ADD ALTERNATE THREE: INTEGRATED DAIS CAMERA

Drawing ID	Make	Model	Description	Unit
CAM.442.05	MARSHALL ELECTRONICS	CV350-10XB	COMPACT 10X FULL-HD CAMERA	
MNT.442.05	CUSTOM MOUNT			
NDI.442.05	NEWTEK	FG-001776-R001	CONNECT SPARK SDI	

1.94 TAXES

- A. There is no exemption from payment of taxes.
- B. Include all sales, use, excise, and any other taxes that are required by law.
- C. Contractor shall be required to pay all taxes associated with the project.

1.95 SELECTION OF ALTERNATES

- A. Bids will be evaluated on the base bid price. After determination of a successful bidder, consideration will be given to Alternates and bid price adjustments.

1.96 WARRANTY

- A. OEM Warranties extended.
 - 1. Contractor shall extend and honor all manufacturers warranties and shall facilitate the removal, shipping and replacement of failed OEM equipment at no additional cost to owner for a period of 365 calendar days from final completion.
- B. Contractor Warranty
 - 1. Contractor shall provide a warranty for the entire system for a period of 365 days from final completion.
 - 2. Contractor shall at no additional cost to the Owner, respond to, troubleshoot and repair any failed system, equipment, software, firmware, hardware, connectors, or cabling.
 - 3. Contractor shall respond within 48-hours of a service request from the Owner and have the problem satisfactorily resolved within five business days from service request by Owner.

END OF SECTION

SECTION 27 51 19

SOUND MASKING SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Electronic noise generators.
 - 2. Amplifiers.
 - 3. Wiring.
 - 4. Masking speaker assemblies.
 - 5. Controls.
 - 6. Component mounting racks.

1.3 DEFINITIONS

- A. Covered Spaces: Spaces above which masking speakers are installed.

1.4 SYSTEM DESCRIPTION

- A. Zones: (3)
 - 1. Lobby
 - 2. General Areas
 - 3. Offices
- B. Channels: Single channel of masking sound to each zone.
- C. Signal Levels: Individually adjustable for each of 14 one-third octave bands centered at 200 through 4000 Hz, for sound-masking noise channels.
- D. Sound-Power Level Produced by System: Match contour between 400 and 2000 Hz with smooth roll-off above and below those frequencies.
 - 1. Initial Level: 40 dB , A-weighted.
 - 2. Final Adjusted Level: 40 to 50 dB, A-weighted. Determine final level for each space individually by measurement as specified in Part 3.
 - 3. Measurements: Made under calibration conditions.

- E. Directional Effect: People in covered spaces under calibration conditions cannot determine source of masking sound.
- F. Sound Quality: No audible hum or noise from this system in covered spaces when noise generators are off and power amplifiers are on with input volume controls set at 50 percent.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include nationally recognized testing laboratory listing data.
- B. Shop Drawings: Dimensioned plans and elevations showing minimum clearances and installed features and devices for system components. Show types and locations of masking speakers and their wiring connections, channel assignments, and axis orientations. Show ducts, beams, and other significant sound-reflecting and -absorbing elements in ceiling space and show locations of partitions below ceiling. Include a diagram showing interconnection of major system components for each zone and channel and indicating grounding connections.
 - 1. Wiring Diagrams: For power, signal, and control wiring.

1.6 INFORMATIONAL SUBMITTALS

- A. Qualification Data: For qualified Installer.
- B. Product Certificates: For sound-masking equipment and components, signed by product manufacturer.
- C. Field quality-control reports.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For sound-masking equipment and components to include in emergency, operation, and maintenance manuals.

1.8 MAINTENANCE MATERIAL SUBMITTALS

- A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Sound-Masking Speaker Assemblies: 6

1.9 QUALITY ASSURANCE

- A. Installer Qualifications: An experienced installer trained and approved by manufacturer of sound-masking equipment.
- B. Testing Agency Qualifications: An independent agency with the experience and capability to conduct testing of sound-masking systems according to ASTM E 1130. Required experience

includes having tested a minimum of five different systems within the last five years, each system similar in size and complexity to Project system.

- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- D. Comply with NFPA 70.
- E. Comply with UL 813 unless a more stringent standard is specified in Part 2.

1.10 COORDINATION

- A. Coordinate quantity and arrangement of speaker assemblies with ceiling space configuration and with components occupying ceiling space, including structural members, pipes, air-distribution components, raceways, cable trays, recessed lighting fixtures, and other items.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. American Sound Masking
- B. Atlas Sound
- C. Lencore

2.2 GENERAL REQUIREMENTS FOR SOUND-MASKING EQUIPMENT

- A. Components: Modular plug-in, heavy-duty, industrial-grade integrated circuit devices.
- B. AC Supply Voltage Tolerance: 105 to 130 V with no degradation of system performance.
- C. Component Housings: Suitable for mounting in standard 19-inch relay racks, with connections at rear and controls either on rear panel or protected by a screw-fastened security cover.

2.3 NOISE GENERATOR AND FILTER UNITS

- A. Digital Masking Generator Spectra: Pink & White
- B. Pink Noise Generator: Output octave bands from 30 to 4000 Hz.
- C. Filters for One-Third Octave Bands: Adjustable from 10 dB of boost to 10 dB of cut at each center frequency.
- D. Mixer Inputs: Two high level and one microphone level.
- E. High-Pass Filter: Approximate range of cutoff adjustment is 37 to 400 Hz.

- F. Low-Pass Filter: Adjustable roll-off frequency 100 Hz to 10 kHz.
- G. High-Cut Filter: Approximate range of cutoff adjustment is 180 to 9000 Hz with slope varying to 12 dB per octave.
- H. Mounting: rack.

2.4 PROGRAMMABLE AUDIO-LEVEL CONTROL UNIT

- A. Muting: Control unit shall be programmed to permit muting for emergency paging.
- B. Built-in zone-level control shall drive other amplifiers and provide minimum [4] four position level control.
- C. Program Memory: Nonvolatile for at least one year without power. When re-energized after a power outage, control starts at zero level and automatically advances system sound level at same rate used for programmed level changes.

2.5 POWER AMPLIFIERS

- A. Power Amplifiers: Comply with CEA-426, and have the following minimum features:
 - 1. Mounting: Rack mounted.
 - 2. Output Regulation: Less than 2 dB from zero to full load.
 - 3. Signal-to-Noise Ratio: 60 dB or greater, at rated output.
 - 4. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.
 - 5. Input: From internal masking or mixer board, or from an exterior source such as an automatic level control or other mixer.

2.6 MASKING SPEAKER ASSEMBLIES

- A. Speakers: Cone type, with the following minimum features:
 - 1. Minimum Axial Sensitivity: 45 dB.
 - 2. Frequency Response: Within plus or minus 3 dB from 50 to 15,000 Hz.
 - 3. Size: 8 inches with 1-inch voice coil unless otherwise indicated.
 - 4. Dispersion Angle: 100 degrees.
 - 5. Rated Output Level: 10 W.
- B. Configuration: Dual 8-inch and dual 5-inch units mounted on metal baffles and arranged for optimum, multidirectional, angular sound distribution. Arrange units for suspension from the building structure above the ceiling.
- C. Matching Transformers: Full-power rated with 4 standard taps, and a maximum insertion loss of 0.5 dB.
- D. Assemblies installed in air-handling spaces shall comply with NFPA 70 requirements for rate of heat-release and rate of smoke-release characteristics. Tests for these requirements shall be according to UL 2043.

2.7 WIRE

- A. Speaker Wire: UTP cable complying with manufacturer's requirements; listed and labeled for environmental air plenums where cable is indicated in plenum spaces and is not indicated to be in raceway. Comply with requirements in Section 271500 "Communications Horizontal Cabling."

2.8 COMPONENT MOUNTING RACKS

- A. Configuration: Comply with CEA-310-E. Factory-fabricated units designed for interchangeable mounting, forced or convection air cooling, wiring connection, and enclosure of standard 19-inch relay rack modules.
- B. Mounting Provisions: Equipped for rack mounting.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Speaker Assemblies: Suspend with chains from building structure above ceilings so bottom of assembly is 6 to 8 inches above upper plane of finished ceiling material. Use eyebolts on speaker assemblies for attachment. Suspend independently of supports for components of other building systems.
- B. Install seismic restraints on speakers. Comply with requirements for seismic-restraint devices specified in Section 260548.16 "Seismic Controls for Electrical Systems."
- C. Speaker Connections: For two- or three-channel systems, connect speaker assemblies alternatively so masking sound is redundant throughout zones of coverage.
- D. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.
 - 1. Install plenum cable in environmental air spaces, including plenum ceilings.
 - 2. Comply with requirements specified in Section 271500 "Communications Horizontal Cabling" for cable trays
 - 3. Comply with requirements for raceways and boxes specified in Section 260533 "Raceway and Boxes for Electrical Systems."
 - 4. Comply with requirements in Section 271500 "Communications Horizontal Cabling."
- E. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.
- F. Exposed Cable: Install parallel to building lines, follow surface contours, and support as recommended by manufacturer.
- G. Grounding: As recommended by manufacturers unless more stringent requirements are indicated. Ground equipment and conductors to eliminate shock hazard and to minimize ground

loops, common-mode returns, noise pickup, cross talk, and other impairments with a maximum of 5-ohm to ground at main equipment location. Measure, record, and report ground resistance.

- H. Impedance Matching: For system components, including connecting cable, provide end-to-end level and impedance-matched signal paths. Use matching networks and balancing devices at connections where necessary to avoid mismatches.
- I. Splices, Taps, and Terminations: Make splices, taps, and terminations on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.2 IDENTIFICATION

- A. Use color-coded conductors and apply wire and cable marking tape to designate wires and cables so media are identified in coordination with system wiring diagrams. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Label speaker assemblies as to channel, zone, and address.

3.3 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 inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. 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.
- D. Tests and Inspections:
 - 1. Operational Test: Start system to confirm proper operation. Remove malfunctioning units, replace with new units, and retest. Make initial sound-spectrum and -level adjustments for each zone.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified.
 - 4. Pretesting: Tune, align, and adjust system and pretest components, wiring, and functions to verify they comply with specified material, installation, and performance requirements. Correct deficiencies and retest until satisfactory performance and conditions are achieved.
 - 5. Masking Sound-Power-Level Adjustments: Adjust independently for each space to minimum level between 40 and 50 dB that will provide speech privacy between adjacent workstations while complying with other system requirements.
- E. Final Acceptance Testing: Provide a minimum of 10 days' notice of acceptance test performance schedule. Schedule tests after pretesting has been successfully completed.

1. Tests and Calibration Conditions: Spaces shall be completely furnished but unoccupied; lights and HVAC systems shall be on; HVAC system testing and balancing shall be completed; and electronic ballasts, lighting relay panels, and low voltage transformers shall be in place.
 2. Test Conditions: Complying with ASTM E 1130 and calculated according to ANSI S3.5.
 3. Instrumentation: Use a professional-quality, sound-level meter with octave-band filters and documentation of recent calibration against recognized standards.
 4. Record test observations, readings, and corrective actions.
 5. System Tests: Include the following for each system zone:
 - a. Speaker Circuit Impedance Test: Measure impedance at 1000 Hz with amplifier disconnected, using a professional impedance meter or bridge. Locate and correct faults denoted by abnormal readings.
 - b. Ambient Sound-Level Tests: With system off, measure ambient sound level in one-third octave bands. Also measure ambient sound level as a single, wide-band, A-weighted reading.
 - c. Amplifier Noise Test: Check for performance specified in "System Description" Article with masking noise generator off and amplifiers on.
 - d. System Noise Test: With masking noise signal on and amplifiers adjusted at a working level 10 dB above ambient sound level, check for hum, buzz, rattle, or other operating deficiencies.
 - e. Spatial Uniformity Test: Measure sound level at locations no greater than 15 feet o.c. throughout covered spaces to determine compliance with specified performance level.
 - f. Frequency Response Adjustment and Test: Adjust one-third octave frequency bands and other unit filters to provide response. Adjust to meet requirement of space speech intelligibility and quality of background sound. Comply with ANSI S3.2, CEA 426, and ASTM E 1110.
 6. Adjust level of masking sound for each space so one-third octave band centered at 500 Hz has final selected sound-power level for that space. Measure deviation from listed values in one-third octave bands from 100 to 1000 Hz. Measured values must not deviate from those listed by more than 4 dB for open plan areas and 8 dB for enclosed offices. The total of individual band deviations in eight bands must not exceed 16 dB for open plan areas and 30 dB for enclosed offices.
 7. Walk-through Test: People in covered spaces cannot discern speaker locations.
 8. Temporal Stability Test: Check for uniformity of time by measuring sound level in each of 14 octave bands at one-minute intervals over a 30-minute test period. Deviations must not exceed limits specified in "System Description" Article.
 9. Where required, space shall meet the Health Insurance Portability and Accountability Act for privacy and the Gramm-Leach Bliley Act to protect consumer personal and financial information in open office layouts.
- F. Retest: Correct deficiencies identified by tests and observations and retest until meeting specified requirements.
- G. Recording Control Settings and System Adjustments: Record final control settings and programming, and final tap setting of speaker matching transformers. Record final sound-level measurements and observations.

3.4 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.5 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain services.

END OF SECTION

SECTION 28 05 00

COMMON WORK RESULTS FOR ELECTRONIC SAFETY AND SECURITY

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. Electronic safety and security equipment coordination and installation.
 - 2. Sleeves for raceways and cables.
 - 3. Sleeve seals.
 - 4. Grout.
 - 5. Common electronic safety and security installation requirements.

1.03 DEFINITIONS

- A. EPDM: Ethylene-propylene-dieneterpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.04 SUBMITTALS

- A. Product Data: For sleeve seals.

1.05 COORDINATION

- A. Coordinate all Division 28 work with Division 26 Contractor requirements.
- B. Coordinate arrangement, mounting, and support of electronic safety and security equipment:
 - 1. To allow maximum possible headroom unless specific mounting heights that reduce headroom are indicated.
 - 2. To provide for ease of disconnecting the equipment with minimum interference to other installations.
 - 3. To allow right of way for piping and conduit installed at required slope.
 - 4. So connecting raceways, cables, wireways, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- C. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- D. Coordinate location of access panels and doors for electronic safety and security items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08 Section "Access Doors and Frames."

- E. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 2: PRODUCTS

2.01 SLEEVES FOR RACEWAYS AND CABLES

- 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.
- C. Sleeves for Rectangular Openings: Galvanized sheet steel.
 - 1. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side more than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter equal to, or more than, 50 inches (1270 mm) and 1 or more sides equal to, or more than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.02 SLEEVE SEALS

- A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.
 - 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Advance Products & Systems, Inc.
 - b. Calpico, Inc.
 - c. Metraflex Co.
 - d. Pipeline Seal and Insulator, Inc.
 - 2. Sealing Elements: EPDM or NBR interlocking links shaped to fit surface of cable or conduit. Include type and number required for material and size of raceway or cable.
 - 3. Pressure Plates: Carbon steel. Include two for each sealing element.
 - 4. Connecting Bolts and Nuts: Carbon steel with corrosion-resistant coating of length required to secure pressure plates to sealing elements. Include one for each sealing element.

2.03 GROUT

- A. Nonmetallic, Shrinkage-Resistant Grout: ASTM C 1107, factory-packaged, nonmetallic aggregate grout, noncorrosive, nonstaining, mixed with water to consistency suitable for application and a 30-minute working time.

PART 3: EXECUTION

3.01 COMMON REQUIREMENTS FOR ELECTRONIC SAFETY AND SECURITY INSTALLATION

- A. Comply with NECA 1.
- B. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.
- C. Headroom Maintenance: If mounting heights or other location criteria are not indicated, arrange and install components and equipment to provide maximum possible headroom consistent with these requirements.
- D. Equipment: Install to facilitate service, maintenance, and repair or replacement of components of both electronic safety and security equipment and other nearby installations. Connect in such a way as to facilitate future disconnecting with minimum interference with other items in the vicinity.
- E. Right of Way: Give to piping systems installed at a required slope.

3.02 SLEEVE INSTALLATION FOR ELECTRONIC SAFETY AND SECURITY PENETRATIONS

- A. Electronic safety and security penetrations occur when raceways, pathways, cables, wireways, or cable trays penetrate concrete slabs, concrete or masonry walls, or fire-rated floor and wall assemblies.
- B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.
- C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
- D. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.
- E. Cut sleeves to length for mounting flush with both surfaces of walls.
- F. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level.
- G. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable, unless indicated otherwise.
- H. Seal space outside of sleeves with grout for penetrations of concrete and masonry
 - 1. Promptly pack grout solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect grout while curing.
- I. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
- J. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway and cable penetrations. Install sleeves and seal raceway and cable penetration sleeves with firestop materials. Comply with requirements in Division 07 Section "Penetration Firestopping."

- K. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- L. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.
- M. Underground, Exterior-Wall Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing mechanical sleeve seals.

3.03 SLEEVE-SEAL INSTALLATION

- A. Install to seal exterior wall penetrations.
- B. Use type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.04 FIRESTOPPING

- A. Apply firestopping to penetrations of fire-rated floor and wall assemblies for electronic safety and security installations to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

END OF SECTION 28 05 00

SECTION 28 05 13

CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

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. Fire alarm wire and cable.
 - 2. Identification products.

1.03 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Source quality-control reports.
- C. Field quality-control reports.
- D. Maintenance Data: For wire and cable to include in maintenance manuals.

1.04 QUALITY ASSURANCE

- A. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.
 - 1. Flame-Spread Index: 25 or less.
 - 2. Smoke-Developed Index: 50 or less.
- 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.

1.05 PROJECT CONDITIONS

- A. Environmental Limitations: Do not deliver or install cables and connecting materials until 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.

PART 2: PRODUCTS

2.01 PATHWAYS

- A. Support of Open Cabling: Install all fire alarm wiring per NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.
 - 1. Support brackets with cable tie slots for fastening cable ties to brackets.
 - 2. Lacing bars, spools, J-hooks, and D-rings.
 - 3. Straps and other devices.
- B. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." Flexible metal conduit shall not be used.
 - 1. Outlet boxes shall be no smaller than 2 inches wide, 4 inches high, and 2-1/4 inches deep.
- C. Sleeves: Provide 1" conduit sleeves with bushed ends from main corridors into each room with fire alarm devices. Sleeves are not indicated on plans.

2.02 FIRE ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Draka USA.
 - 2. Genesis Cable Products; Honeywell International, Inc.
 - 3. West Penn Wire/CDT; a division of Cable Design Technologies.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Twisted, shielded pair, not less than No. 16 AWG.
- D. Non-Power-Limited Circuits: Solid-copper conductors with 600-V rated, 75 deg C, color-coded insulation.
 - 1. Low-Voltage Circuits: No. 16 AWG, minimum.
 - 2. Line-Voltage Circuits: No. 12 AWG, minimum.

2.03 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Brady Corporation
 - 2. HellermannTyton.
 - 3. Kroy LLC.
 - 4. Panduit Corp.
- B. Comply with UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.
- C. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.04 SOURCE QUALITY CONTROL

- A. Cable will be considered defective if it does not pass tests and inspections.
- B. Prepare test and inspection reports.

PART 3: EXECUTION

3.01 INSTALLATION OF PATHWAYS

- A. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.
- B. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems." for installation of conduits and wireways.
- C. Install manufactured conduit sweeps and long-radius elbows whenever possible.
- D. Pathway Installation in Equipment Rooms:
 - 1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
 - 2. Secure conduits to backboard when entering room from overhead.
 - 3. Extend conduits 4 inches above finished floor.
 - 4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.
- E. Provide 1" bushed conduit sleeves from main corridors to each room with fire alarm devices.

3.02 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. General Requirements for Cabling:
 - 1. Cables may not be spliced. 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.
 - 2. 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.
 - 3. 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.

4. Cold-Weather Installation: Bring cable to room temperature before de-reeling. Heat lamps shall not be used for heating.
5. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend copper cable not in a wireway or pathway 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 or in contact with pipes, ducts, or other potentially damaging items.

D. Separation from EMI Sources:

1. Separation between Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches.
2. Separation between Cables and Fluorescent Fixtures: A minimum of 5 inches.

3.03 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. Wiring Method: Install wiring, where required, in metal raceway according to Division 26 Section "Raceway and Boxes for Electrical Systems."

1. All cable shall be plenum-rated.
2. Fire alarm circuits and equipment control wiring associated with the fire alarm system shall be installed in a dedicated raceway system. This system shall not be used for any other wire or cable.
3. Install fire alarm cabling in metal raceway in all walls, inaccessible ceilings, and unfinished spaces such as mechanical, electrical, gyms, storage rooms, locker rooms, etc. Exposed fire alarm cabling is not allowed.
4. Plenum-rated cabling may be installed without raceway above accessible ceiling space only.

C. Wiring Method:

1. Cables and raceways used for fire alarm circuits, and equipment control wiring associated with the fire alarm system, may not contain any other wire or cable.
2. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

D. Wiring within Enclosures: Separate power-limited and non-power-limited conductors as recommended by manufacturer. Install conductors parallel with or at right angles to sides and back of the enclosure. Bundle, lace, and train conductors to terminal points with no excess. Connect conductors that are

terminated, spliced, or interrupted in any enclosure associated with the fire alarm system to terminal blocks. Mark each terminal according to the system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

- E. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.
- F. Color-Coding: Color-code fire alarm conductors differently from the normal building power wiring. Use one color-code for alarm circuit wiring and another for supervisory circuits. Color-code audible alarm-indicating circuits differently from alarm-initiating circuits. Use different colors for visible alarm-indicating devices. Paint fire alarm system junction boxes and covers red.
- G. Wiring to Remote Alarm Transmitting Device: 1-inch conduit between the fire alarm control panel and the transmitter. Install number of conductors and electrical supervision for connecting wiring as needed to suit monitoring function. Provide (2) dedicated analog phone lines at annunciator.

3.04 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits, No. 14 AWG.
2. Class 2 low-energy, remote-control and signal circuits, No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm and signal circuits, No. 12 AWG.

3.05 CONNECTIONS

- A. Comply with requirements in Division 28 Section "Fire Detection and Alarm" for connecting, terminating, and identifying wires and cables.

3.06 FIRESTOPPING

- A. Comply with requirements in Division 07 Section "Firestopping."
- B. Comply with TIA/EIA-569-A, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.07 GROUNDING

- A. For communications wiring, comply with ANSI-J-STD-607-A and with BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.
- B. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.08 IDENTIFICATION

- A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.09 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
- C. Document data for each measurement. Print data for submittals in a summary report that is formatted using Table 10.1 in BICSI TDMM as a guide, or transfer the data from the instrument to the computer, save as text files, print, and submit.
- D. End-to-end cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 28 05 13

SECTION 28 31 11

FIRE-ALARM SYSTEM

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 SCOPE:

- A Provide an extension of the existing Notifier AFP-200 fire alarm system for devices indicated on the plans. The existing system is a located in the police station as indicated on the Electrical Title Sheet.

1.03 SUMMARY

- A. Section Includes:

1. System smoke detectors.
2. Heat detectors.
3. Notification appliances.
4. Magnetic door holders.
5. Addressable interface device.
6. Duct smoke detectors
7. New provisions for Activate Emergency Communication Devices

1.04 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

1.05 SYSTEM DESCRIPTION

- A. Existing system is a non-coded, fully addressable, low voltage system manufactured by xxx

1.06 SUBMITTALS

- A. General Submittal Requirements:

1. Submittals shall be approved by authorities having jurisdiction prior to submitting them to Architect.
2. Shop Drawings shall be prepared by persons with the following qualifications:
 - a. Trained and certified by manufacturer in fire-alarm system design.

- B. Product Data: For each type of product provided as a part of the extension of the existing system.

- C. Shop Drawings: For the existing fire-alarm system extension. Include plans, elevations, sections, details, and attachments to other work.
1. Comply with recommendations in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72.
 2. Include voltage drop calculations for the new and existing notification appliance circuits.
 3. Include battery-size calculations identifying requirements for adding notification appliances to the existing system.
 4. Include performance parameters and installation details for each detector, verifying that each detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
 5. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale and coordinating installation of duct smoke detectors and access to them. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
 6. Include floor plans to indicate all (new and existing) final outlet locations showing address of each (new and existing) addressable device. Show size and route of cable and conduits.
- D. Qualification Data: All work provided for this extension of the existing system shall be completed and supervised by an trained and certified manufacturer's technician..
- E. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
1. Comply with the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 2. Provide "Record of Completion Documents" according to NFPA 72 article "Permanent Records" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter.
 3. Record copy of site-specific software.
 4. Provide "Maintenance, Inspection and Testing Records" according to NFPA 72 article of the same name and include the following:
 - a. Frequency of testing of installed components.
 - b. Frequency of inspection of installed components.
 - c. Requirements and recommendations related to results of maintenance.
 - d. Manufacturer's user training manuals.
 5. Manufacturer's required maintenance related to system warranty requirements.
 6. Abbreviated operating instructions for mounting at fire-alarm control unit.
 7. Copy of NFPA 25.

1.07 QUALITY ASSURANCE

- A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.
- B. Source Limitations for Fire-Alarm System and Components: Obtain fire-alarm system from single source from existing system manufacturer. Components shall be compatible with, and operate as, an extension of existing system

- 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.

1.08 PROJECT CONDITIONS

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

1.09 SEQUENCING AND SCHEDULING

- A. Existing Fire-Alarm Equipment: Maintain existing equipment fully operational until new equipment has been tested and accepted. As new equipment is installed, label it "NOT IN SERVICE" until it is accepted. Remove labels from new equipment when put into service and label existing fire-alarm equipment "NOT IN SERVICE" until removed from the building.
- B. Equipment Removal: After acceptance of new fire-alarm system, remove existing disconnected fire-alarm equipment and wiring.

1.10 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no less than 1 unit.
 - 2. Audible and Visual Notification Appliances: one of each type installed.
- B. In addition to the devices and appliances shown on drawings, the following devices and appliances shall be furnished and installed in locations as directed during construction:
 - 1. Smoke detectors: Provide an additional two (2) smoke detectors with addressable bases. **A credit of \$250.00 will be required for any detectors not installed at Project Close-out.**
 - 2. Audio-Visual Appliances: Provide an additional four (4) audio-visual appliances. **A credit of \$200.00 will be required for any appliances not installed at Project Close-out.**
 - 2. Audio-Visual Appliances: Provide an additional four (4) audio-visual appliances. **A credit of \$200.00 will be required for any appliances not installed at Project Close-out.**
 - 3. Duct Smoke Detectors: Provide an additional two (2) duct smoke detectors. **A credit of \$750.00 will be required for any detectors not installed at Project Close-out.**

PART 2: PRODUCTS

2.01 MANUFACTURERS

- 1. Manufacturers: Subject to compliance with requirements; Provide devices that are equal to the existing system manufacturer Notifier for this extension.

2.02 SYSTEMS OPERATIONAL DESCRIPTION

- A. Fire-alarm signal initiation shall be consistent with the existing system operation.

2.03 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. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.04 SYSTEM SMOKE DETECTORS

- A. General Requirements for System Smoke Detectors:
 - 1. Comply with UL 268; operating at 24-V dc, nominal.
 - 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
 - 3. Base Mounting: Detector and associated electronic components shall be mounted in a twist-lock module that connects to a fixed base. Provide terminals in the fixed base for connection to building wiring.
 - 4. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
 - 5. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
 - a. Rate-of-rise temperature characteristic shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
- 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.
- C. Ionization Smoke Detector:
 - 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.).
- D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
4. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit. Provide all wiring, components etc for proper operation.

2.05 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
 1. Heat Detector, Combination Type: Provide detectors equal to existing detectors installed in other similar areas of the building.

2.06 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Individually addressed, connected to a signaling line circuit, equipped for mounting as indicated and with screw terminals for system connections. Provide as required for code and ADA compliant operation to include additional power supplies.
 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. Provide appliances to match existing appliances.
- B. Visible Notification Appliances: Xenon strobe lights comply with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (25-mm-) high letters on the lens. Provide appliances that match existing appliances installed in similar areas of the building. Provide as required for code and ADA compliant operation to include additional power supplies.
 1. Rated Light Output:
 - a. 15/30/75/110 cd, selectable in the field.
 2. Mounting: Wall mounted unless otherwise indicated.
 3. For units with guards to prevent physical damage, light output ratings shall be determined with guards in place.
 4. Flashing shall be in a temporal pattern, synchronized with other units.
 5. Strobe Leads: Factory connected to screw terminals.

- C. Emergency Notification Device: Amber in color located in general areas throughout the building, gyms, cafeterias and on the exterior. Device shall be activated through the "Lockdown Button" Provide separate power supplies, cards and programming as required for the addition of these devices to the existing system.

2.7 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate. Provide units that match existing complete with additional power supplies as required.
1. Electromagnet: Requires no more than 3 W to develop 25-lbf (111-N) holding force.
 2. Wall-Mounted Units: Flush mounted unless otherwise indicated.
 3. Rating: 24-V ac or dc.
- B. Material and Finish: Match door hardware.

2.8 ADDRESSABLE INTERFACE DEVICE

- A. Description: Microelectronic monitor module, NRTL listed for use in providing a system address for alarm-initiating devices for wired applications with normally open contacts.

2.9 DEVICE GUARDS

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, or other device requiring protection.
1. Factory fabricated and furnished by manufacturer of device.
 2. Finish: Paint of color to match the protected device.

PART 3: EXECUTION

3.01 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.
- B. Equipment Mounting: Install fire-alarm control unit on concrete base with tops of cabinets not more than 72 inches (1830 mm) above the finished floor.
- C. Connecting to Existing Equipment: Verify that existing fire-alarm system is operational before making changes or connections.
1. Connect new equipment to existing control panel in existing part of the building.
 2. Connect new equipment to existing monitoring equipment at the supervising station.
 3. Expand, modify, and supplement existing equipment as necessary to extend existing functions to the new points. New components shall be capable of merging with existing configuration without degrading the performance of either system.
- D. Smoke- or Heat-Detector Spacing:
1. Comply with NFPA 72, "Smoke-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for smoke-detector spacing.

2. Comply with NFPA 72, "Heat-Sensing Fire Detectors" Section in the "Initiating Devices" Chapter, for heat-detector spacing.
 3. Smooth ceiling spacing shall not exceed 30 feet (9 m).
 4. Spacing of detectors for irregular areas, for irregular ceiling construction, and for high ceiling areas shall be determined according to Appendix A in NFPA 72.
 5. HVAC: Locate detectors not closer than 3 feet (1 m) from air-supply diffuser or return-air opening.
 6. Lighting Fixtures: Locate detectors not closer than 12 inches (300 mm) from any part of a lighting fixture.
- E. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
- F.
- G. No "In Duct" duct detectors shall be used for duct smoke detectors.
- H. Remote Status and Alarm Indicators: Install near each smoke detector and each sprinkler water-flow switch and valve-tamper switch that is not readily visible from normal viewing position.
- I. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille.
- J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling.
- K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.02 CONNECTIONS

- A. For fire-protection systems related to doors in fire-rated walls and partitions and to doors in smoke partitions, comply with requirements in Division 08 Section "Door Hardware." Connect hardware and devices to fire-alarm system.
1. Verify that hardware and devices are NRTL listed for use with fire-alarm system in this Section before making connections.
- B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 3 feet (1 m) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.
1. Alarm-initiating connection to smoke-control system (smoke management) at firefighter smoke-control system panel.
 2. Alarm-initiating connection to stairwell and elevator-shaft pressurization systems.
 3. Smoke dampers in air ducts of designated air-conditioning duct systems.
 4. Alarm-initiating connection to elevator recall system and components.

3.03 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by authorities having jurisdiction.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. 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. A complete (new and existing) system test shall be completed and report submitted to the local Authority Having Jurisdiction with a copy submitted to the Owner and Engineer prior to Project close-out.
- D. Tests and Inspections:
 - 1. Visual Inspection: Conduct visual inspection prior to testing.
 - a. Inspection shall be based on completed Record Drawings and system documentation that is required by NFPA 72 in its "Completion Documents, Preparation" Table in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter.
 - b. Comply with "Visual Inspection Frequencies" Table in the "Inspection" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.
 - 2. System Testing: Comply with "Test Methods" Table in the "Testing" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
 - 3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
 - 4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
 - 5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
 - 6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" Section of the "Fundamentals of Fire Alarm Systems" Chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" Section of the "Inspection, Testing and Maintenance" Chapter in NFPA 72.
- E. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- F. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- G. Prepare test and inspection reports.

END OF SECTION 28 31 11

SECTION 31 00 00

EARTHWORK

PART 1 - GENERAL

1.01 SUMMARY

- A. The extent of earthwork is shown on the Drawings. This work will generally consist of, but is not limited to, the following:
1. Employ a utility locating company to locate all privately owned utilities.
 2. Construction of temporary drainage piping and conveyance ways and removal of these temporary facilities (including full restoration) following use.
 3. Stripping and stockpiling of topsoil and other soils to be reused.
 4. Earthwork (cutting and filling).
 5. Excavating unsuitable soils from underneath proposed building area (building pad soil correction). Work is affected by Unit Prices.
 - a. Conduct a preconstruction meeting prior to beginning building pad soil correction. Required attendees:
 - 1) Civil Engineer
 - 2) Geotechnical Engineer
 - 3) Earthwork Contractor
 - 4) General Contractor
 - 5) Other Owner's representative
 6. Construction of building pad (engineered fill) for the building additions.
 7. Construction of sand sub-base on the building pad and coordination with other contractors as to the appropriate time to install the sand sub-base.
 8. Footing and foundation excavation, backfill and compaction.
 9. Provide adequate shoring, bracing and underpinning of existing buildings.
 10. Construction of sand subbase at frost-footed stoops.
 11. Construction of sand base or stabilized aggregate base under walks and ramps.
 12. Construction of draintile from the frost footed stoop sand subbase and connecting draintile to storm sewer where indicated on the Drawings. Construct flexible joints, backwater valves and cleanouts.
 13. Construction, shaping, compacting, and maintenance (on interim basis) of pavement subgrades prior to placement of pavement base materials thereon. Maintenance shall be continual until the Paving Contractor accepts the subgrade (approximately the time the areas will be paved).
 14. Compacting fill and backfill.
 15. Removal and replacement of unsuitable and unstable soils, rocks, etc.
 16. Importing granular fill and other specified materials for construction of engineered fill, pavement subgrades, sand subbases, sand bases, and in conjunction with dewatering operations, as needed.
 17. Exporting excess, unsuitable or waste materials from site and importing suitable materials to the site to complete work indicated on the Drawings.
 18. Dewatering of site and excavations to maintain workable conditions and to protect on-site soils from becoming unstable.
 19. Spreading and respreading of topsoil.
 20. Maintaining existing site, adjacent properties and public streets clean (on a daily basis) from construction caused dirt and debris.
 21. Maintaining dust control during grading operations. Providing for watering of soils as required to control dust.
 22. Restoration and cleanup.
- B. Related work not included in this Specification Section and specified elsewhere:
1. Draintile for Retaining Walls - Refer to Section 31 23 25 Drainage Aggregate.
- C. Work under this section is affected by Unit Prices. Refer to specification section 01 22 00 Unit Prices.

1.02 SUBMITTALS

- A. In accordance with Spec Section 01 33 00 Submittals, submit shop drawings for the following products and materials:
 - 1. Draintile
 - 2. Draintile cleanout
 - 3. Backwater Valve
 - 4. Tracer Wire
 - 5. Flexible Joints at Storm Structure connections.
- B. Submit samples of proposed backfill and fill materials to the testing laboratory at least three days prior to placement for evaluation of their suitability and determination of the optimum moisture content and maximum dry density.
- C. Submit shoring, bracing and underpinning plans and calculations for review by the Geotechnical Engineer.

1.03 DEFINITIONS

- A. Clearing: Removal of trees, vegetation, rubble and other unsuitable materials from the site or limits of work.
- B. Stripping: Excavation and removal of topsoil, fill and any other upper layers of soils.
- C. Excavation: Cutting, digging and removing soil materials of every classification and of whatever substance encountered to dimensions, limits, elevation and contours shown on the Drawings.
- D. Unsuitable Materials: Rock, shale, loam, gumbo, mud, muck, silt, organic silty clay, peat, boulders, debris, rubbish, old foundations, pavements, slabs, vegetation or highly organic soils.
- E. Unstable Materials: Materials which are not classified as unsuitable materials, but due to their condition of being too wet, too dry, over-compacted or frozen, are unacceptable.
- F. Soil Classification: Classification of soils for engineering purposes, ASTM D2487 Unified Soils Classification System (USCS) with divisions, group symbols, typical names and criteria referenced herein.
- G. Engineered Fill: Placing of approved site material or borrow material in accordance with specified procedures and compaction to achieve an assumed soil bearing capacity specified herein for footings and retaining walls.
- H. Backfill: Placing of approved site soil or borrow material in accordance with specified procedures and compaction to establish elevations shown for site improvements and general rough grading.
- I. Subbase: Compacted fill upon which stabilized base course is placed.
- J. Subgrade: Subsoil in place, backfill or fill material upon which subbase, stabilized base course, footings, or sand bases are placed.
- K. Compacted Subgrade: Upper part of subgrade that is compacted to a greater density than lower portion of subgrade or subsoil. This material occurs beneath drives, roadways and parking areas.
- L. Subsoil: Natural soil in place on the site.
- M. Existing Site Material: Stripped and excavated material from work, of approved classification. Material must be approved by soils testing agency prior to placement.
- N. Borrow Material: Approved soil materials for fill, backfill, or rough grading required, from sources other than those made available by stripping of excavation of site.

- O. Building Area: The area of the site within a line three feet outside of the proposed building perimeter and extending at a slope of 1:1 (horizontal to vertical) to the bottom of the excavation.
- P. Retaining Wall Area: The area of the site within a line five feet each way of the proposed retaining wall base and extending at a slope of 1:1 (horizontal to vertical) to the bottom of the excavation.
- Q. Rock: Rock excavation is defined to include all hard, solid rock in ledge formation, bedded deposits and unstratified masses; all natural conglomerate deposits so firmly cemented as to present all the characteristics of solid rock; and any boulder stone, masonry or concrete fragments exceeding one cubic yard in volume. Materials such as shale, hard pan, soft or disintegrated rock which can be dislodged with a power operated excavator will not be classified as rock excavation.
- R. Topsoil: Fertile, friable, natural loam containing a liberal amount of humus and capable of sustaining vigorous plant growth. The pH value of the topsoil shall be between 5.5 and 7.5.

1.04 JOB CONDITIONS

- A. Site Information:
 - 1. All information concerning property boundaries, ground elevations, present obstructions on or near the site, location of conduits, pipes, wires, etc., has been obtained from a source the Owner believes reliable. Present ground and subsurface conditions are documented by test boring logs included herein, however accuracy of this data is not guaranteed, and is furnished solely for the convenience of the Bidder. Use of this data is at Bidder's risk and no additional compensation will be granted because of the Bidder's lack of knowledge of the existing site.
 - 2. Additional test borings and other exploratory operations may be conducted by a Bidder (at no cost to the Owner), provided the methods and operations are acceptable to the Owner.
 - 3. Should uncharted, or incorrectly charted, piping or other utilities be encountered during excavation, consult appropriate utility owner immediately for directions. Cooperate with Owner and utility companies in keeping respective services and facilities in operation. Repair any damaged utility(s) to satisfaction of utility owner.
 - 4. Visit the site prior to bidding; be familiar with actual conditions in the field. Extra compensation will not be allowed for conditions which could have been determined or anticipated by examination of the site, the Contract Drawings and the information available pertaining to existing soils, utilities and other site characteristics.
 - 5. Maintain carefully, as established, temporary bench marks, monuments and other reference points and, if disturbed or destroyed by the Contractor, pay for replacement by a registered Engineer or Land Surveyor.
 - 6. Locate existing underground utilities in areas of work. If utilities are to remain in place, provide adequate means of support and protection during earthwork operations.

1.05 QUALITY ASSURANCE

- A. The Contractor shall employ and pay for the services of a Registered Land Surveyor to layout the Work and locate and mark associated benchmarks (refer to Section 01 71 23 - Field Engineering).
- B. The Owner will employ and pay for the services of a soil testing and inspection service (Geotechnical Engineer) for quality control testing of the earthwork operations.
- C. All work shall comply with the requirements of the Department of Labor and Industry and the rules and regulations identified in the Minnesota Plumbing Code.

- D. The Owner's representative from the testing laboratory (Geotechnical Engineer) must be continually present during stripping, excavation, backfilling, and compaction operations. Services which will be performed by the testing laboratory are as follows:
1. Inspect all excavations within the building areas, retaining wall areas, and prepared areas to be paved prior to any filling to ensure that unsuitable and unstable soils have been completely removed. Tests will be performed in the bottoms of the excavations to evaluate if the bearing capacity of the natural soils is at least 3,000 pounds per square foot (psf) for building footings and at least 2,000 psf for retaining walls.
 2. Test imported fill materials and aggregates prior to delivery to the site. This will consist of sieve analyses to determine the suitability of the materials for the intended use. Once the source has been approved, the materials being delivered to the project will be tested on a regular basis to aid in evaluating their uniformity.
 3. Inspect fill and backfill materials and operations, determine optimum use of various on-site soils, review and approve method of subcutting unsuitable soils.
 4. Take density tests as backfilling occurs to ensure that material is uniformly compacted to conform with the specifications. Compaction tests will be taken at an interval of at least one for every 100 cubic yards of fill placed in building and retaining wall areas, one for every 100 feet of footing trench backfill, and at least one for every 400 cubic yards of fill placed in pavement areas, at maximum vertical intervals of 2 feet of fill placed.
 5. Observe proof roll. Make recommendations for areas that do not pass the proof roll test.
- E. Contractor's Responsibilities:
1. Submit samples of proposed backfill and fill materials to the testing laboratory at least three days prior to placement for evaluation of their suitability and determination of the optimum moisture content and maximum dry density.
 2. Inform testing laboratory representative of proposed earthwork schedule at least 48 hours prior to commencing work. Earthwork operations which require inspection by testing laboratories shall not be performed unless the Geotechnical Engineer is present. Coordinate all earthwork activities with the testing laboratory.
 3. Provide fully loaded tandem axle dump truck for proof rolling operations and perform proof rolling in presence of the Geotechnical Engineer (as many times as necessary as determined by the Geotechnical Engineer to the satisfaction of the Geotechnical Engineer).

PART 2 - PRODUCTS

2.01 EARTH MATERIALS

- A. Building Pad (Engineered Fill)
1. Engineered fill shall be free of rock, cobbles, boulders, stones larger than 3 inches, debris, rubble, lumps, wood, topsoil, organic material, soft, frozen or other unsuitable material. The fill shall consist of on-site mineral soils, or imported coarse-grained soils with less than 20% of the particles by weight passing a #200 sieve and 100% passing a 3 inch sieve. The cost of imported soils is incidental to the Contract.
- B. Retaining Wall Subgrade (Engineered Fill)
1. Engineered fill shall meet the specifications for Building Pad (Engineered Fill).
- C. Backfill for Foundation Walls
1. Backfill shall meet the specifications for Engineered Fill for the Building Pad, unless otherwise noted.
 2. Backfill for Below Grade Building Walls shall consist of imported, free draining, uniformly graded clean sand with 100% passing the 1 inch sieve, with less than 5% passing the #200 sieve and less than 40% passing the #40 sieve.
 - a. Backfill for use behind below-grade building walls in exterior landscaped areas shall be capped with a minimum of 18" of low permeability clay soils having at least 35% by weight passing the #200 sieve, and capped with a minimum of 6" of topsoil.

- D. Sand Subbase
 - 1. Sand shall consist of imported, free draining, uniformly graded clean sand with 100% passing the 1 inch sieve, with less than 5% passing the #200 sieve and less than 40% passing the #40 sieve.
- E. Sand Base
 - 1. Sand shall meet the requirements for Sand Subbase.
- F. Stabilized Aggregate Base
 - 1. Aggregate shall meet the requirements of the current Mn/DOT Spec 3138, Class 5, Table 3138-1 (100% crushed limestone) or Table 3138-4 (recycled concrete / asphalt).
- G. Pavement Areas
 - 1. Fill for pavement area subgrade shall meet the specifications for Engineered Fill for the Building Pad, unless otherwise noted.
- H. General Site Fill
 - 1. Fill for general site areas outside the buildings and paved areas shall be free of rock, boulders, debris, rubble, lumps, wood, topsoil, soft, frozen or other unsuitable material. The fill shall consist of on-site or imported soils, type GP, GW, SP, SW, SP-SM, or SM, modified to 100% passing a 6 inch sieve. Soils shall have an organic content less than 10%. The cost of imported soils is incidental to the Contract.
- I. Topsoil
 - 1. Topsoil shall be a fertile, friable, natural loam containing a liberal amount of humus and capable of sustaining vigorous plant growth.
 - 2. The pH value of the topsoil shall be between 5.5 and 7.5.
 - 3. Topsoil shall be obtained from naturally well-drained areas and shall be clean and reasonably free of subsoil, stones, clods of hard earth, plants or their roots and other extraneous matter. Buried organic soil or organic soil taken from hydric areas is not acceptable for use as topsoil.
 - 4. Topsoil obtained from stripping the site may be used.
 - 5. Imported topsoil shall meet Mn/DOT 3877.2C Sandy Clay Loam Topsoil Borrow.

2.02 MISCELLANEOUS MATERIALS

- A. Drintile and Related Components
 - 1. Drintile (subsoil drains) shall meet or exceed ASTM D2729. Drintile shall be perforated PVC Pipe, Contech A-2000 perforated sewer pipe, as supplied by Contech Construction Products, Inc., or approved equal. Pipe shall not be directly wrapped in geotextile fabric.
 - 2. Cleanouts, covers, and other related products shall be as specified on the Drawings and details.
 - 3. Flexible Joints at Storm Sewer Structure Connections (applies to ALL pipe connections)
 - a. In accordance with Minnesota Plumbing Code, provide Flexible Joints at all pipe connections to all storm sewer structures.
 - b. Acceptable manufacturers / products:
 - 1) Fernco, "Concrete Manhole Adaptors" or "Large-Diameter Waterstops"
 - 2) Press-Seal, Waterstop Grouting Rings"
 - 3) Or approved equal.
 - 4. Tracer Wire
 - a. All trace wire and trace wire products shall be domestically manufactured in the U.S.A.
 - b. All trace wire shall have HDPE insulation intended for direct bury, color coated per APWA standard for the specific utility being marked.
 - c. Trace Wire
 - 1) Open Trench Trace wire shall be #12 AWG Copper Clad Steel, High Strength with minimum 450 lb. break load, with minimum 30 mil HDPE insulation thickness.

- d. Direct Bury Wire Connectors
 - 1) Connectors shall be dielectric silicon filled to seal out moisture and corrosion, and shall be installed in a manner so as to prevent any uninsulated wire exposure.
 - 2) Non locking friction fit, twist on or taped connectors are prohibited.
- e. Termination/Access
 - 1) All trace wire termination points must utilize an approved trace wire access box (above ground access box or grade level/in-ground access box as applicable), specifically manufactured for this purpose.
 - 2) All grade level/in-ground access boxes shall be appropriately identified with “sewer” or “water” cast into the cap and be color coded.
 - 3) A minimum of 2 ft. of excess/slack wire is required in all trace wire access boxes after meeting final elevation.
 - 4) All trace wire access boxes must include a manually interruptible conductive/connective link between the terminal(s) for the trace wire connection and the terminal for the grounding anode wire connection.
 - 5) Grounding anode wire shall be connected to the identified (or bottom) terminal on all access boxes.
- 5. Backwater Valve
 - a. Valve shall be NDS 6" Backwater Valve, part number 675PS, PVC non-pressure backwater valve, or approved equal.

PART 3 - EXECUTION

3.01 SPECIAL PRECAUTIONS

- A. Dewatering (Incidental to Contract)
 - 1. Prevent surface water and subsurface (ground) water from flowing into excavations and from flooding the site and surrounding area.
 - 2. Do not allow water to accumulate in excavations. Remove water to prevent soil changes detrimental to stability of subgrades and foundations. Provide and maintain pumps, well points, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations. Groundwater shall be drawn down below the anticipated excavation bottom in advance of excavation. Sump pits shall be located outside the building pad and its oversize area.
 - a. Discharged water from pumping, diversion, or similar operations shall not be discharged to Waters of the State without being free of sediment and suspended materials and shall be treated in accordance with Mn/DOT Spec 3875 Water Treatment. “Waters of the State” (as defined in Minn. Stat. § 115.01, subd. 22) means all streams, lakes, ponds, marshes, watercourses, waterways, wells, springs, reservoirs, aquifers, irrigation systems, drainage systems and all other bodies or accumulations of water, surface or underground, natural or artificial, public or private, which are contained within, flow through, or border upon the state or any portion thereof. Waters of the State include storm sewer, curb and gutter, and pavements.
 - 3. If the soils become disturbed and unstable, they shall be removed and replaced with drier compacted fill. Alternatively, under favorable weather conditions, the disturbed and / or unstable soils may be scarified, dried and recompacted back into place.
 - 4. Convey water removed from excavations and rain water to collecting or run-off areas. Establish and maintain temporary drainage ditches and other diversions outside excavation limits for each structure. Do not use trench excavations as temporary drainage ditches.
 - 5. Do not place fill or compacted fill in standing water or over softened soils.

- B. Stability of Excavations
 - 1. Sidewalls of all excavations shall comply with the most current OSHA regulations and applicable local codes and ordinances. Shore and brace where adequate sloping is not feasible because of space restrictions or stability of material being excavated.
 - 2. Maintain slopes of excavations in safe condition until completion of backfilling.
 - 3. Soils on site may be sensitive to moisture and may be easily disturbed by construction traffic. Provide stabilization materials (sand, aggregate, hydrated lime, fly ash, etc.) to stabilize. Limit use of rubber tired equipment on subgrade. Measures to protect subgrade from becoming unstable and maintaining stability of subgrade soils shall be provided. Subgrade stabilization will be incidental to the Contract. Subgrade stabilization shall be the responsibility of the Earthwork Contractor until the Stabilized Aggregate Base course is installed by the Paving Contractor.
- C. Cold Weather Protection
 - 1. If site grading and construction takes place during cold weather, good winter construction practices shall be observed. All snow and ice shall be removed from cut and fill areas prior to additional grading. No fill, footings nor slabs shall be placed on soils which have frozen or contain frozen material. No frozen soils should be used as fill.
 - 2. Protect excavation bottoms against freezing when atmospheric temperature is less than 35° F.

3.02 LAYOUT

- A. The Contractor shall employ and pay for the services of a registered Engineer or Land Surveyor, acceptable to the Engineer / Architect, to stake and tape limits of construction, accurately locate the site boundaries, pavements, walks, building addition, retaining walls, and elevations, and establish temporary bench marks for use during construction (refer to Section 31 71 23 - Field Engineering).
- B. Applicable portions of the building addition shall be frequently staked (horizontal and vertical reference points) during excavation and backfilling operations to facilitate orientation of the testing laboratory representative.

3.03 EXCAVATIONS

- A. Excavations within a zone horizontally outward a minimum 3 feet from the outside of the existing footings and slabs, and extending at a 1 to 1 horizontal to vertical slope outward and downward from the bottom of the existing foundation will require support of existing foundations.
 - 1. Provide adequate shoring, bracing and underpinning of the existing building for construction of the building pads as described for excavations within the limits noted in the Construction Documents. Under this contract, stability of the existing building will be the responsibility of the contractor. All shoring, bracing and underpinning shall be reviewed and approved by the Geotechnical Engineer during construction.
- B. Excavate to the lines, grades and slopes shown on the Drawings.
- C. Provide temporary drainage where construction interferes with existing drainage.
- D. Excavate and remove all vegetation, topsoil, loose soils, unsuitable soils, and soils with organic content within building and retaining wall areas, and within the upper three (3) feet of final subgrade elevation of all proposed pavement areas. Remove all organic soils and vegetation under pavement areas. Remove any soft soils which are unsuitable for loads as directed by the Geotechnical Engineer. No proposed slabs or similar loads shall bear on soil with questionable bearing capacity.
- E. Excavation shall extend a minimum of six inches below elevation of observed unsuitable soil. Extend excavations in wet or fine-grained soils to remove disturbed bottom soils.
- F. Oversize building and retaining wall excavations at least three feet beyond the edge of the wall plus 1 foot horizontally for each foot of excavation below the bottoms of the footings (1:1 oversizing).

- G. In pavement areas, excavations shall be oversized one foot beyond the outside edges pavement, plus 1 foot horizontally for each foot of excavation below the pavement (1:1 oversizing).
- H. The building pad shall be constructed to finish subgrade (uniform elevation) prior to construction of footings.
- I. In building, retaining wall, and paved areas, subsequent to completing excavations, the exposed soils shall be scarified to a depth of 12", moisture conditioned to within the specified percentages of optimum moisture content, and surface compacted to the compaction requirements specified herein. Soils that cannot be stabilized with reasonable effort, as determined by the Geotechnical Engineer, shall be removed and replaced in accordance with Paragraph 3.13 of this Section. Subsequent stripping soils as described herein and prior to placement of fill, proof roll the exposed soils in accordance with Proof Roll requirements specified in this Section.

3.04 BUILDING PAD SOIL CORRECTION

- A. Prior to construction, conduct a preconstruction meeting prior to beginning building pad soil correction. Procedures outlined herein will be reviewed and discussed at the preconstruction meeting. Required attendees:
 - 1. Civil Engineer
 - 2. Geotechnical Engineer
 - 3. Earthwork Contractor
 - 4. General Contractor
 - 5. Other Owner's representative
- B. Excavate to the estimated depths shown on the Geotechnical Table on the Drawings under the base bid condition.
- C. Subsequent to excavating unsuitable soil and subgrade approval by the Geotechnical Engineer, the Geotechnical Engineer will record the bottom of the excavation. The Contractor shall allow time for this work to occur and shall coordinate this work with the Geotechnical Engineer.
- D. Following recording by the Geotechnical Engineer, place approved fill in approved lifts as noted herein up to building subgrade elevation.
- E. Building Pad Soil Correction, affected by Unit Price, shall include excavation of unsuitable soils and backfilling and compacting of soils specified for Engineered Fill.
- F. The base bid soil correction quantities will be based on the in-place volume. The in-place volume will be calculated as follows:
 - 1. Upper limit will be the building pad subgrade elevation.
 - 2. The lower limit will be bottom of excavation described by the estimated depths noted on the Geotechnical Table.
 - a. For the areas between the borings, include in the base bid calculations a straight line interpolation between the depths shown on the Geotechnical Table. If there is a situation where no borings were taken outside the building pad limits or if the Table does not represent depths at borings that are outside the building pad, the depth at the edge of the building pad shall be assumed to be equal to depth described by the nearest boring listed in the Table.
 - 3. Side limits shall be as follows:
 - a. Where adjacent to the existing building, the existing building vertical wall will be the limit.
 - b. Where not adjacent to the existing building, the limit shall begin at subgrade elevation, ten feet beyond the limits of the building addition shown on the drawings. The side slopes shall slope down at a 1:1 slope out and away from the building addition limits until this line intercepts the lower limit.
 - 4. The in-place volume is defined as the volume contained within the upper, lower and side limits described above.

- G. The base bid will be adjusted by Unit Price (additional cost to the contractor or credit to the Owner) based on the survey prepared by the Geotechnical Engineer.
- H. Actual soil correction quantities will be calculated as noted above, except the lower limit will be the field measurements recorded by the Geotechnical Engineer.
- I. The soil quantity for the unit price will be the difference between the actual soil correction quantity and the base bid soil correction quantity. Where the actual soil quantity is more than the base bid, the result will be an add to the Contract, and vice versa.
- J. Excavation, backfilling and compaction beyond the in-place volume limits described above will not count towards the building pad soil correction quantity, unit price quantity, or actual field measured quantity, and will be considered incidental to the Contract.

3.07 FOOTING AND FOUNDATION EXCAVATION, BACKFILLING AND COMPACTING

- A. Disposition of Materials
 - 1. Material Stockpiles
 - a. Stockpile excavated material which is suitable for reuse as backfill.
 - b. Locate stockpiles to avoid impairment of later operations by other contractors. Consult with other trades prior to stockpiling.
 - 2. Surplus Materials
 - a. Remove surplus materials from site (export) at no additional cost to the Owner.
 - b. All unsuitable materials shall be removed from site (export), at no additional cost to the Owner.
- B. General Method of Procedure
 - 1. The building pad shall be constructed to uniform subgrade elevation prior to construction of footings.
 - 2. Trench and hand excavate for footings.
 - 3. Prior to placing forms or reinforcement, surface compact the exposed subgrade to a minimum 98% of the standard Proctor maximum dry density.
 - 4. The Geotechnical Engineer shall inspect footing trenches to determine that actual soil bearing values meet the requirements specified herein and that no unstable or inadequate soils exist beneath the proposed footings.
 - 5. Allow for pouring of concrete footings and laying up of foundation walls.
 - 6. Shore foundation walls or backfill and compact with soils on both sides of foundation walls simultaneously.
 - 7. Backfill and compact with backfill material to underside of Sand Subbase below the Building Floor Slab.
 - 8. Footing excavation shall progress with the schedule of footing installation. Do not excavate footing trenches beyond the footing installation limits for the day.
- C. Unauthorized Excavation
 - 1. Fill shall not be permitted under footings where the excavation is made beyond the indicated subgrade elevations, without specific approval by the Geotechnical Engineer.
 - 2. If an excavation is made too deep, it shall be filled with concrete to proper footing elevation and the cost associated with the additional concrete will be at Contractor's expense.

- D. **Compaction and Backfill**
1. Subsequent to footing trench excavation and prior to footing placement, surface compact the trench bottom with a vibratory compactor to the satisfaction of the soils engineer to ensure a uniform bearing capacity.
 2. **General Compaction Requirements**
 - a. Provide soil compaction at areas where soil does not meet requirements of these Specifications.
 - b. Footings shall not rest on unsuitable or unstable soil.
 3. **Foundation Wall Backfill**
 - a. Deposit approved fill against foundation walls in uniform layers not exceeding 8 inches (loose) thickness (dependent upon review by the Geotechnical Engineer).
 4. Manually operated vibratory plate compactors shall be used to compact fill and backfill placed within five feet from building foundation walls. Self propelled compactors shall only be used outside of this five foot limit.

3.08 SAND SUBBASE AT DOORS AND FROST FOOTED STOOPS

- A. Strip, excavate and remove all topsoil.
- B. Remove all frost susceptible soils within the limits described below.
1. The subexcavation shall be wedge-shaped, with a 5' depth adjacent to the frost-footed stoops, six foot depth five feet away from the stoop, and then tapering to a four inch depth 25' beyond the frost-footed slabs. All distances shall be measured radially away from the stoop but shall be limited to 2 feet laterally on each side of the walk serving the stoop. Backfill areas with sand as specified, compacted to 100% Standard Proctor.

3.09 INSTALLATION OF THE DRAINTILE ASSEMBLY

- A. **Trenching:**
1. Excavate to proper depth and width necessary for construction of piping system according to Drawings. Maximum width of excavation be the outside diameter of pipe plus 36 inches.
 2. Trench shall be dug in advance of pipe installation, only so far as Engineer permits. Slope and brace sides of trenches so that workers can work safely and efficiently. Discharge water shall be drained to natural drainage channels or to storm sewers if approved by Engineer.
- B. **Installing Piping and Appurtenances:**
1. Provide and use the proper implements and facilities for the safe and convenient prosecution of work.
 2. Unload and distribute materials at site carefully to prevent materials from being damaged, minimize handling, and not hamper construction activities. In no case shall materials be thrown or dumped from truck.
 3. Lower pipe into trench carefully to prevent damage to pipe and protective coatings and linings. Under no circumstances shall pipe be dumped into trench.
 4. Provide, without additional compensation, suitable temporary channels for water that flows along or across site and is restricted by work. Place excavated material on one side of trench, except when permitted by Engineer to use both sides. Excavated material shall be so placed as not to obstruct any site drainage pattern.
 5. Drain tile shall be laid carefully to line and grade, with uniform bearing throughout and with the perforations down.
 6. All junctions and turns shall be made with wyes, tees and bends fabricated from the same material as the pipe. Close and plug ends of all drain tile.
 7. Connect dRAINTILE to storm sewer structure where noted on the Drawings. Provide flexible joint at dRAINTILE connection as specified in Section 33 40 00. Construct backwater valve on end of dRAINTILE for dRAINTILE lines that extend from the building area.

8. Unless otherwise permitted by the Engineer, bell and spigot pipe shall be laid with the bell ends facing upgrade and the laying shall start on the downgrade end and proceed upgrade. As each length of bell and spigot pipe is placed in laying position, the spigot end shall be centered in the bell and the pipe forced home and brought to correct line and grade. The joint areas shall remain exposed and precautions shall be taken to prevent the soil from entering the joint space, until the joint seal is effected.
9. Tracer Wire Installation
 - a. Trace wire installation shall be performed in such a manner that allows proper access for connection of line tracing equipment, proper locating of wire without loss or deterioration of low frequency (512Hz) signal for distances in excess of 1,000 linear feet, and without distortion of signal caused by multiple wires being installed in close proximity to one another.
 - b. Trace wire systems must be installed as a single continuous wire, except where using approved connectors. No looping or coiling of wire is allowed.
 - c. Any damage occurring during installation of the trace wire must be immediately repaired by removing the damaged wire, and installing a new section of wire with approved connectors. Taping and/or spray coating shall not be allowed.
 - d. Trace wire shall be installed at the bottom half of the pipe and secured (taped/tied) at 5' intervals.
 - e. Trace wire must be properly grounded as specified.
 - f. At all mainline dead-ends, trace wire shall go to ground using an approved connection to a drive-in magnesium grounding anode rod, buried at the same depth as the trace wire.
 - 1) Grounding
 - a) Trace wire must be properly grounded at all dead ends/stubs.
 - b) Grounding of trace wire shall be achieved by use of a drive-in magnesium grounding anode rod with a minimum of 20ft of #14 red HDPE insulated copper clad steel wire connected to anode (minimum 0.5 lb.) specifically manufactured for this purpose, and buried at the same elevation as the utility.
 - c) When grounding the trace wire at dead ends/stubs, the grounding anode shall be installed in a direction 180 degrees opposite of the trace wire, at the maximum possible distance.
 - d) When grounding the trace wire in areas where the trace wire is continuous and neither the mainline trace wire or the grounding anode wire will be terminated at/above grade, install grounding anode directly beneath and in-line with the trace wire. Do not coil excess wire from grounding anode. In this installation method, the grounding anode wire shall be trimmed to an appropriate length before connecting to trace wire with a mainline to lateral lug connector.
 - e) Where the anode wire will be connected to a trace wire access box, a minimum of 2 ft. of excess/slack wire is required after meeting final elevation.
 - g. Mainline trace wire shall not be connected to existing conductive pipes. Treat as a mainline deadend, ground using an approved waterproof connection to a grounding anode buried at the same depth as the trace wire.
 - h. In occurrences where an existing trace wire is encountered on an existing utility that is being extended or tied into, the new trace wire and existing trace wire shall be connected using approved splice connectors, and shall be properly grounded at the splice location as specified.
 - i. A mainline trace wire must be installed, with all service lateral trace wires properly connected to the mainline trace wire, to ensure full tracing/locating capabilities from a single connection point.
 - j. Lay mainline trace wire continuously, by-passing around the outside of manholes/structures on the North or East side.

- k. Tracer Wire Testing
 - 1) All new trace wire installations shall be located using typical low frequency (512Hz) line tracing equipment, witnessed by the contractor, engineer and facility owner as applicable, prior to acceptance of ownership.
 - 2) This verification shall be performed upon completion of rough grading and again prior to final acceptance of the project.
 - 3) Continuity testing in lieu of actual line tracing shall not be accepted.
 - 10. Place backfill and compact as outlined herein.
- C. Pumping and Bailing Trench Water
- 1. Remove water which may exist in trenches and form dams or other works necessary for keeping excavation clear of water during progress of work. Provide labor and materials necessary to maintain trenches in a dry state.
 - 2. No pipe or fittings shall be laid in water or when trench conditions are unsuitable for work.
 - 3. Provide labor and materials necessary to control erosion at outfall and downstream of dewatering pipe.
- D. Backfilling Procedures
- 1. Backfilling the drain tile shall proceed without delay as the installation is made.
 - 2. All backfill material shall be compacted to a density equivalent to that of the adjacent soils, or to the specified density where applicable.
- E. Clean Up
- 1. All drain tile, including the surrounding bedding, at the time of final acceptance, shall be free of silt and debris accumulation, or other obstruction.

3.10 COMPACTED FILL

- A. Prior to the placement of fill by the Contractor, the Geotechnical Engineer must inspect and approve the bottom of each excavation. Once approved, the exposed surfaces shall be scarified to a depth of not less than 12 inches, moistened or dried to within the percentage of the soils optimum moisture content (ASTM D698) specified herein, and compacted to the specified density. Disc and dry soils as required to accomplish the specified moisture content. Moisture conditioning will be incidental to the Contract.
 - 1. In pavement areas, subsequent to stripping soils as described herein and prior to placement of fill, proof roll the exposed soils in accordance with Proof Roll requirements specified in this Section.
- B. Before placing fill on a slope steeper than 4 horizontally to 1 vertically (4:1), the Contractor shall, at his option: (a) flatten the existing slope to the extent that it will not be steeper than 4 to 1; or (b) construct steps in the slope, with the back surface being as nearly vertical as practicable and with the horizontal cuts being made as close together as the slope permits, but with no step being less than ten feet in width.
- C. Fill shall not be placed on frozen ground, nor shall filling operations continue when the temperature is such as to permit the layer under placement to freeze.
- D. Fill shall not be placed in standing water, wet conditions, or over softened soils.
- E. Soil clumps or slabs shall be broken up or disced to allow for proper compaction. Discing and compaction operations shall be approved by the Geotechnical Engineer.
- F. Engineered Fill, Retaining Wall Areas, and Pavement Areas
 - 1. Deposit approved fill in uniform layers not exceeding 8 inches (loose) thickness (dependent upon review by the Geotechnical Engineer). Lift thickness shall be reduced by ½ if hand-held equipment is used for compaction. Compact each layer with approved methods and equipment using equipment that will densify the entire lift. Fill shall be placed within the specified moisture content range as approved by the Geotechnical Engineer.

- G. General Site Fill
 - 1. Deposit approved fill in uniform layers not exceeding 12 inches (loose) thickness (dependent upon review by the Geotechnical Engineer). Lift thickness shall be reduced by ½ if hand-held equipment is used for compaction. Fill shall be placed within the specified moisture content range as approved by the Geotechnical Engineer.
- H. The fill material, when being compacted, shall contain the moisture content necessary for the required compaction as designated by the Geotechnical Engineer. The moisture shall be uniform throughout each layer.
- I. Manually operated vibratory plate compactors shall be used to compact fill and backfill placed within five feet from building foundation walls or retaining walls. Self propelled compactors shall only be used outside of this five foot limit.
- J. Spread, disk, or otherwise dry wet soils as required to achieve a uniform moisture content throughout the soil. Moisten soils when too dry to achieve the required moisture content.
- K. Scarify, remove, recompact or otherwise rectify all soft or yielding areas resulting from construction operations, rain or other sources at no additional cost to the Owner.
- L. If there are areas which cannot be compacted, the upper 2 feet of the resulting subgrade shall be scarified to the moisture content range specified herein and compacted to a minimum of 100 percent Standard Proctor. If after scarifying the areas still cannot be compacted, the unstable materials shall be subexcavated to a depth of 3 feet and be replaced with materials which can be compacted.
- M. Installation of sand cushion below building floor slab shall be coordinated with all related or conflicting work (footings, utility trenches, etc.)

3.11 COMPACTION DENSITY REQUIREMENTS

- A. Compaction of all fill and backfill shall meet or exceed the following percentages of standard Proctor density (ASTM D 698):
 - 1. 98% for the for the building pad and retaining wall subgrade (engineered fill).
 - 2. 98% below footings.
 - 3. 95% for the sand subbase below building floor slabs.
 - 4. 95% below proposed walks.
 - 5. 95% for exterior building wall backfill in landscape areas.
 - 6. 95% for backfill placed more than 3 feet below final pavement subgrades.
 - 7. 100% for backfill within upper 3 feet of all pavement subgrades.
 - 8. 90% below landscape areas.
- B. Moisture Content Variance from Optimum:
 - 1. ± 3% for the soils with less than 12% passing a #200 sieve placed for Engineered Fill and oversize areas, wall backfill, and below grade wall backfill.
 - 2. -1% to +3% for soils with more than 12% passing a #200 sieve placed for Engineered Fill and oversize areas, wall backfill, and below grade wall backfill.
 - 3. ±3% for backfill placed more than 3 feet below final pavement subgrades for soils with less than 12% passes a #200 sieve.
 - 4. -1% to +3% for backfill placed more than 3 feet below final pavement subgrades for soils with more than 12% passing a #200 sieve
 - 5. ±3% for backfill within upper 3 feet of all pavement subgrades for soils with less than 12% passes a #200 sieve.
 - 6. -2% to +1% for backfill within upper 3 feet of all pavement subgrades for soils where more than 12% passes a #200 sieve.
 - 7. ±4% for backfill placed in landscaped areas.

- C. Tests falling below the specified density shall be cause for rejection of lift and will require further compacting or removal and recompacting at Contractor's expense until the specification requirements are met. Each lift must be approved before commencing with the next succeeding lift.

3.12 ROUGH GRADING

- A. The grades shown on the drawings are proposed finish grades. The Contractor shall grade to prescribed subgrade elevations, except landscaped areas which shall be graded to finish grade with approved topsoil.
- B. The Contractor shall be solely responsible for determining quantities of cut, fill and waste materials to be handled, and for amount of grading to be done in order to completely perform all work indicated on the Drawings. Import suitable material and export unsuitable / excess / waste material as required at no additional cost to the Owner.
- C. Mining of soils for any purpose other than to construct the proposed improvements is prohibited. Trench borrowing, mining, or other over-excavations within retaining wall areas, pavement areas, or building areas is prohibited.
- D. The building pad shall be constructed to finish subgrade prior to construction of footings.
- E. Provide surfaces free of debris and building materials. Complete rough grading by blading to reasonably smooth contours with neat, uniform transitions and slopes. Remove stones, rocks, debris, and similar undesirable material over 1" in diameter, weeds, root masses, sod / vegetation clumps, branches, vegetation, and other deleterious materials. Ease new grades into surrounding existing grades without awkward or abrupt transitions.
- F. All surfaces shall be finished to such contour that they will not impound surface water (all areas shall be graded to drain).
- G. All curbing shall be backfilled flush with the top of curb.
- H. Backfill in landscape areas placed against walks or pavements shall be graded flush with the walk or pavement surface on the up gradient side and held down one inch below the walk or pavement surface on down gradient side.
- I. Rough grade tolerances are as follows:
 - 1. Unpaved areas outside building: Not more than 0.15' above or below finish grade elevations shown on the drawings.
 - 2. Building, retaining wall, and paved areas: Surfaces shall not vary by more than 0.10' above or below the subgrade elevations referenced to herein.
- J. The subgrade shall reflect the same grade (percent slope) as the finish grade to ensure a consistent depth of topsoil or pavement section.
- K. Protect newly graded areas from traffic and erosion. Repair and re-establish grades in settled, eroded and rutted areas to specified tolerances.
- L. Immediately prior to placement of the aggregate base, and in the presence of the Geotechnical Engineer, proof roll all subgrades of proposed pavement areas to detect signs of instability. Correct all unstable areas to the satisfaction of the Geotechnical Engineer.

3.13 SUBGRADE PREPARATION / FINISH GRADING OF BUILDING, RETAINING WALL AND PAVEMENT AREAS

- A. The Contractor shall compact and shape the subgrade for its entirety as may be necessary to produce, at the time the sand subbase or stabilized aggregate base is placed, the specified density and stability in the top 12 inches of the subgrade and the grades shown on the Drawings.
- B. The exposed surfaces shall be scarified to a depth of not less than 12 inches, moistened or dried to within the percentage of the soils optimum moisture content (ASTM D698) specified herein, and compacted to the specified density. Disc and dry soils as required to accomplish the specified moisture content. Moisture conditioning will be incidental to the Contract.
1. Spread, disk, or otherwise dry wet soils as required to achieve a uniform moisture content throughout the soil. Moisten soils when too dry to achieve the required moisture content.
 2. Scarify, remove, recompact or otherwise rectify all soft or yielding areas resulting from construction operations, rain, groundwater, or other sources at no additional cost to the Owner.
 3. If there are areas which cannot be compacted, the upper 2 feet of the resulting subgrade shall be scarified to a moisture content not more than 1 percent above optimum and compacted to a minimum of 100 percent Standard Proctor. If after scarifying the areas still cannot be compacted, the unstable materials shall be subexcavated to a depth of 3 feet and be replaced with materials which can be compacted.
- C. Uniformly slope the subexcavation bottoms to coincide with the proposed surface grades. Blade subexcavation to a smooth surface prior to proof roll and subsequent to construction of stabilized aggregate base. All areas to be paved shall be brought to within 0.06' of subgrade elevations and cross sections.
- D. Grade Tolerance: All building areas, retaining wall areas, and areas to be paved shall be brought to within 0.06' (3/4 inch) of subgrade elevations and cross sections.
- E. Proof Roll for Pavement Areas:
1. PROPOSED PAVEMENT AREAS SHALL BE TEST ROLLED IN ACCORDANCE WITH Mn/DOT 2111 SUBSEQUENT TO FINISH GRADING IN THE PRESENCE OF THE GEOTECHNICAL ENGINEER.
 2. Proposed pavement subgrades shall be test rolled, using a fully loaded tandem rear axle dump truck, immediately prior to placement of stabilized aggregate base or sand subbase. Proof roll shall occur no more than 48 hours before placement of subsequent courses. Proof roll shall be redone if precipitation falls on the subgrade between initial proof roll and placement of subsequent courses. Test rolling shall not be performed until the Geotechnical Engineer and Contractor mutually agree that the subgrade has been properly prepared and is acceptable for test rolling. The test rolling shall be performed by making 2 passes over each strip covered by the width of a tire. Unrolled areas between the tire paths shall not be wider than 12 inches. The roller shall be operated at a speed of not less than 2½ nor more than 5 miles per hour and in a pattern approved by the Geotechnical Engineer. Coordinate scheduling of proof roll with paving contractor.
 3. The required subgrade stability shall be such that during placement of the stabilized aggregate base or sand subbase, rutting and displacement does not occur. Maximum yield: 1" (measured from the top of the constructed subgrade to the bottom of the rut).
 4. If test rolling shows any area to be unstable (yielding or rutting at the time the roller passes over the grade of more than 1 inch, measured from the top of the constructed grade to the bottom of the rut), the Contractor shall, at his expense, scarify the area and aerate or add moisture to the soil as necessary, and recompact the soil to the extent it will be stable when retested by rolling. The Contractor shall furnish a device that will mark the surface of the subgrade where rutting or yielding occurs.
 5. Areas shall be reworked and retested to the satisfaction of the Geotechnical Engineer.

3.14 FINISH GRADING OF TURF AREAS

- A. Spread topsoil material to a minimum depth of 6 inches (after compaction) over all turf areas within grading limits, subsequent to installation of pavements and walks. Complete grading of site and bring entire site to finish elevations shown on drawings.
 - 1. General Turf areas shall be bladed smooth with light weight grading equipment. Equipment shall be equipped with large wide tires to maintain grade uniformity without overcompacting the topsoil.

- B. Compaction:
 - 1. Compact the subsoil and topsoil as necessary to prevent future settlement without inhibiting vertical drainage and subsequent turf establishment.
 - 2. If over compaction occurs (defined as a relative density above 90% Standard Proctor density), the Contractor shall scarify the soil to full depth of topsoil and regrade as required.

- C. Grade Tolerances are as follows:
 - 1. General turf areas: Not more than 0.08' (one inch) above or below finish grade elevations.

END OF SECTION 31 00 00

SECTION 31 23 25

DRAINAGE AGGREGATE

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, material, equipment, and accessories to provide the following Work:
 - 1. Provide and install all drainage aggregate materials for the segmental retaining walls and related piping to the lines and grades designated on the project construction plans or as otherwise recommended by the Contractor's structural engineer designing the retaining wall system.

1.02 CERTIFICATION

- A. Contractor shall submit a notarized manufacturer's certification, prior to start of work, stating that the drainage aggregate meets the requirements of this specification.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Pipe shall be stored in accordance with the manufacturer's recommendations to prevent damage and deleterious materials from becoming affixed.
- B. Drainage aggregate shall be stored to prevent contamination with other site and/or fill soils.

PART 2 - PRODUCTS

2.01 DEFINITIONS

- A. Drainage collection pipe shall be a perforated/slotted PVC or corrugated HDPE pipe. The pipe may be covered with a knitted or non-woven geotextile sock specifically designed to function as a filter.
- B. Drainage aggregate shall be a free draining material, relative to the surrounding soil, so as to prevent build up of hydrostatic pressure.
- C. Drainage geotextile shall have to the following minimum properties or as recommended by the Engineer.

AOS	ASTM D 4751	70-100
Grab Tensile	ASTM D 4632	110 lb.
Trap	ASTM D 4533	40 lb.
Water Flow Rate	ASTM D 4491	75 gpm/ft
Puncture	ASTM D	40 lb.

2.02 AGGREGATE

A. Drainage aggregate shall be a clean 1-inch minus crushed stone or granular fill meeting the following gradation:

Sieve Size	Percent Passing
1 inch	100-75
3/4 inch	50-75
No. 4	0-60
No. 40	0-50
No. 200	0-5

- B. Drainage pipe shall be manufactured in accordance with ASTM D 3034 and/or ASTM D 1248.
- C. Geotextile placed around the drainage aggregate or drain pipe shall be as outlined in Paragraph 2.01.

PART 3 - EXECUTION

3.01 DRAINAGE COLLECTION PIPE

- A. Install the drainage collection pipe according to the line, grades and sections shown in the project construction plans or as otherwise recommended by the Contractor’s structural engineer designing the retaining wall system.
- B. Install the drainage collection pipe to maintain gravity flow of water to outside the reinforced soil zone. Discharge the drainage collection pipe as indicated on the Drawings.
- C. The main collection drain pipe just behind the segmental units shall be a minimum of 4 inches in diameter. Any secondary collection drain pipe can gravity flow independently or tie into the main collection drain pipe with laterals at a maximum 50 foot spacing along the wall face.

3.02 DRAINAGE AGGREGATE

- A. Install the drainage aggregate to the line, grades and sections shown on the project construction plans or as otherwise recommended by the Contractor’s structural engineer designing the retaining wall system.
- B. Place the drainage aggregate to a minimum finished thickness and widths shown on the details herein, or as directed by the Engineer.
- C. When a blanket drain is installed, a non-woven geotextile shall be installed prior to aggregate placement in accordance with the details provided on the drawings.

END OF SECTION 31 23 25

SECTION 31 25 00

EROSION CONTROL

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, material, equipment, and accessories to complete the following Work:
 - 1. Provide full implementation (installation, maintenance and removal) of all erosion control devices and procedures identified on the Drawings and noted herein.
 - 2. Provide all erosion control devices per the drawings and as may be required by Local or State regulations.
 - 3. Have erosion control devices inspected and approved by local authorities prior to commencement of earthwork operations.
 - 4. Provide maintenance of all erosion control devices until final vegetation is established.
- B. Schedule and Permits:
 - 1. The Contractor shall prepare and submit to the Engineer for acceptance, his proposed schedule for accomplishment of the affected work, including a detailed description of all proposed erosion control measures.

1.02 SUBMITTALS

- A. Submit product data for all products demonstrating compliance with these specifications.
- B. Submit a proposed schedule for implementation of erosion control devices.
- C. Submit erosion control maintenance logs on a weekly basis.

1.03 PROJECT CONDITIONS

- A. Environmental Requirements: The Contractor shall protect adjacent properties and water resources from erosion and sedimentation damage throughout Work.

PART 2 - PRODUCTS

2.01 SILT FENCE

A. Silt Fence Requirements

Silt Fence Type	Width <i>in</i>	Grab Tensile (machine direction) <i>lb</i> *	Apparent Opening Size	Puncture Strength †	UV Stability 500 h % ‡	Minimum Flow Rates <i>gpm/sq.ft</i>
Machine Sliced (MS), Hand Installed (HI) woven geotextile §	36	130	No. 30 sieve	—	70	100
Pre-Assembled (PA) woven geotextile	36	130	No. 30 sieve	—	70	100
Values in table are Minimum Average Roll Values (MARV) * ASTM 4632 ASTM 4751 Maximum Average Roll Value † ASTM 4833 ‡ ASTM 4355 § Provide MS, HI woven geotextile with monofilament in both directions. Do not make substitutions.						

B. Fasteners

1. Fasteners shall have a tensile strength of at least 50 lb. For MS and HI applications, provide plastic ties to attach geotextile materials to posts.

C. Posts

1. For MS and HI applications, provide steel posts that meet the following:
 - a. Type: T-post
 - b. Weight: 0.95 lb/ft
 - c. Length: ≥5.0 ft
 - d. Embedment: ≥ 24 in
 - e. Post spacing: ≤6.0 ft
2. For PA applications, provide wood posts that meet the following:
 - a. Type: Hardwood
 - b. Size: ≥2 in x 2 in
 - c. Length: ≥4.0 ft
 - d. Embedment: ≥ 18 in
 - e. Post spacing: <5.0 ft

2.02 SEDIMENT CONTROL DEVICES AT STORM SEWER INLETS

A. Acceptable Products:

1. Wimco Top Slab™ Model RD 27.
2. Infracafe® Sediment Control Barrier, distributed by Royal Environmental Systems, Inc. SCB's shall be sized specifically for the structure and casting specified. SCB's shall be equipped with Frame and Perforated Shroud and shall be wrapped on the outside, covering the perforated wall only, with a geotextile sock.
3. Dandy Bag® or Dandy Bag II® distributed by Brock White Company, St. Paul, MN (615) 647-0950. Dandy Bag shall be used only for curb inlets after pavement (binder course or wear course) is installed or at existing paved areas.
4. InfraSafe® Debris Collection Device by Royal Environmental Systems, Inc., distributed by Ess Brothers, 9350 County Road 19, Corcoran, MN 55357 . DCD's shall be sized specifically for the structure and casting specified. Provide filter bags and ties for complete installation.
5. Or approved equal.

2.03 SEDIMENT CONTROL LOG

A. Sediment Control Logs shall consist of an outside open weave containment fabric filled with curled Aspen fibers. Fibers shall be curled with soft, interlocking barbs to form a strong, organic filtration matrix. A minimum of 80% of the fibers shall be 6 inches or longer in length. Fibers shall be seed free. Fibers shall be evenly distributed throughout the diameter and length of the Sediment Control Log.

B. Acceptable Manufacturers:

1. American Excelsior Co., "Curlex Sediment Log". Use Type II, III or IV for swale applications.
2. Or approved equal.

PART 3 - EXECUTION

3.01 PREPARATION

- A. Review the Erosion Control Plans and SWPPP.
- B. Notify the Engineer of deficiencies or changes in the Erosion Control Plans or SWPPP required by current site conditions. Revisions to the SWPPP shall be made as determined by the Engineer.

3.02 PHASING OF THE WORK

- A. Schedule and conduct operations so as to minimize erosion of soils and to prevent sedimentation of Surface Waters of the State (surface waters include curb and gutter, pavements, storm sewer, swales, stormwater treatment areas, or other similar storm water conveyance devices).
- B. Construction of drainage facilities, turf establishment items, and other contract work which will contribute to the control of erosion and sedimentation shall be carried out concurrently with earthwork operations or as soon thereafter as practicable.

3.03 CONSTRUCTION SCHEDULE

- A. Prepare and submit to the Engineer for acceptance, the proposed schedule for accomplishment of the affected work, including a detailed description of all proposed erosion control measures.
- B. No work shall be started in the affected areas until the schedule and proposed methods of operation have been reviewed and approved by the Engineer.

3.04 LIMITATION OF WORK AREA

- A. The Engineer will have authority to limit the surface area of erodible soil that can be exposed to possible erosion at any one time, without having the permanent erosion control features completed and operative.
- B. The Contractor shall incorporate the erosion control features into the work at the earliest practicable time, and provide all additional temporary control measures as may be needed to correct conditions developing during construction.

3.05 INSTALLATION OF EROSION CONTROL DEVICES

- A. Silt Fence
 - 1. Silt fence shall be installed according to Mn/DOT 3886 and Mn/DOT 2573 B.1, B.2, B.3 and B.5. Once installed, provide continual maintenance as identified in the SWPPP Narrative.
 - 2. Following final turf and vegetation establishment, silt fence and posts shall be completely removed and the trench backfilled and restored with vegetation.
- B. Sediment Control Devices at Storm Sewer Inlets
 - 1. Products shall be installed in accordance with manufacturer's recommendations.
 - 2. Once installed, provide continual maintenance as identified in the SWPPP Narrative.
 - 3. Following final turf and vegetation establishment, sediment control devices at storm sewer inlets shall be completely removed.
- C. Sediment Control Log
 - 1. Sediment Control Log shall be installed according to Mn/DOT spec 3889 Type 2 or 3 Bioroll Blanket System.
 - 2. Once installed, provide continual maintenance as identified in the SWPPP Narrative.
 - 3. Following final turf and vegetation establishment, sediment control log and stakes shall be completely removed and restored with vegetation.

3.06 MAINTENANCE

- A. All erosion control devices shall remain in place until other means of permanent control such as turf establishment and paving have taken place. The Contractor shall maintain these devices throughout their temporary life and to remove them and when so instructed by the Engineer. Removal of erosion control devices includes restoration of affected areas. Maintenance and removal will be considered incidental to the Contract and no additional compensation shall be made therefore.
- B. Silt fences which have washed out shall be reinforced with additional stakes and backed by snow fence to reduce the possibility of future washouts.
- C. Maintenance of erosion control devices shall be in strict accordance with the SWPPP Narrative and the NPDES permit requirements.

3.07 CONCRETE TRUCK WASHOUT AREAS

- A. All liquid and solid wastes generated by concrete washout operations shall be contained in a leak proof containment facility or impermeable liner. A compacted clay liner that does not allow washout liquids to enter ground water is considered an impermeable liner. The liquid and solid wastes must not contact the ground and there must not be runoff from the concrete washout operations or areas. Liquid and solid wastes shall be disposed of properly and in compliance with MPCA regulations. A sign shall be installed adjacent to each washout facility to inform concrete equipment operators to utilize the proper facilities.

3.08 RESTORATION

- A. Control of drainage and erosion shall include restoration work as the Engineer considers necessary in preventing siltation of public waters.
- B. Restoration shall include cleanup, shaping, replacement of topsoil, and establishment of vegetative cover on all disturbed areas where water pollution potentials have been increased due to the Contractor's operations.

3.09 COMPENSATION

- A. All expenses related to complying with the provisions hereof shall be borne by the Contractor with no direct compensation being made therefore.

END OF SECTION 31 25 00

SECTION 31 34 19

GEOSYNTHETIC WALL REINFORCEMENT

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, material, equipment, and accessories to provide the following:
 - 1. Furnish and install geosynthetic reinforcement to the lines and grades designated on the plans or as otherwise recommended by the Contractor's structural engineer designing the retaining wall system.

1.02 CERTIFICATION

- A. Contractor shall submit a notarized manufacturer's certification, prior to start of work, stating that the geosynthetic reinforcement meets the requirements of this specification.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall check the geosynthetic reinforcement upon delivery to assure that the proper grade and type of material has been received. A product certification should be provided with each shipment.
- B. The geosynthetic reinforcement shall be stored above -20°F.
- C. Rolled geosynthetic material shall be stored in accordance with manufacturer's recommendations.

PART 2 - PRODUCTS

2.01 DEFINITIONS

- A. Geosynthetic reinforcement shall be a polymer product specifically manufactured as a soil reinforcement element that meets the requirements of this specification.
- B. Concrete segmental retaining wall (SRW) units are as detailed on the drawings and specified under Section 32 32 23: Segmental Retaining Wall.
- C. SRW Unit pins are as detailed on the drawings and specified under Section 32 32 23: Segmental Retaining Wall.
- D. Leveling pad material is sand or gravel as specified under Section 32 32 23: Segmental Retaining Wall or low strength unreinforced concrete.
- E. Reinforced backfill (infill soil) is the soil used within reinforced soil mass.
- F. Retained backfill or common backfill is the soil behind the reinforced soil mass and leveling pad.

2.02 GEOSYNTHETIC REINFORCEMENT PROPERTIES

A. The geosynthetic reinforcement shall possess the following minimum design properties, determined by product specific testing as defined in the NCMA Design Manual for Segmental Retaining Walls (Section 3.5).

	LTDS	Ci	CDs
Geogrid Type "A"	(1000 lb/ft)	(0.7)	(0.7)
Geogrid Type "B"	(if required)		

PART 3 - EXECUTION

3.01 FOUNDATION SOIL PREPARATION

A. Foundation soil preparation shall be as specified in Section 32 32 23 Segmental Retaining Wall.

3.02 WALL ERECTION

A. Wall erection shall be as specified in Section 32 32 23 Segmental Retaining Wall.

3.03 GEOSYNTHETIC REINFORCEMENT INSTALLATION

- A. The geosynthetic reinforcement shall be installed at the wall height, horizontal location, and to the extent as shown the project construction plans, or as directed by the Engineer.
- B. The geosynthetic reinforcement shall be laid horizontally on compacted reinforced backfill and connected to the concrete SRW units. Embedment detail shall be consistent with the SRW manufacturer's recommendations.
- C. Correct orientation (roll direction) of the geosynthetic reinforcement shall be verified by the Contractor.
- D. Place segmental unit and fill in accordance with Section 32 32 23: Segmental Retaining Wall.
- E. The geosynthetic reinforcement shall be pulled taut and free of wrinkles prior to placement of soil fill. The geosynthetic may be secured in place with staples, pins, sandbags, or fil as required by fill properties, fill placement procedures, or weather conditions, or as directed by the Engineer.
- F. For constructability considerations, maximum spacing between geogrid layers shall be 2.0 vertical feet.
- G. Coordinate installation with fencing subcontractor to ensure efficient and timely installation of fence posts and railings.

END OF SECTION 31 34 19

SECTION 32 12 16

ASPHALTIC CONCRETE PAVING

PART 1 - GENERAL

1.01 SUMMARY

- A. This work shall consist of the following:
 - 1. Constructing stabilized aggregate base on prepared subgrade in accordance with Mn/DOT 2211.
 - 2. Performing a proof roll on the stabilized aggregate base prior to paving the binder course.
 - 3. Constructing bituminous binder and wear courses in accordance with Mn/DOT 2360.

1.02 SUBMITTALS

- A. Certification of Materials: Bituminous mix plant shall have, on file, a report by an approved testing laboratory certifying that materials are in accordance with Specification requirements.
- B. Job-Mix Design: Submit a job mix formula for each pavement course. Bituminous mix plant shall have, on file, a report by an approved testing laboratory that indicates the proportions of materials used in each type of bituminous course being provided and temperature of mix.
- C. Samples: Provide samples of materials for laboratory testing and job-mix design.
- D. During paving, provide hot mix samples to the Independent Testing Lab (ITL) for determination of the actual bituminous mixture properties during production.
- E. Certificates: Provide certificates, signed by the asphalt concrete producer and Contractor, certifying that materials comply with Specification requirements.

1.03 QUALITY ASSURANCE

- A. Subcontractor's Qualifications: Construction of bituminous paving, including stabilized aggregate base, shall be done by a responsible Paving Subcontractor having necessary equipment, plant, and not less than 10 years experience in performing Work similar to that included under this Contract.
- B. Governing Codes: Work of this section occurring on public property shall be constructed in accordance with laws, ordinances, rules, regulations, and orders of any public authority having jurisdiction. Where such work is required to be constructed in a manner differing from the Contract Documents, Contractor shall notify Engineer before proceeding with Work.
- C. Qualifications of Asphalt Concrete Producer: Use only materials which are furnished by a bulk asphalt concrete producer regularly engaged in production of hot-mix, hot-laid asphalt concrete. The plant shall be a Mn/DOT certified plant.
- D. The Contractor shall employ and pay for the services of a registered Engineer or Land Surveyor, acceptable to the Engineer/Architect, to stake and tape limits of pavements.

- E. In addition to other specified conditions, comply with the following minimum requirements:
1. The Owner will employ and pay for the services of a testing and inspection service for quality control testing (Independent Testing Lab (ITL)).
 2. The ITL will obtain hot-mix asphalt samples behind the paver, prior to compaction, for purposes of determining maximum specific gravity of bituminous pavement in accordance with AASHTO T209, Mn/DOT modified procedure.
 3. The ITL will test in-place asphalt concrete courses for compliance with requirements for density and thickness.
 4. Provide final surfaces of uniform texture, conforming to required grades and cross-sections.
 5. Take one (1) - 4" diameter pavement specimen for each completed course, from locations as directed by ITL. Provide specimens to the ITL.
 6. Repair holes from test specimens as specified for patching defective work.
- F. Density Requirements:
1. The ITL will determine maximum specific gravity (G_{mm}) of asphalt materials in accordance with AASHTO T209, Mn/DOT modified procedure.
 2. Minimum required wear and non-wear course densities will be as stated in Mn/DOT Spec 2360, Table 2360-19.
 3. Payment for placed asphalt shall be in accordance with Mn/DOT Spec 2360, Table 2360-22 and Table 2360-23 for the respective mix designs, except for payment incentives (payment factors greater than 1) shall be eliminated.
 - a. In place pavement with density than 90.0% of maximum shall be removed and replaced by the Contractor at the Contractor's expense.
- G. Thickness: In-place compacted thicknesses will not be acceptable if exceeding following allowable variation from thickness shown on Drawings.
1. Wear Course: $\frac{1}{2}$ ", +/-
 2. Non-wear Course: $\frac{1}{2}$ ", +/-
 3. THE TOTAL THICKNESS OF ANY BITUMINOUS PAVEMENT SHALL NOT BE LESS THAN THE AGGREGATE DIMENSION OF THE BITUMINOUS COURSES SHOWN ON THE DRAWINGS. Bituminous pavement not meeting the minimum overall thickness referenced above shall be removed and replaced at the Contractor's expense.
- H. Surface Smoothness:
1. Test finished surface of each asphalt concrete course for smoothness, using a 10' straight edge applied parallel to and at right angles in Centerline of paved areas.
 2. Check surfaced areas at intervals directed by Engineer.
 3. Surfaces will not be acceptable if exceeding the following:
 - a. Binder Course: $\frac{1}{4}$ " in 10'
 - b. Wear Course: $\frac{3}{16}$ " in 10'
- I. Ponding: Surfaces will not be acceptable if ponding water exceeds $\frac{3}{16}$ " as determined by the Engineer. Remove and replace all unacceptable ponding pavement areas at no additional cost to the Owner.
- J. The Contractor will be responsible for all drainage of the finished surface. Any "bird baths" will be considered unacceptable and shall be remedied by the Contractor at his expense to the satisfaction of the Owner.

1.04 SITE CONDITIONS

- A. Weather Limitations:
1. Apply bituminous tack coat only when the ambient temperature in the shade is at least 50° F and when the temperature has not been below 35° F for 12 hours immediately prior to application.
 2. Do not apply when the base surface is wet or contains an excess of moisture which would prevent uniform distribution and the required penetration.
 3. Construct asphalt concrete surface course only when atmospheric temperature is above 40° F, when the underlying base is dry, and when weather is not rainy.
 4. Refer to "Minimum Placement Temperature Chart" prepared by the National Asphalt Pavement Association for Minimum Bituminous Placement Temperatures.
 5. Paving shall not take place when, in the opinion of the testing laboratory, the weather or surface conditions are considered unfavorable.
- B. Grade Control: Establish and maintain the required lines and grades, including crown and cross-slope, for each course during construction operations.
- C. Protection: Protect grass, vegetation, concrete work, building and other work adjacent to paving, with building paper or other suitable material, so that stains of bitumen shall not reach these surfaces.
- D. Traffic Control:
1. Maintain vehicular and pedestrian traffic during paving operations as required for other construction activities.
 2. Provide flagmen, barricades, warning signs, and warning lights for movement of traffic and safety and to cause the least interruption of work.
- E. Coordination and Responsibility:
1. Coordinate pavement construction with casting adjustments.
 2. Coordinate installation of Stabilized Aggregate Base with Earthwork Contractor. Stabilized Aggregate Base shall not be installed until proof roll is conducted by the Earthwork Contractor and approved by the Geotechnical Engineer. Once approved, stability of the subgrade soils shall be the responsibility of the Asphalt Paving Contractor. Measures to protect subgrade from becoming unstable and maintaining stability of subgrade soils shall be provided. Subgrade stabilization will be incidental to the Contract. If unstable areas are encountered, provisions for testing and corrective action outlined in Section 31 00 00 Earthwork shall be strictly adhered to by the Paving Contractor.
 3. Coordinate installation of Stabilized Aggregate Base with exterior concrete Contractor.

1.05 REQUIREMENTS

- A. Job-Mix Criteria:
1. Provide job-mix formulas for each required asphalt-aggregate mixture.
 2. Establish a single percentage of aggregate passing each required sieve size, a single percentage of asphalt cement to be added to aggregate, and a single temperature at which asphalt concrete is to be produced.
 3. Comply with the mix requirements of the Minnesota Department of Transportation (Mn/DOT) standards.
 4. Maintain material quantities within allowable tolerances of the governing standards.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Stabilized Aggregate Base: Aggregate shall meet the requirements of the current Mn/DOT Spec 3138, Class 5, Table 3138-1 (100% crushed limestone) or Table 3138-4 (recycled concrete / asphalt).
- B. Binder and Wear Course Mix Designs shall conform to Mn/DOT Section 2360.2, except as modified herein:
 - 1. Sewage Sludge Ash (SSA) (2360.2A2j) is not allowed in binder or wear course pavements.
- C. Asphalt Binder Course: Materials and methods of preparation and construction shall meet requirements of Mn/DOT Spec 2360.
 - 1. Binder Course Mix Design: SP NW B 3 30 B
- D. Bituminous Tack Coat: Tack coat shall be CSS-1H or CRS-2 cationic emulsified asphalt diluted 50/50 with clean water. Tack coat shall meet requirements of Mn/DOT Spec 2357.
- E. Asphalt Wear Course: Materials and methods of preparation and construction shall meet requirements of Mn/DOT Spec 2360.
 - 1. Wear Course Mix Design: SP WE A 3 30 B

PART 3 - EXECUTION

3.01 PREPARATION PRIOR TO PAVING

- A. Proof Roll:
 - 1. Refer to Section 31 00 00 for proof roll requirements. Stabilized Aggregate Base shall not be installed until the subgrade is reviewed, tested and approved.
 - 2. Do not begin paving work until such conditions have been corrected and are ready to receive paving. Once subgrade is accepted by the paving contractor, cost of subgrade correction, if required, will be borne by the paving contractor.
- B. Stabilized Aggregate Base: In accordance with Mn/DOT 2211, construct aggregate base to the thickness shown on the Drawings. Extend aggregate base to one foot beyond edge of pavement. Aggregate base shall be compacted to 100% Standard Proctor (ASTM D698).
- C. Loose and Foreign Material:
 - 1. Remove loose and foreign material from compacted sub-base surface immediately before application of paving.
 - 2. Do not displace sub-base material.
- D. Proof Roll on Stabilized Aggregate Base:
 - 1. All proposed pavement areas shall be test rolled in accordance with Mn/DOT 2111 subsequent to finish grading the aggregate base in the presence of the geotechnical engineer.
 - 2. The pavement aggregate base shall be test rolled, using a fully loaded tandem rear axle dump truck immediately prior to placement the binder course. Proof roll shall occur no more than 48 hours before placement of subsequent courses. Proof roll shall be redone if precipitation falls on the site between initial proof roll and placement of subsequent courses. Test rolling shall not be performed until the Geotechnical Engineer and Contractor mutually agree that the aggregate base has been properly prepared and is acceptable for test rolling. The test rolling shall be performed by making 2 passes over each strip covered by the width of a tire. Unrolled areas between the tire paths shall not be wider than 12 inches. The roller shall be operated at a speed of not less than 2½ nor more than 5 miles per hour and in a pattern approved by the Geotechnical Engineer. Coordinate scheduling of proof roll with paving contractor.

3. The required subgrade stability shall be such that during placement of the base, rutting and displacement does not occur. Maximum yield: 0" (no deflection).
4. The Contractor shall furnish a device that will mark the surface where rutting or yielding occurs.
5. If test rolling shows any area to be unstable (yielding or rutting at the time the roller passes over the grade), the Contractor shall, at his expense, remove the aggregate base course to expose the subgrade, scarify the subgrade and aerate or add moisture to the subgrade soil as necessary, and recompact the soil to the extent it will be stable when retested by rolling.
 - a. The exposed subgrade shall be scarified to a depth of not less than 12 inches, moistened or dried to within the percentage of the soils optimum moisture content (ASTM D698) specified herein, and compacted to the specified density. Disc and dry soils as required to accomplish the specified moisture content.
 - 1) Spread, disk, or otherwise dry wet soils as required to achieve a uniform moisture content throughout the soil. Moisten soils when too dry to achieve the required moisture content.
 - 2) Scarify, remove, recompact or otherwise rectify all soft or yielding areas resulting from construction operations, rain, groundwater, or other sources at no additional cost to the Owner.
 - 3) If there are areas which cannot be compacted, the upper 2 feet of the resulting subgrade shall be scarified to a moisture content not more than 2 percent above optimum and compacted to a minimum of 100 percent Standard Proctor. If after scarifying the areas still cannot be compacted, the unstable materials shall be subexcavated to a depth of 3 feet and be replaced with materials which can be compacted.
6. Areas shall be reworked and retested to the satisfaction of the Geotechnical Engineer.

E. Tack Coat:

1. Apply to contact surfaces of previously constructed asphalt concrete or Portland cement concrete and similar surfaces.
2. Apply at rate of 0.05 to 0.15 gal. per sq. yd. of surface.
3. Apply tack coat by brush to contact surfaces of curbs, gutters, manholes, and other structures projecting into or abutting asphalt concrete pavement.
4. Allow surfaces to dry until material is at condition of tackiness and to receive pavement.

3.02 PAVING

A. General Requirements

1. Contractor shall prepare the site to receive the subsequent improvements shown on Drawings and outlined herein.
2. Remove loose and foreign materials from compacted surfaces immediately before application of paving.
3. Do not displace subbase material. Uniformly grade all ruts and ridges prior to installation of Stabilized Aggregate Base to provide uniform material thickness.
4. Construct bituminous binder and wear courses with self-propelled power operated paving equipment. The paver shall be equipped with a heated, adjustable screed.
5. Unless otherwise directed, begin placing at the high side of the section on one-way slope. After first strip has been placed and rolled, place succeeding strips.
6. Complete binder courses for a section before placing wear courses.
7. Place mixture in as continuous an operation as practicable.
8. Hand Placing:
 - a. Spread, tamp and finish mixture using hand tools in areas where machine spreading is not possible, as acceptable to Engineer.
 - b. Place mixture at a rate that will insure handling and compaction before mixture becomes cooler than acceptable working temperature.

9. Joints:
 - a. Gradually make joints between old and new pavements, or between successive days' work, to ensure a continuous bond between adjoining work.
 - b. Construct joints to have same texture, density and smoothness as adjacent sections of asphalt concrete course.
 - c. Clean contact surfaces free of sand, dirt, or other objectionable material and apply tack coat.
 - d. Offset transverse joints in succeeding courses not less than five feet.
 - e. Cut back edge of previously placed course to expose an even, vertical surface for full course thickness.
 - f. Offset longitudinal joints in succeeding courses not less than 6".
 - g. When the edges of longitudinal joints are irregular, honeycombed, or inadequately compacted, cut back unsatisfactory section to expose an even, vertical surface for full course thickness.

- B. Asphalt Binder Course:
 1. General Requirements: Construct an asphalt binder course with power operated paving equipment designed for paving. Inaccessible and small areas may be placed by hand. Place at a thickness so that when compacted it will be in accordance with indicated grade, cross-section, finish thickness, and density indicated.
 2. Apply tack coat to all vertical surfaces of existing concrete or bituminous which will be in contact with new pavement.
 3. Construct an asphalt binder course over the previously placed stabilized aggregate base course. Thickness shall be as shown on the Drawings.
 4. Compact binder course as outlined herein.

- C. Asphalt Wear Course:
 1. General Requirements: Construct an asphalt wear course with power operated paving equipment designed for paving. Inaccessible and small areas may be placed by hand. Place at a thickness so that when compacted it will be in accordance with indicated grade, cross-section, finish thickness, and density indicated.
 2. Apply tack coat to all vertical surfaces of existing concrete or bituminous which will be in contact with new pavement. Apply tack coat to previously installed binder course.
 3. Construct an asphalt wear course over the previously placed asphalt binder course or stabilized aggregate base course. Thickness shall be as shown on the Drawings.
 4. Compact wear course as outlined herein.

3.03 COMPACTING THE MIX

- A. General Requirements
 1. Breakdown and second rolling shall be accomplished by a self-propelled, steel-wheel type, tandem roller weight not less than eight tons and exerting a compression of not less than 250 pounds per inch on the rear rollers. During break-down rolling, vibratory rollers shall operate at 8 to 10 impacts per foot.
 2. Provide sufficient number of rollers to obtain the minimum required pavement density of 95% of the recorded laboratory specimen density.
 3. Begin rolling operation as soon after placing when the mixture will bear weight of roller without excessive displacement.
 4. Roller must be properly moistened, must operate continually and not stand on newly placed mixture.
 5. Do not permit heavy equipment, including rollers to stand on finished surface before it has thoroughly cooled or set.
 6. Compact mixture with hot hand tampers or vibrating plate compactors in areas inaccessible to rollers.
 7. Start rolling longitudinally at extreme lower side of sections and proceed toward center of pavement. Roll to slightly different lengths on alternate roller runs.
 8. Do not roll centers of section first under any circumstances.

- B. Breakdown Rolling (Binder and Wear Courses)
 - 1. Accomplish breakdown or initial rolling immediately following rolling of transverse and longitudinal joints and outside edge.
 - 2. Operate rollers as close as possible to paver without causing pavement displacement.
 - 3. Check crown, grade, and smoothness after breakdown rolling.
 - 4. Repair displaced areas by loosening at once with lutes or rakes and filling, if required, with hot loose material before continuing rolling.
- C. Second Rolling (Binder and Wear Courses)
 - 1. Follow breakdown rolling as soon as possible, while mixture is hot and in condition for compaction.
 - 2. Continue second rolling until mixture has been thoroughly compacted.
- D. Finish Rolling (Wear Courses)
 - 1. A pneumatic tired roller followed by a smooth drum steel wheeled roller shall be used for finish rolling. Pneumatic tired rollers shall be capable of exerting a pressure of not less than 200 pounds per inch of rolling width.
 - 2. Perform finish rolling while mixture is still warm enough for removal of roller marks.
 - 3. Continue rolling until roller marks are eliminated and course had attained specified density.
 - 4. Depression or high areas which develop during rolling shall be corrected to produce a surface with no variations greater than 1/8 inch as measured by a ten-foot straight edge. Roller marks shall be rolled-out to provide smooth surface, however over compaction shall require removal and replacement of the area.

3.04 PATCHING

- A. Remove and replace defective/unacceptable areas.
- B. Remove deficient areas for full depth of course.
- C. Cut sides perpendicular and parallel to direction of traffic with edges vertical.
- D. Apply tack coat to exposed surfaces before placing new asphalt concrete mixture.
- E. Cut-out and fill with fresh, hot asphalt concrete.
- F. Compact by rolling to specified surface density and smoothness.

3.05 CLEANING

- A. Cleaning: After completion of paving operations, clean surfaces of excess or spilled asphalt materials to the satisfaction of Architect/Engineer.

3.06 PROTECTION

- A. After final rolling, do not permit vehicular traffic on asphalt concrete pavement until it has cooled and hardened and in no case sooner than 6 hours.
- B. Provide barricades and warning devices as required to protect pavement and the general public.
- C. Cover openings of structures in the area of paving until permanent coverings are placed.

END OF SECTION 32 12 16

SECTION 32 13 13

EXTERIOR CONCRETE WORK

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, materials, equipment, and accessories to provide the following work:
1. Provide cast-in-place concrete as follows:
 - a. Provide concrete walks.
 - b. Provide concrete slabs.
 - c. Provide concrete ADA ramps (pedestrian curb ramps) with truncated domes.
 - d. Provide various concrete curbs, gutters, and curb and gutter.
 - e. Provide exterior concrete stairs.
 2. Provide stamped and colored concrete where indicated on the Drawings.
 3. Provide expansion joint material.
 4. Provide formwork for cast-in-place concrete.
 5. Provide reinforcing steel and welded wire fabric for cast-in-place concrete.
 6. Provide concrete cylinders for testing of cast-in-place concrete.
 7. Coordinate work with miscellaneous metals contractor for layout and installation of railing.
 8. Provide caulking over expansion joints where concrete pavement meets stoops and building walls.
- B. Related Work By Owner:
1. Concrete Tests: The Owner will provide concrete testing services performed by a testing laboratory, except where test fails, Contractor shall correct the failure and pay costs for retesting until approved by testing laboratory inspector and Owner.
- C. Work not included in this Section:
1. Stabilized aggregate base under miscellaneous curbs, gutters, curb and gutter. Refer to Section 32 12 16 Asphaltic Concrete Pavement.
 2. Sand base or stabilized aggregate base under concrete stairs, walks and ramps. Refer to Section 31 00 00 Earthwork.
 3. Miscellaneous pads / slabs for electrical equipment. Refer to Electrical specifications.
 4. Railings and stair nosing - refer to 05 50 00 Miscellaneous Metals.

1.02 QUALITY ASSURANCE

- A. Source Limitations: Obtain each type or class of cementitious material of the same brand from the same manufacturer's plant, obtain aggregate from one source, and obtain admixtures including integral color through one source from a single manufacturer.
- B. All work shall comply with the requirements of the Department of Labor and Industry and the rules and regulations identified in the Minnesota Plumbing Code.

1.03 SUBMITTALS

A. Quality Control Submittals:

1. Contractor Submittal Requirements:
 - a. Submit representative samples of each type of aggregate proposed to be used on this Project to testing laboratory for testing and for use in concrete mix.
 - b. Submit representative samples of each type of cement proposed to be used on this Project to testing laboratory for use in concrete mix.
 - c. Prepare concrete test cylinders for testing by Owner's testing laboratory as specified under Field Quality Control in Part 3 of this Section.
 - d. Submit Design Mix For Approval: Mix designs shall be submitted on the mix design submittal form included at the end of the specification. Testing laboratory shall submit copies of reports of aggregate testing and of concrete mix designs for approval. Submit copies not less than 14 days before start of concrete installation. Do not start concrete installation until aggregate test reports have been reviewed and concrete mix designs approved.
2. Submit shop drawings (product data) for truncated dome panels and exterior stairs.
3. The Contractor shall construct at least four "mock ups", of various shades of the color selected by the Architect, for the Architect's review and approval. Each mock up shall include the imprint and shall be no less than 48" by 48" in size.

PART 2 - PRODUCTS

2.01 CONCRETE MATERIALS

- A. Portland Cement: ASTM C150, Type I or Type III
- B. Supplementary Cementitious Materials: Fly Ash ASTM C618, Class C or F. Not more than 15% by weight.
- C. Aggregate:
 1. Applicable Standard: ASTM C33
 2. Maximum Nominal Size of Course Aggregate: 1.5 inch
 - a. Minimum total coarse aggregate content for slabs on grade and topping slabs of 12 cubic feet for 1 1/2" or larger top size aggregate; 11.5 cubic feet for top size aggregate 1 1/4" or larger but less than 1 1/2"; 11 cubic feet for top size aggregate 1" or larger but less than 1 1/4"; or 10.5 cubic feet for top size aggregate less than 1".
 - b. Combined aggregate gradation for slabs on grade, topping slabs, and other designated concrete shall be 8% - 18% for large top size aggregates (1 1/2 in.) or 8% - 22% for smaller top size aggregates (1 in. or 3/4 in.) retained on each sieve below the top size and above the No. 100.
- D. Water: Clean, potable, and free of deleterious amounts of acids, alkalies, and organic materials.
- E. Concrete Admixtures:
 1. Acceptable Manufacturers:
 - a. The Euclid Chemical Company
 - b. BASF Building Materials, Inc.
 - c. Sika Chemical Corporation
 - d. General Resource Technology
 - e. W.R. Meadows
 - f. Or Approved Equal
 2. Air-Entraining Admixture: Shall meet or exceed ASTM C260.
 3. Water-Reducing Admixture: Shall meet or exceed ASTM C 494/C 494M, Type A.
 4. Retarding Admixture: Shall meet or exceed ASTM C 494/C 494M, Type B.

5. Water-Reducing and Retarding Admixture: Shall meet or exceed ASTM C 494/C 494M, Type D.
 6. High-Range, Water-Reducing Admixture: Shall meet or exceed ASTM C 494/C 494M, Type F.
 7. High-Range, Water-Reducing and Retarding Admixture: Shall meet or exceed ASTM C 494/C 494M, Type G.
 8. Plasticizing and Retarding Admixture: Shall meet or exceed ASTM C 1017/C 1017M, Type II.
 9. Non-Chloride, Non-Corrosive Accelerating Admixture: The admixture shall conform to ASTM C494, Type C or E, and not contain more chloride ions than are present in municipal drinking water. The admixture manufacturer must have long-term non-corrosive test data from an independent testing laboratory (of at least a year's duration) using an acceptable accelerated corrosion test method such as that using electrical potential measures.
 10. Viscosity Modifying Admixture (VMA): Shall meet or exceed ASTM C 494/C 494M, Type S.
 11. Alkali-Silica Reactivity Inhibitor: Shall meet or exceed ASTM C1293.
 12. Calcium Chloride: Not permitted.
 13. Chemical Admixtures: Provide admixtures certified by manufacturer to be compatible with other admixtures. Calcium chloride thiocyanates or admixtures containing more than 0.05 percent chloride ions are not permitted.
 14. Certification: Written conformance to the above-mentioned requirements and the chloride ion content of admixtures will be required from the admixture manufacturer prior to mix design review by the Engineer.
- F. Entrained Air: Concrete exposed to weather shall be air-entrained. Proportions of entrained air, as determined by ASTM C138, ASTM C173 or ASTM C231, shall be 4.5% to 7.5% by volume for concrete with 3/4-inch maximum nominal size coarse aggregate.

2.02 CONCRETE CURING MATERIALS

- A. Evaporation Retarder: Waterborne, monomolecular film forming, manufactured for application to fresh concrete.
1. Products:
 - a. Euclid Chemical Company (The); Eucobar
 - b. BASF; Confilm
- B. Absorbent Covers: AASHTO M 182, Class 2, burlap cloth made from jute or kenaf, weighing approximately 9 oz./sq. yd. (305 g/sq. m) when dry. Material must be free of harmful substances, such as sugar or fertilizer, or substances that may discolor the concrete. To remove soluble substances, burlap should be thoroughly rinsed in water before placing it on the concrete.
- C. Moisture Retaining Covers:
1. Plastic Film Curing Membrane: 4-10 mil thick polyethylene sheeting, complying with ASTM C171 and Product Standard PS17. Use white for exterior warm weather applications. Use either white or black for exterior cold weather applications.
 2. White burlap-polyethylene sheet meeting ASTM C 171.
 3. Moisture Retaining Fabric: Conforming to ASTM C171: A naturally colored, non woven polypropylene fabric with a 4 mil non perforated reflective (white) polyethylene coating containing stabilizers to resist degradation from ultraviolet light. Fabric shall exhibit low permeability and high moisture retention.
 - a. Products
 - 1) PNA Construction Technologies, Inc.; Hydracure M15.
 - 2) Reef Industries Incorporated; Transguard 4000.
- D. Water: Potable
- E. Liquid Curing Compounds
1. Penetrating reactive silicate based materials will not be accepted as liquid curing compounds

- F. Liquid Curing and Sealing Material: (at concrete surfaces)
1. Clear, Membrane-Forming Curing and Sealing Compound: ASTM C 1315, Type 1, Class A. Moisture loss shall be not more than 0.40 Kg/m² when applied at 300 sq. ft./gal. Manufacturer's certification is required. Subject to project requirements provide one of the following products:
 - a. Solvent Bourne Products:
 - 1) Euclid Chemical Company (The); Super Diamond Clear
 - 2) L&M Construction Chemicals, Inc.; Lumiseal Plus
 - 3) Meadows, W. R., Inc.; CS-309/30
 - b. Water Bourne Products:
 - 1) Euclid Chemical Company (The); Super Diamond Clear VOX
 - 2) L&M Construction Chemicals, Inc.; Lumiseal WB Plus
 - 3) Meadows, W. R., Inc.; Vocomp-30

2.03 PENETRATING LIQUID WATER REPELLENT TREATMENT

- A. Penetrating silane/siloxane water repellent treatment providing minimum 85% reduction in water absorption, and 82% reduction in chloride penetration when tested in accordance with NCHRP 244.
1. Products:
 - a. Euclid Chemical Company (The): Barricade WB 244
 - b. BASF Construction Chemicals: Enviroseal 40

2.04 CONCRETE QUALITY, STRENGTH AND PROPORTIONS

- A. Type and Strength: Concrete shall have a minimum comprehensive strength, in place, at 28 days as follows:
1. Concrete Exposed to Weather: 4,500 psi.
- B. Water-Cement Ratio: Concrete exposed to weather shall have a water-cement ratio of not more than 0.42.
- C. Slump: Concrete slump shall be as determined by ASTM C143 and shall be as follows:
1. Walks, Ramps, and similar: 3 to 4 inches
 2. Slabs On Grade: 3 to 4 inches
 3. Machine curbing, gutters, and similar: 1 to 2 inches
 4. Hand-formed stairs, curbing, gutters, and similar: 3 to 4 inches
 5. Unless otherwise noted concrete mixes shall be proportioned to achieve a maximum slump of 8" for concrete containing high range water reducing admixture, 6" for concrete containing a mid-range water reducing admixture, or 4" for other concrete. All mixes shall have a water slump of 2" – 3" (3" to 4" for concrete receiving a "dry-shake" hardener).
- D. Air Content: All concrete exposed to freezing and thawing and/or required to be watertight shall have an air content of 4.5% to 7.5%.
- E. High-Early Strength Cement: Contractor may use Type III Portland cement to produce high-early strength concrete. Adding additional amounts of Type I Portland cement to produce high-early strength concrete will not be permitted.
- F. Workability: Concrete shall be of a consistency which will fill forms without voids or honeycombs, completely embed and bond to reinforcing without permitting materials to separate, and not promote excess water to collect on surface.

- G. Admixtures: Use admixtures according to manufacturer's written instructions.
1. Use water-reducing or high-range water reducing admixture in concrete, as required, for placement and workability.
 2. Use water-reducing and retarding admixture when required by high temperatures, low humidity, or other adverse placement conditions.
 3. Use high-range water-reducing admixture in pumped concrete, concrete for heavy-use industrial slabs, fiber reinforced concrete, and parking structure slabs, concrete required to be watertight, and concrete with a water-cementitious materials ratio below 0.50.
 4. Use non-corrosive accelerator for all concrete, less than 8 inches thick, placed at air temperatures below 50°F.
 5. Use alkali-silica reactivity inhibitor unless ready mix company confirms that the aggregates to be used on the job are non-reactive.

2.05 FORM MATERIALS

- A. General Requirements For Form Materials:
1. Lumber or plywood forms as appropriate for application.
 2. Thoroughly clean and remove surface irregularities from forms to be reused.
- B. Lumber Forms: Surfaced 4 sides (S.S.)

2.06 REINFORCING MATERIALS

- A. Reinforcing Steel: New billet, intermediate grade, deformed bars, meeting requirements of ASTM A615, Grade 60, with a yield stress of 60,000 pounds per square inch, unless otherwise noted on Drawings. Reinforcing steel shall be epoxy coated unless otherwise noted.
- B. Welded Wire Fabric (WWF): 6 by 6, W1.4, cold-drawn welded steel wire fabric, meeting requirements of ASTM A185, unless otherwise noted on Drawings.

2.07 MISCELLANEOUS MATERIAL

- A. Expansion Joint Material:
1. Applicable Standards:
 - a. Federal Specifications HH-F-341E, Type 1
 - b. ASTM D1751
 2. Description: Composed of fibers of cellular nature bonded together with bituminous binder with sheets saturated in asphalt.
 3. Acceptable Manufacturer's: As follows or approved equal:
 - a. Celotex Corporation, "Flexcell"
 - b. Philip Carey Company, "Elastite"
 - c. W.R. Meadows Company, "Sealtight Fibre Expansion Joint"
 - d. North Central, "Fibre Expansion Joint Filler"
- B. Truncated Dome Panels:
1. Approved Products:
 - a. Neenah Foundry Company - Detectable Warning Plates
 - b. East Jordan Iron Works - Detectable Warning Plates
 2. Natural Color.
 3. Truncated Dome Panel Joint Filler Compound: Dow 888.

- C. Stamped and Colored Concrete: Chromix® Admixture C-14 French Gray with “platinum release” as manufactured by L.M. Scofield Company, supplied locally by Cemstone Products Co., or approved equal. Color shall be verified with the Architect prior to construction (submit cured sample of concrete prior to placing concrete for Architect approval). Mix design shall be in accordance with manufacturer’s recommendations and manufacturer’s technical bulletin A-304.11 (a copy of which may be obtained from the Engineer upon request). Stamp Pattern shall be Running Bond New England Slate SL.
- D. Miscellaneous Materials for Exterior Stairs
 - 1. Stair Nosing – Refer to Section 05 50 00.
 - 2. Railings – Refer to Section 05 50 00.

PART 3 - EXECUTION

3.01 FIELD QUALITY CONTROL

- A. Water Content Slump Tests:
 - 1. Test Procedure: Maintain a slump cone on job site during concreting operations. Conduct slump tests in accordance with ASTM C143.
 - 2. Reports: Report results of each slump test to Engineer.
 - 3. Verify Water Content in accordance with AASHTO T-318 “Standard Method of Test for Water Content Using Microwave Oven Drying.”
- B. 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. Verify air content with unit weight test per ASTM C 138.
- C. Compression Tests of Concrete Cylinders:
 - 1. Cost Responsibility for Tests: Contractor shall have concrete test cylinders tested by the Owner’s testing laboratory and shall pay cost for making these samples. Make test cylinders in accordance with the "Standard Method of Making and Curing Concrete Compression and Flexure Test Specimens in the Field" (ASTM C31).
 - 2. Frequency of Testing: Take 2 sets of test cylinders for every concrete placement and not less than 2 sets of test cylinders per 50 cubic yards of concrete. The first set of cylinders shall be considered control cylinders and shall be laboratory cured at 70°F of the control set; 1 cylinder shall be tested at 7 days, 1 at 28 days, and the third cylinder shall be tested only if the 28 day cylinder failed. The second set of cylinders shall be job cured and used to determine when forms and shoring may be removed. The first of these cylinders shall be tested at 7 days and the other 2 cylinders tested only if required.
 - 3. Number of Tests Per Set: Each set of test cylinders shall consist of 3 concrete test cylinders, 6 inches by 12 inches, and each set shall be considered as 1 test. Cylinders in each set shall be taken from the same batch of concrete. Note date, location, and concrete slump on each cylinder made.
 - 4. Location of Making Cylinders: Make concrete test cylinders at discharge end of chute, slide or pipe and not at truck or mixer.
 - 5. Strength Requirements: The strength level of the concrete will be considered satisfactory so long as the averages of all sets of 3 consecutive strength test results equal or exceed the specified strength f_c' and no individual strength test result falls below the specified strength f_c' by more than 500 psi.
 - 6. Compression Test Failure: Failure of concrete compression tests to meet specified strength shall require a load test or test cores at Contractor's expense. Failure to meet required live and dead loads or meet strength requirements of cores shall constitute rejection or consideration for rejection by Engineer. Cost of measures to make work satisfactory shall be paid for by the Contractor.
- D. Non-Compliant Test Reports: All test reports indicating non-compliance shall be emailed immediately to all parties on the test distribution list. Copies shall be on different colored paper.

3.02 INSTALLATION OF FORMWORK

- A. Inspection: Examine subgrade and conditions under which concrete formwork is to be performed.
- B. Correction of Deficiencies: Do not proceed with work until unsatisfactory conditions have been corrected.
- C. Formwork Design Requirements: Design, support, brace, and maintain formwork to safely support loads that will be applied.
- D. Form Construction: Construct forms in accordance with ACI 301, to the sizes, lines, and dimensions shown and as required to obtain accurate alignment, location, and grades. Level and plumb work in finished structures.

3.03 PREPARATION BEFORE PLACING CONCRETE

- A. General Requirements: Before concrete placement, formwork shall be completed, reinforcement shall be secured in place, and embedded items shall be positioned.
- B. Cleaning Equipment: Remove hardened concrete and foreign materials from inner surfaces of conveying equipment.
- C. Cleaning Forms: Remove ice, water, wire, and other debris from forms and excavations before placing concrete.
- D. Fog-spray forms, reinforcement, and subgrade just before placing concrete. Keep subgrade uniformly moist without standing water, soft spots, or dry areas.
- E. Base materials shall be compacted to 100% standard Proctor density (ASTM D 698).

3.04 INSTALLATION OF REINFORCING STEEL

- A. Applicable Standards: Place reinforcing steel in accordance with CRSI 63 and CRSI 65.
- B. Cleaning: Clean reinforcement to remove loose rust, mill, scale, earth, and other materials which reduce or destroy bond with concrete.
- C. Supporting Reinforcement: Support reinforcing as noted on Shop Drawings. Provide sufficient quantity, of strength to carry reinforcement. Do not place reinforcing bars more than 2 inches beyond last leg of any continuous bar support. Do not use supports as bases for runways for concrete conveying equipment and similar construction loads.
- D. Placing and Securing Reinforcement: Position, support and secure reinforcement against displacement. Arrange, space, and securely tie bars and bar supports together with wire to hold reinforcement accurately in position during concrete placement operations. Set wire ties so twisted ends are directly away from exposed concrete surfaces.
- E. Splicing Reinforcement: When splicing of reinforcement becomes necessary due to lengths of reinforcement required not being available in single lengths, provide standard reinforcement splices by lapping ends, placing bars in contact, and tightly wire tying. Overlap bars by a minimum of 30 times the diameter of the bar, unless otherwise noted on the Drawings.
- F. Concrete Protection For Reinforcement: Place reinforcement to obtain minimum coverage for concrete protection as follows, unless otherwise noted on Drawings:
 - 1. Concrete Cast Against Permanently Exposed to Earth: Provide a minimum concrete coverage of 3 inches.
 - 2. Concrete Exposed to Weather: Provide a 2 - inch minimum cover for No. 6 through No. 11 bars. Provide a 1 ½ -inch minimum concrete cover for bars No. 5 or smaller.

3.05 INSTALLATION OF WIRE FABRIC

- A. Lengths: Install welded wire fabric in lengths as long as practical.
- B. Lapping: Lap adjoining pieces at not less than 6 inches.
- C. Securing: Wire tie fabric securely to hold in position and prevent fabric from being exposed at concrete surface.
- D. Wire Fabric in Walks: Support wire fabric to be in center of slab thickness. Do not lift/pull wire fabric up into slab while concrete is being placed.

3.06 CONVEYING CONCRETE

- A. General Requirements: Handle concrete from mixer to place of final deposit as rapidly as practical by methods which shall prevent segregation or loss of ingredients and in a manner which shall ensure that concrete quality is maintained.

3.07 PLACING CONCRETE

- A. Do not allow concrete to drop freely more than 4 feet for conventional concrete and 10 feet for concrete containing the high range water reducing admixture.
- B. Do not begin to place concrete while rain, sleet, or snow is falling unless adequate protection is provided and, when required, acceptance of protection is obtained. Do not allow rain water to increase mixing water or to damage the surface of the concrete.
- C. 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.
- D. When average high and low temperature is expected to fall below 40°F (4.4°C) for three successive days, maintain delivered concrete mixture temperature within the temperature range required by ACI 301.
- E. Do not use frozen materials or materials containing ice or snow. Do not place concrete on frozen subgrade or on subgrade containing frozen materials.
- F. Use only the specified non-corrosive accelerator. Do not use calcium chloride, salt, or other admixtures containing antifreeze agents or chemical accelerators unless otherwise specified and approved in mixture designs.
- G. Hot-Weather Placement: Comply with ACI 301 and as follows:
 - 1. Maintain concrete temperature below 90°F (32°C) 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. Use specified evaporation retarder when high temperatures, low humidity and wind will cause crusting and plastic cracking. Use evaporation retarder one or more times after the strikeoff.

- H. Placing Exterior Walks, Slabs and Ramps:
1. Reinforcing: Provide welded wire fabric only where panels are wider than 8 feet or as otherwise required on drawings.
 2. Thickness: As noted on the Drawings. Provide thickened slab where indicated on the Drawings.
 3. Control Joints: Provide control joints at maximum 8-foot centers for walks and ramps, unless otherwise noted. Provide sawcut joints for slabs.
 4. Expansion Joints: Provide a ½-inch thick expansion joint in sidewalks at intervals a maximum of 60 feet in length of run and between sidewalks and curbs. Provide expansion joint between all walks and stoops and between walk and building where walk is adjacent to building. Provide caulk sealant over expansion joint at all stoops and building areas.
 5. Colored / imprinted concrete:
 - a. The Contractor shall construct at least four “mock ups”, of various shades of the color selected by the Architect, for the Architect’s review and approval. Each mock up shall include the imprint and shall be no less than 48" by 48" in size.
 - b. All walks shall be constructed in accordance with manufacturer’s recommendations and technical bulletins.
- I. Placing Miscellaneous Curbs and Gutters:
1. Contraction Joints: Provide contraction joints 10 feet on center. Form joints by using oiled steel plates. Remove plates as soon as concrete has set. Rub edges of joints smooth with a jointing tool. Seal joints with hot poured concrete joint sealer.
 2. Expansion Joints: Provide expansion joints a maximum of 60 feet on center. Rub edges of joints smooth with a jointing tool. Fill joints with ½-inch joint filler material. Provide expansion joints between existing walks and new curbing.
 3. Subgrade: Build curbs on compacted granular stabilized base material specified for beneath bituminous paving.
 4. Slip-Form Construction: Mechanical curb machines may be used to place curb and gutter using an approved extrusion machine that will produce a finished curb meeting the standards, workmanship, and appearance that would be achieved using metal forms. The same tolerances which apply using metal forms shall apply to work done with curb machines.
- J. Placing Pedestrian Curb Ramps and truncated dome area:
1. Construct ramps and truncated dome area as detailed on the Drawings.
- K. Placing Concrete Stairs:
1. Construct stairs in accordance with details shown on Plan.
 2. Construct stair nosing per manufacturer’s recommendations. Refer to Section 05 50 00.
 3. Provide steel handrails (both sides) in accordance with ADA requirements and as generally shown on the drawings. Refer to Section 05 50 00.

3.08 CONSOLIDATING CONCRETE

- A. General Requirements: Consolidate concrete by vibrating, spading, rodding or forking so that concrete is thoroughly worked around reinforcement, around embedded items, and into corners of forms to eliminate air or stone pockets which may cause honeycombing, pitting or planes of weakness.

3.09 FINISHING CONCRETE

- A. Walks, Slabs, and similar:
1. Level concrete after striking off with template or straightedge. After water sheen has left surface, float and follow with a light trowel finish. Care shall be taken not to bring an excess of water and fine sand to surface.
 - a. Walks and Slabs: Give surface a light broom finish with a coarse broom.
 2. Joints:
 - a. Provide control joints at maximum 8-foot centers.
 - b. Joints shall be tooled or sawcut to a minimum of 1/3 the thickness of the concrete section depth.
 - c. Tooled Joints:
 - 1) Round surface edges and edges adjacent to control joints and expansion joints to a 1/4-inch radius. Maximum joint radius is 1/2 inch unless noted otherwise. Concrete with joints larger than 1/2 inch radius will require the sections of concrete to be removed and replaced.
 - d. Sawcut Joints:
 - 1) Sawcut lines shall be measured for uniformity (equal distance between joint lines) and chalk lined before making the cuts.
 - 2) A walk-behind type sawcut machine shall be used. Handheld saws will not be permitted. Use wet-cut saws for dust control.
 - 3) Sawcut joints shall be 1/8 inch width.
 - 4) Begin transverse joint sawing as soon as the concrete has hardened sufficiently to allow sawing without raveling or moving of aggregate. Saw joints before uncontrolled cracking takes place.
- B. Miscellaneous Curbs and Gutters: Fill cavities with mortar and finish edges with an edging tool immediately after removal of forms and divider plates. Trowel exposed face to a smooth, uniform surface and then brush top and face lightly.
- C. Pedestrian Curb Ramps: Finish detailed on the Drawings.
- D. Exterior Concrete Stairs: Fill cavities with mortar and finish edges with an edging tool immediately after removal of forms. Trowel exposed concrete face to a smooth, uniform surface. Provide coarse broom finish to tread surfaces. All other exposed surfaces shall receive light brush finish.

3.10 CURING CONCRETE

- A. General: Protect freshly placed concrete from premature drying and excessive cold or hot temperatures. Comply with ACI 306.1 for cold-weather protection and ACI 301 for hot-weather protection during placement.
- B. Protect newly placed concrete from damage by adjacent vibratory or backfilling operations for a minimum of 24 hours. Perform vibratory operations and backfilling 72 hours after placing concrete or after the concrete reaches a compressive strength of at least 3,000 psi.
- C. Evaporation Retarder: Apply evaporation retarder to unformed concrete surfaces if hot, dry, or windy conditions cause moisture loss approaching 0.1 lb/sq. ft. x h (1 kg/sq. m x h) before and during finishing operations. Apply according to manufacturer's written instructions one or more times after placing, screeding, and bull floating or darbying concrete, but before float finishing.
- D. Formed Surfaces: Cure formed concrete surfaces utilizing final curing methods per ACI 308.1, including underside of beams, supported slabs, and other similar surfaces. If forms remain during curing period, moist cure, after loosening forms. If removing forms before end of curing period, continue curing for the remainder of the curing period.

- E. Unformed Surfaces: Begin curing immediately after finishing concrete. Cure unformed surfaces, including floors and slabs, concrete floor toppings, and other surfaces.
- F. Immediately after conclusion of concrete finishing operations, cure newly placed concrete slabs to receive exterior concrete penetrating sealer, or other subsequent finishes or treatments in accordance with ACI 308.1 utilizing one or a combination of the following methods.
1. Water Cure continuously for seven days utilizing sprinklers, soaker hoses, ponding, or fog spray. Take care to prevent erosion damage to the surface of the concrete.
 2. Absorbent Cover: water saturated, and kept continuously wet. Cover concrete surfaces and edges with 12-inch lap over adjacent absorbent covers when placing. Provide continuous supply of moisture such as sprinklers or soaker hoses when high temperature, low humidity, or windy conditions prevail. Do not allow Absorbent Cover materials to dry out during specified curing period.
 3. Moisture Retaining Cover Curing: Cover concrete surfaces with moisture-retaining cover meeting ASTM C 171 as soon as possible after final finishing without marring the surface. Place in widest practicable width, with sides and ends lapped at least 12 inches, and sealed by waterproof tape or adhesive. On flat surfaces such as pavements, the cover shall extend beyond the edges of the slab at least twice the thickness of the slab. The cover shall be placed flat on the concrete surface, avoiding wrinkles, to minimize mottling immediately after wetting the slab to rejection. It shall be placed and weighted so that it remains in contact with the concrete during the specified duration of curing. Windrows of sand or earth, or pieces of lumber shall be placed along all edges and joints in the film to retain moisture and prevent wind from getting under the film and displacing it. Immediately repair any holes or tears during curing period using cover material and waterproof tape.
 - a. Moisture Retaining Fabric shall be installed in accordance with manufacture's written recommendations, in largest practical widths. Wet the slab to rejection then thoroughly wet fabric side of cover and install with poly side up. Lap over adjacent covers a minimum 18". Weight all laps and outside edges to prevent displacement and to ensure intimate contact with concrete and adjacent covers. Rewet as necessary and protect covers from damage during curing process.
 - b. Moisture cure or use moisture-retaining covers to cure concrete surfaces to receive penetrating sealers, coatings, adhesives, or other subsequent treatments.
- G. Curing and Sealing Compound: Immediately after conclusion of concrete finishing operations apply specified ASTM C 1315 curing and sealing compound to indicated areas, in a uniform, continuous operation by power spray or roller according to manufacturer's instructions.

3.11 CLEANUP

- A. Remove all form materials, excess joint materials, concrete spoils and excess concrete from the site.

3.12 CONCRETE TRUCK WASHING AREA

- A. Provide effective containment for all liquid and solid wastes generated by washout operations (concrete, stucco, paint, form release oils, curing compounds and other construction materials) related to the construction activity. The liquid and solid washout wastes must not contact the ground, and the containment must be designed so that it does not result in runoff from the washout operations or areas. Liquid and solid wastes must be disposed of properly and in compliance with MPCA rules. A sign must be installed adjacent to each washout facility that requires site personnel to utilize the proper facilities for disposal of concrete and other washout wastes.

END OF SECTION 32 13 13

SECTION 32 17 23

PAVEMENT MARKING

PART 1 - GENERAL

1.01 SCOPE OF WORK

- A. Section includes labor, material, equipment, and accessories to complete the following Work:
 - 1. Prepare pavement surfaces and furnish and apply traffic paint for pavement striping as shown on the Drawings and specified herein.

1.02 WIDTH OF STRIPING

- A. Striping for parking lot markings shall be 4" in width, unless otherwise noted.

PART 2 - PRODUCTS

2.01 MATERIALS

- A. Paint:
 - 1. Low VOC Acrylic Copolymer Traffic Marking Paint.
 - a. Paint shall be 100% acrylic, conventional dry (non-heat applied) acetone based paint.
 - b. Paint shall be developed for use over concrete, asphalt, brick, and for use on highways and parking lots.
 - c. Paint shall have the following performance characteristics:

Test Name	Test Method	Results
Bleed Ratio	TT-P-115F	0.95 min (white)
Directional Reflectance	ASTM E97	84% min (white)
Dry-No-Pickup	ASTM D-711	10 min max (white)
Dry Opacity (contrast ratio) - White	Fed. Test Method 141C (5 mils bird applicator)	0.92 min
Dry Opacity (contrast ratio) - Yellow	Fed. Test Method 141C @ 15 mils	0.97 min
Hegman Grind	ASTM D-1210	3 min (white)
Viscosity	ASTM D-562	75-90 KU (white)
Water Resistance	TT-P-115-F	Pass (white)

- 2. Color shall be white.

PART 3 - EXECUTION

3.01 RESTRICTIONS

- A. No painting shall be done during the threat of rain or when the pavement surface is damp.
- B. Paint shall be applied when the air temperature is between 40°F and 90°F and at least 5°F above the dew point. Paint shall be applied when the relative humidity is 85% or less.
- C. The Contractor shall not begin marking pavement surface until conditions are acceptable to the Engineer.

3.02 PAVEMENT SWEEPING

- A. Immediately prior to application of the traffic paint, the surface shall be properly swept.
- B. All sweeping operations and disposal of sweepings shall be the responsibility of the Contractor and will be considered incidental to the Contract.

3.03 PAINT APPLICATION

- A. All paint shall be applied according to the manufacturer's suggested application procedure.
- B. The applicator shall be capable of producing a uniform straight line with sharp edges.
- C. Traffic paint shall be applied at the rate of 320 lineal feet of standard 4" stripe per gallon, unless otherwise recommended by the paint manufacturer.

3.04 DISPOSAL OF PAINT CONTAINERS

- A. Paint containers shall be properly disposed of in accordance with applicable regulatory requirements.

END OF SECTION 32 17 23

SECTION 32 32 23

SEGMENTAL RETAINING WALL

PART 1 - GENERAL

1.01 SUMMARY

- A. Work includes furnishing and installing segmental retaining wall (SRW) units to the lines and grades designated on the Construction Drawings or as directed by the Engineer.

1.02 SITE CONDITIONS

- A. Site Improvements: Other improvements will be occurring at the site. Coordinate wall work with other contractors to ensure proper and timely installation.

1.03 QUALITY ASSURANCE

- A. Manufacturers Qualification: Contractor shall submit a notarized manufacturer's certification prior to start of work stating that the SRW units meet the requirements of this specification.

1.04 DELIVERY, STORAGE AND HANDLING

- A. Contractor shall check the materials upon delivery to assure that specified type, grade, color and texture of SRW units has been received.
- B. Contractor shall prevent excessive mud, wet cement, epoxy, and like materials which may affix themselves, from coming in contact with the materials.
- C. Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the retaining wall system.

1.05 SUBMITTALS

- A. Product Data
 - 1. Material description and installation instructions for each manufactured product specified including Segmental Retaining Wall Units (SRW) and Geosynthetic Reinforcement.
 - 2. Furnish one unit demonstrating the color, face pattern, and texture of the SRW unit.
- B. Submit the following prior to start of construction for approval
 - 1. Retaining Wall Final Design Submittals (must be signed and certified by a Licensed Engineer employed by the Contractor).
 - a. Shop Drawings: Retaining wall system design, including wall elevation views, geosynthetic reinforcement layout, pertinent details, and drainage provisions. A registered professional engineer licensed in the state of wall installation shall sign and certify that the shop drawings are designed in accordance with the project civil plans and specifications.
 - b. Design Calculations: Engineering design calculations prepared in accordance with the NCMA Design Manual For Segmental Retaining Walls, Third Edition, Fourth Printing, 1997. Analysis shall include Internal, External, Global Stability, and Bearing Capacity Calculations.
- C. All submittals must be provided and reviewed prior to the start of retaining wall construction.

PART 2 - PRODUCTS

2.01 SEGMENTAL RETAINING WALL UNITS:

- A. Concrete Wall Units shall be Anchor Wall “Vertica Pro”, Anchor Wall “Diamond Pro”, Keystone “Standard”, Keystone “Compac”, Rockwood “Classic 8”, Versa-Lok “Square Foot Unit”, Versa-Lok “Nexus”, Allan Block “Classic”, or approved equal. Use the same brand and style of Units for all proposed walls. Materials shall meet the following requirements:
1. High strength, high density concrete units, freeze-thaw resistant.
 2. Provide a maximum 7° set back.
 3. Units shall be a minimum 8" high. Depth may vary as determined by the Contractor and Structural Engineer.
 4. Color shall match the existing retaining wall on the north side of the school (generally a tan color). Use the same color for all retaining walls on site. Color sample shall be provided to the Architect prior to construction.
 5. Face Pattern shall match the existing retaining wall on the north side of the school (generally a beveled cut / split face pattern).
 6. All SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction. Cracking or excessive chipping may be grounds for rejection. Units showing cracks larger than ½” when measured along their length shall not be used within the wall. Units showing visible chips at a distance of 20 feet from the wall shall not be used within the wall.
- B. Concrete Cap Units (Anchor “Vertica Cap”, Keystone “Universal Cap”, Rockwood “4” Classic Universal Cap”, Versa-Lok “Standard Cap”, Allan Block “Universal Cap”, or approved equal). Materials shall meet the following requirements:
1. High strength, high density concrete units, freeze-thaw resistant.
 2. Units shall be 4" high.
 3. Color shall match the existing retaining wall on the north side of the school (generally a tan color). Use the same color for all retaining walls on site. Color sample shall be provided to the Architect prior to construction.
 4. Face Pattern shall match the existing retaining wall on the north side of the school (generally a straight cut / split face pattern).
 5. All SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the construction. Cracking or excessive chipping may be grounds for rejection. Units showing cracks larger than ½” when measured along their length shall not be used within the wall. Units showing visible chips at a distance of 20 feet from the wall shall not be used within the wall.

2.02 LEVELING PAD

- A. Material for leveling pad shall consist of compacted sand or gravel and shall be a minimum of 6 inches in depth. The leveling pad should extend laterally at least a distance of 6 inches beyond the toe and heel of the lower most SRW unit.
- B. Do not run mechanical vibrating plate compactors on top of the units. Compact fill between units by running hand-operated compaction equipment just behind unit. Compact to a minimum 95% Standard Proctor Density (ASTM D 698).

2.03 DRAINAGE

- A. Drainage aggregate shall be a clean 1-inch minus crushed stone or granular fill meeting the following gradation:

<u>Sieve Size</u>	<u>Percent Passing</u>
1 inch	100-76
3/4 inch	50-75
No. 4	0-60
No. 40	0-50
No. 200	0-5

- B. Vertical drainage layer behind the wall face shall be placed no less than 1 ft³ per 1 ft² of wall face.

2.04 REINFORCED BACKFILL (INFILL SOIL)

- A. The reinforced backfill material shall be free of debris and consist of either of the following inorganic soil types according to their USCS designations (GP, GW, SW, SP, SM, ML, CL). The maximum particle size shall be 4 inches. There shall be less than 20% by weight of particles greater than 1 ½ inches, maximum 60% by weight passing the #200 sieve and PI<20.
- B. The reinforced backfill shall be compacted in a maximum 8-inch-thick compacted lifts to a minimum density of 95% of the maximum Standard Proctor Density (ASTM D 698).

2.05 RETAINED BACKFILL OR COMMON BACKFILL

- A. Soil placed behind the reinforced backfill shall be any inorganic soil with a liquid limit less than 50 and plasticity index less than 30, or as directed by Engineer.
- B. Retained backfill shall be compacted to a minimum 90% maximum Standard Proctor Density (ASTM 698).

PART 3 - EXECUTION

3.01 EXCAVATION

- A. Contractor shall excavate to the appropriate lines and grades. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Engineer, at the Contractor's expense.
- B. The Geotechnical Engineer will inspect the excavation and approve the subgrade prior to placement of leveling pad material.
- C. Excavate of deleterious soils and replacement with compacted infill material. See Section 31 00 00 - Earthwork.
- D. Over-excavated areas in front of wall face shall be filled with compacted infill material at the Contractor's expense, or as directed by the Engineer.
- E. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation.

3.02 LEVELING PAD CONSTRUCTION

- A. Provide forming for line and grade and construct leveling pad as shown on the construction drawings with a minimum thickness of 6 inches. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lower most SRW Unit.
- B. Foundation soil shall be proof rolled and compacted to 95% Standard Proctor Density and inspected by the Soil Technician prior to placement of leveling pad materials.
 - 1. Soil leveling pad material shall be compacted to provide a level hard surface on which to place the first course of units. Well-graded sand can be used to smooth the top ½ to 1/4 inch of the leveling pad. Compaction will be with mechanical plate compactors to 95% of maximum Proctor density (ASTM D 698).
 - 2. Leveling pad shall be prepared to ensure intimate contact of SRW units with pad.

3.03 SRW UNIT INSTALLATION

- A. First course of SRW Units shall be placed on the leveling pad. The Units shall be leveled side-to-side, front-to-rear and with adjacent units and aligned. The first course is the most important to ensure accurate and acceptable results.
- B. Ensure that units are in full contact with base.
- C. Place the front of the Units side-by-side. Do not leave gaps between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units or along the pinning grooves. Lay out of curves and corners in accordance with SRW manufacturer's installation guidelines.
- D. Place and compact drainage fill between and behind units. Place and compact infill soil behind drainage fill.
- E. Place geosynthetic wall reinforcement. Refer to Section 31 34 19.
- F. Clean all excess debris from top of Units and install next course.
- G. Repeat procedures to the extent of the wall height, ensuring that pins (depending on system) are engaged in each successive course.
- H. SRW caps shall be glued to underlying units with manufacturers recommended concrete adhesive. Caps shall overhang from the top course of units.

END OF SECTION 32 32 23

SECTION 32 38 00

SITE FURNISHINGS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, materials, equipment and accessories to complete the following work:
 - 1. Furnish and install bike racks.
- B. Work Specified in Other Sections:
 - 1. Coordinate work with walk installation.

1.02 SUBMITTALS

- A. General Requirements: Furnish submittals in accordance with Section 01 33 00.
- B. Product Data:
 - 1. Furnish complete specifications and product data which indicate compliance with specified requirements.
 - 2. Submit shop drawings (product data / cut sheets) for all products listed in this Section.
 - 3. Submit shop drawings that include layout information and recommended installation instructions.
- C. Maintenance Data:
 - 1. Include recommended methods for repairing damage to products.

PART 2 - PRODUCTS

2.01 BIKE RACKS

- A. Loop Style Bike Rack
 - 1. ASTM A53, 2" Schedule 40 pipe (2 3/8" O.D. x 0.154" thick wall or better).
 - 2. Galvanized finish. Prior to galvanizing, steel shall be free of any scale, paint, varnish, or rust.
 - 3. In-Ground mount
 - 4. Bicycle parking racks shall carry a one year manufacturer's warranty against defects in materials and workmanship.
 - 5. Approved Products / Manufacturers:
 - a. Manufacturer: MadRax, 1080 Uniek Drive, Waunakee, WI 53597, phone 800-448-7931, distributed by Webber and containing Recreational Design, Inc., 1442 Brooke Court, Hastings, MN 55033-3266, phone (651) 438-3630.
 - b. Product: Heavy Duty Winder, HW238-19-IG-G. Provide one (1) bike rack.
 - 1) Or approved equal.

PART 3 - EXECUTION

3.01 BIKE RACK INSTALLATION

- A. Install in accordance with manufacturer's recommendations.
- B. Coordinate installation with concrete walk installation.

END OF SECTION 32 38 00

SECTION 32 80 00

IRRIGATION SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

- A. Work shall include labor, materials, equipment, and accessories to install a fully operative irrigation system as follows:
1. Provide accurate layout of irrigation system.
 - a. Provide excavation and backfill for installation of irrigation system components.
 - b. Provide coordination with earthwork contractor installing topsoil.
 - c. Provide connection to existing irrigation water supply piping and control.
 - d. Provide pipe, joint restraints, thrust blocking, sprinkler heads, valves, valve boxes, communication circuitry, wire, and other related equipment for complete system.
 - e. Provide sleeving under all pavements.
 - f. Provide protection of completed system until accepted by Owner.
 - g. Provide any necessary adjustment in sprinkler heads and valve box elevations after completion of fine grading and sodding.
 - h. Mark each sprinkler head with a flag.
 - i. Provide demonstration and documentation of start-up and winterization.
 - j. Provide As-Built drawings.

1.02 SITE CONDITIONS

- A. Site Access: Other activities will be occurring at the site. Coordinate irrigation work with the General Contractor and Owner to ensure proper and timely installation of piping and equipment.
- B. Source of Water: Water will be available from the existing 2" mainline.

1.03 SUBMITTALS

- A. Shop Drawings: Submit Shop Drawings which indicate sprinkler heads, control equipment, valves, piping, and other related equipment to be used.
- B. Design Document: Prior to the work, the Contractor shall prepare and provide a design for the irrigation system, to be approved by the Landscape Architect, showing all sprinkler heads, valves, drains, control lines, and pipe main and lateral lines to scale with dimensions.
 1. Design shall provide head-to-head coverage to provide 1" water per week to all irrigated areas.
- C. As-Built Drawing: After completion of the installation, the Contractor shall furnish an as-built drawing, in PDF form or similar, showing all sprinkler heads, valves, control lines, and pipe lines to scale with dimensions where required.
- D. Catalog and Instruction Data: The Contractor shall collect two sets of catalog data, including instructions for installation, operation, suggested watering schedule, spare parts lists, and care of equipment for all pieces of equipment furnished under this Contract, to include electrical equipment installed on the job.
 1. This data shall be bound in a 3-ring loose leaf notebook of appropriate size or in binders approved by the Engineer. Two notebooks shall be delivered to the Owner upon completion of the work and before receipt of final payment.

1.04 QUALITY ASSURANCE

- A. Workmanship: Work shall be performed by an experienced installer well qualified in underground irrigation installation. The Contractor shall have a minimum of three years experience installing systems of this size and complexity. The Contractor shall provide proof of competence prior to Contract award.

PART 2 - PRODUCTS

2.01 ACCEPTABLE MANUFACTURERS

- A. System: The lawn sprinkler equipment shall be as manufactured by the Hunter Company or approved equal.

2.02 PIPE

- A. General: All materials and equipment furnished under this Contract shall be new.
- B. Polyvinyl-Chloride Pipe (PVC):
1. Main line pipe and pressure pipe to valve, shall be virgin, high impact, polyvinyl chloride (PVC) pipe (Class 200), having a minimum 200 psi working pressure rating. Lateral line and disconnect pipe to valve shall be polyvinyl chloride (PVC) pipe (Class 160) with a minimum working pressure of 160 psi. PVC pipe shall be continuously and permanently marked with manufacturer's name, material, and schedule or type.
 2. Pipe shall meet the requirements of ASTM D2241 and D2672, latest revision. Materials shall meet the requirements of ASTM D1784, latest revision.
- C. Pipe Fittings for PVC Pipe: Pipe fittings for 3" diameter and less shall be constructed of Schedule 40 PVC and shall be joined to pipe by solvent welding.
- D. Polyethylene Pipe:
1. Pipe shall be flexible non-toxic polyethylene pipe made from 100 percent virgin polyethylene material meeting NSF (National Sanitation Foundation) Standard 14 for use in pressure potable water applications, for 800 design stress.
 2. Sizes shall have a minimum 100 psi working pressure rating. Polyethylene pipe shall be continuously and permanently marked with the manufacturer's name, material, size, and schedule. Pipe shall meet requirements of ASTM D2239 and D1248 (3C5PE34) or latest revision.
- E. Polyethylene Pipe Fittings: Plastic Type PVC or nylon insert fittings and brass saddle tees, where applicable, shall be used. Joints shall be double clamped with all stainless steel clamps.
- F. Swing Joint Assemblies: Swing joints shall be Spears preassembled PVC swing joint or approved equal.
- G. Sleeving:
1. Sleeving within parking lots shall be PVC pipe sized to accommodate irrigation pipe and control wires.
 2. Sleeving under drives and roadways shall be ductile iron pipe Cl. 52. sized to accommodate irrigation pipe and control wires.

2.03 VALVES

- A. Electric Remote Control Valves: Valves used in the electrically controlled automatic system shall be Hunter ICV with Filter Sentry Series, as noted on the Drawings. Valves shall be sized as shown and noted on the Drawings and shall be installed in valve boxes of appropriate size and type as described under valve boxes. Provide reclaim water tags for valves on pump station systems.
1. 1" Globe Valve, with Filter Sentry and Accu-set, pressure regulator: Hunter ICV-101G- FS-AS-ADJ
 2. 1-1/2" Globe Valve, with Filter Sentry and Accu-set, pressure regulator: Hunter ICV-151G-FS-AS-ADJ

- B. Valve Boxes for Electric Remote Control Valves: Valve boxes shall be plastic as manufactured by Carson and shall be minimum 12 inches or jumbo size with locking lid. Valve box shall be of a size that provides adequate space for valve repairs. Valve boxes shall be placed on a bed of gravel sized 6 inches larger than box perimeter with a depth not less than 12 inches. Gravel must be placed prior to the placement of the valve box.
- C. Quick Coupling Valves, Keys and Hose Junction:
 - 1. Quick coupling valves shall be:
 - a. Hunter QCV-100 with a 1-inch service riser.
 - 2. Keys and hose swivels shall be:
 - a. Hunter QCV-100K with a Hunter HS-100 1-inch hose swivel. Provide two (2) to Owner.
 - 3. At quick coupler winterization blow-out points, provide 1-1/2" quick coupler assembly including locking key cover.

2.04 SPRINKLER HEADS

- A. Sprinkler heads shall be the following series as manufactured by the Hunter Company or approved equal.
 - 1. Type and location of heads are keyed and shown on the Drawings. Nozzles shall be selected based on providing head to head coverage and spacing as shown on the drawings. Provide reclaim water ID on Stormwater Pond system.
 - a. Rotors:
 - 1) Hunter I-20 Ultra Rotor, 6" pop-up, adjustable with check valve and stainless steel riser:
 - 2) Hunter I-20 Ultra Rotor, 6" pop-up, short radius nozzle, adjustable with check valve and stainless steel riser:
 - b. Rotary:
 - 1) Hunter MP Rotator with Hunter Pro-Spray PRS30 body including factory installed pressure regulator, adjustable with drain check valve and 6' high pop-up at turf area and 12" pop-up at planting areas.

2.05 CONTROL

- A. Communication Circuitry: Electric decoder wire from controller to automatic valves decoders shall be UF approved direct burial wire. Hunter ID 1 Wire 14 gauge
- B. Automatic Controller: Existing – Not Used.

2.06 DEDUCT WATER METER

- A. Existing – Not Used.

2.08 BACKFLOW DEVICE

- A. Existing – Not Used.

2.09 RAIN SWITCH

- A. Provide rain switch, Rain Sensor Wireless, on irrigation system.

2.10 THRUST BLOCKING

- A. Provide concrete thrust block at all bends, tees and ends in mainline. Refer to drawings for construction details.

PART 3 EXECUTION

3.01 INSTALLATION

- A. **Excavating and Backfill:** Perform excavations for installation of irrigation system. Backfill trenches and restore grade to elevation existing before excavating.
1. Contractor shall provide facilities for drainage by blow-out method and shall construct system in such a manner that will ensure positive winter protection.
 2. Make trenches wide enough to allow a minimum of 6 inches between parallel pipe lines. Make trenches for pipe lines of sufficient depths to provide the following minimum cover from finish grade:
 - a. 15-inch minimum cover over lateral lines to heads.
 - b. 18-inch minimum cover over main lines to valves.
 3. Coordinate with Earthwork Contractor to accomplish trenching and backfilling without disruption and contamination of topsoil, including prescribed topsoil and draitile systems at varsity fields.
- B. **Installation of Piping:**
1. Main line pipe which is under constant pressure, shall be installed with a minimum depth of cover of 18 inches. All other pipe shall be installed with a minimum depth of cover of 15 inches.
 2. Pipe shall be installed in accordance with the manufacturer's recommendation.
 3. Cap piping securely at end of each day's work to prevent entrance of foreign material.
- C. **Settlement**
1. The Contractor shall backfill and compact all trenches to final grade as so prevent settlement.
 2. The Contractor shall be responsible for any settlement of backfill which may occur within one year of final acceptance of the completed work.
 3. The Contractor shall make, or provide for, all repairs and replacements to improvements affected by settlement of backfill within 30 days after notice from the Engineer or Owner.
- D. **Thrust Blocking:** Provide 8"x 8"x 16" concrete thrust block at all bends, tees and ends in mainline. Refer to Drawings.
- E. **Installation of Wire:** Install wire with main line piping in same trench. Provide sufficient slack at each connection to valve to facilitate future service. Underground splices shall be waterproofed with wire connectors and Direct Burial Splice Kit (DBY) as manufactured by 3M Company.
- F. **Sleeving:** Enclose pipe and wire in PVC sleeves at each pavement crossing. Provide 1.5 foot section of rebar with 6" minimum bury at each end for future locating. Sleeving shall be directionally bored or mechanically pushed. Damage to pavement above sleeving shall be repaired by the Contractor, at his own expense and to the satisfaction of the Landscape Architect.
- G. **Sprinkler Head Installation:** Install sprinklers per manufacturer's recommendations. Use Teflon tape on PVC threaded fittings.
- H. **Automatic Control Valve Installation:** All control valves shall be installed in valve boxes that provide adequate space for valve servicing without excavation. Provide waterproof connections where control wires attach to valve. Center valve in an upright position within the valve box. Provide a minimum 4 inch space between the top of the valve and bottom of box cover and a minimum 4 inch space between the bottom of valve and top of gravel sump. Provide a 12 inch gravel sump under each valve box. Gravel sump must be placed prior to valve box placement.
- I. **Water Supply Connection:** Water will be available from existing mainline on the site.

3.02 ELECTRICAL WORK

- A. Minnesota state law requires all low voltage wiring shall be installed & maintained by a company that holds a Technology System Contractor license, and employs a person that holds a Power Limited Technician license.
- B. General Requirements:
 - 1. The Irrigation Contractor shall be responsible for low voltage wiring from controller to zone valves.

3.03 PERFORMANCE TEST

- A. General Requirements: Contractor shall notify Engineer, in writing, that all systems are in place and ready for a performance test. The Contractor is cautioned not to notify the Architect until he, the Contractor, has thoroughly observed the operation of the system and found it to be satisfactory. In the event the performance test fails and additional visits are required by the Architect, the Contractor may be liable to compensate the Engineer for those additional visits.
- B. Manpower: The Contractor shall provide all manpower necessary to conduct the performance test.
- C. As Built Drawings: Contractor shall provide preliminary "As Built" drawings for the Architect's use while observing the performance test and for verifying the location and operation of equipment. Drawings shall include all sprinklers, valves, quick couplers, piping (including sizes), wiring and related pertinent information.

3.04 INSTRUCTIONS

- A. General Requirements: After completion and testing of the system, the Contractor shall instruct the Owner's personnel in the proper operation, maintenance, winterizing and reactivation of the system.

3.05 SEASONAL DRAINAGE

- A. General Requirements: Winter drainage shall be accomplished by replacing the water with compressed air. First year winterizing, including Fall blow-out and Spring start-up, to be accomplished by Contractor.

3.06 GUARANTEE

- A. Description: For a period of one year from date of final acceptance of the work performed under this Contract, the Contractor shall promptly furnish and install, without cost to the Owner, any and all parts which prove defective in material and workmanship.

3.07 CLEANING

- A. General Requirements: Contractor shall be responsible for clean up by removing remnants of materials, containers, debris, and other construction materials and equipment used in this work.

END OF SECTION

SECTION 32 92 23

SODDING

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, materials, equipment, and accessories to provide the following Work:
1. Provide fine grading and soil preparation for lawn planting by tilling, removing extraneous matter, and bringing soil to a smooth grade. Areas to receive lawn planting shall have a topsoil cover and be brought to finish grade under Section 31 00 00 of the Specifications.
 2. Provide fertilizer on sodded areas, as specified.
 3. Provide sodding of areas designated on Drawings.
 4. Provide maintenance and establishment of turf beginning immediately after sodding.
 5. Provide restoration to existing lawn areas beyond construction limits which are damaged by work being performed under the Contract. Patching shall include proper preparation of underlying soils and providing new sod.

1.02 QUALITY ASSURANCE

- A. Installer's Qualifications: Final preparation of earth and sodding work shall be performed by a single firm which specializes in landscape work.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Delivery and Storage of Sod: Time delivery of sod to ensure that sod will be placed within 24 hours after stripping. Protect sod against drying and breaking of rolled strips.
- B. Delivery and Storage of Packaged Materials: Deliver packaged materials in containers showing weight, analysis, and name of manufacturer. Protect materials from deterioration during delivery and while stored at site.

PART 2 - PRODUCTS

2.01 GRASS MATERIALS

- A. Sod:
1. Class of Sod: Sod shall be nursery grown, cultured sod planted on cultivated agricultural land and grown specifically for sod purposes. Sod shall have been mowed regularly and carefully and otherwise maintained from planting to harvest to maintain reasonable quality and uniformity.
 2. Composition: Sod shall be composed of not less than 60 percent Kentucky Bluegrass.
 3. Mowing Height: Before stripping, sod shall be mowed uniformly at a height of 1 inch to 2 ½ inches.
 4. Thatch: Sod shall be relatively free of thatch, up to ½-inch allowable (uncompressed).
 5. Diseases, Nematodes, and Insects: Sod shall be reasonably free of diseases, nematodes, and soil-borne insects.
 6. Weeds: Sod shall be free of objectionable grassy and broad leaf weeds.

2.02 MISCELLANEOUS MATERIALS

- A. Fertilizer: Commercial grade, uniform in composition, free-flowing material suitable for application with approved standard equipment. Deliver fertilizer in original, unopened containers, bearing manufacturer's guarantee, analysis, name and trademark. Fertilizer shall have a formula of 17-3-17 (17 percent Nitrogen, 3 percent Phosphate, 17 percent Potash). Fertilizer shall be formulated with a slow release sulphur coated Nitrogen and a slow release sulphur coated Potassium.

PART 3 - EXECUTION

3.01 SODDING SCHEDULE

- A. Sod all areas in accordance with the scheduling / phasing indicated in the Contract Documents. Maintenance, including mowing and watering, shall continue until the latter of the following:
1. A minimum of 1 growing month from the time sod is installed,
 2. Until Project Substantial Completion,
 3. Or turf establishment as determined by the Landscape Architect / Engineer.

3.02 FINE GRADING

- A. Tilling and Fine Grading: Cultivate to bring soil to a uniformly friable condition with a smooth, even, well drained surface. Perform work only during periods when beneficial results are likely to be obtained. Smooth undulations and irregularities in surface prior to sodding. Reconstruct flooded, washed out, and damaged areas and re-established grades as required.
- B. Clean-Up: Prior to sodding, clear surface of debris, roots, and other objects that would interfere with planting or maintenance operations.

3.03 LAYING SOD

- A. General Requirements: Before laying, correct soft spots and inequalities and remove foreign materials. Sod shall be laid with no voids and shall be well tamped or rolled and thoroughly watered. At completion of Work sod shall be true and finished grade, firm and even at all points.
- B. Fertilizing: Apply 250 pounds of specified fertilizer per acre.
- C. Where new sod meets existing turf, existing turf edge shall be cut to allow a consistent, uniform straight edge. Remove topsoil at joint between existing and new as required to allow new sod surface to be flush with existing.

3.04 WATERING

- A. After sod has been laid, thoroughly soak sod immediately following placement and, thereafter, once per day, except when adequate rain may fall to make watering unnecessary. Begin watering sod the first day sod is laid and continue watering sod during sod laying period. Keep sod adequately watered until maintenance dates noted herein. Dry or dead sod will not be accepted.
- B. Procurement of water will be the responsibility of the Contractor. Construct temporary above ground irrigation systems, consisting of piping, heads, valves, etc., as required to adequately water sodded areas. All costs associated with watering, including temporary irrigation systems, shall be borne by the Contractor.

3.05 MOWING

- A. Mowing: Mowing shall be accomplished by the Contractor until the latter of the time frames noted in Paragraph 3.01 of this Section.
1. Frequent mowing of the grass will be critical to turf development. The Contractor shall make weekly inspections of the turf growth to insure that proper mowing is being accomplished.
 2. Cutting Height: When grass blades have reached a height of 3 to 4 inches, mow the new turf to a height of 2 ½-inches. Mowing shall only be done with a sharp mower. Subsequent mowings shall be accomplished so as never to cut more than 1 inch from the grass blade during each cutting. It is anticipated that mowing will be necessary every 5 to 6 days.
 3. Grass shall not be allowed to go into the winter dormant stage with a greater height than 2 ½ inches.

3.06 CLEANING

A. General Requirements:

1. At completion of work, clean up and remove from site surplus materials, roots, stones, and debris and leave area in a clean, neat condition.
2. Remove promptly soil and other extraneous material brought onto paved areas by work operations. Keep paved areas clean at all times.
3. Restore ground areas disturbed as a result of sodding operations to their original condition or to desired new appearance.

3.07 PROTECTION

- #### **A. General Requirements:** Protect lawn work and materials from damage due to landscape operations, operations by other contractors and trades, and trespassers. Maintain protection during installation and maintenance periods. Treat, repair, and replace damaged lawn work.

END OF SECTION 32 92 23

SECTION 32 93 00

TREES AND PLANTS

PART 1 - GENERAL

1.01 SUMMARY

- A. Section includes labor, material, equipment, and accessories to provide the following:
 - 1. Furnish and install plantings indicated on the Drawings and as specified, including shrubs, perennials, planting soil, and staking.
 - 2. Provide shredded hardwood mulch and steel edging at planting beds.

1.02 SUBMITTALS

- A. Plant Inspection Certificate: Contractor shall submit a certificate issued by the State Nursery Inspectors, Department of Agriculture, to Landscape Architect/Engineer upon delivery of stock declaring that planting stock is free from insects and disease.
- B. Submit cut sheets / product data for steel edging.

1.03 DELIVERY, STORAGE AND HANDLING

- A. Packing and Shipping:
 - 1. Each shipment of planting stock and fertilizer shall include sufficient number of copies of itemized shipping lists prepared by vendor to provide 2 copies to Landscape Architect / Engineer for checking and inspecting purposes.
 - 2. Deliver fertilizer in waterproof bags showing weight, chemical analysis and name of manufacturer.

1.04 SEQUENCING AND SCHEDULING

- A. Planting Schedule:
 - 1. New planting shall occur between July 30, 2019 and August 31, 2019.
 - 2. No plant materials shall be installed before finish grading and other construction has been completed in the immediate planting area, unless otherwise directed by Landscape Architect / Engineer.

1.05 WARRANTY

- A. Warranty Period: New plants shall be guaranteed for 1 year after final acceptance, and shall be alive and in satisfactory condition at end of warranty period.
- B. Inspection: At end of warranty period, inspection will be made by Landscape Architect / Engineer, upon written notice by Contractor, at least 5 days before the anticipated date. Plantings provided under this Contract that are dead or in unsatisfactory condition, as determined by Landscape Architect / Engineer, shall be removed from site and replaced as soon as conditions permit during normal planting season.
- C. Replacements: Replacements shall be plantings of same kind and size as specified in plant list. Replacement costs shall be borne by Contractor. These plantings are subject to inspection and rejection by Landscape Architect / Engineer before and after planting.

PART 2 - PRODUCTS

2.01 PLANTING MATERIALS

- A. Plant Identification: Plant material shall be in accordance with nomenclature of "Standardized Plant Names" as adopted by the Joint Committee of Horticulture Nomenclature, latest edition. Size and grading standards shall meet requirements of American Association of Nurserymen, Inc., as published in "American Standard for Nursery Stocks", latest edition. No substitutions of size or grade shall be permitted without written permission of Landscape Architect / Engineer. Each bundle of plants and separate plant shall be properly identified with legible waterproof tags securely fastened to a plant or bundle of plants.
- B. Plant Form: Plant material shall be well formed for that specific species or variety
- C. Plant Health: Plants, including their roots, shall be free from disease, insects or other injurious qualities. Requirements of local, state, and federal laws pertaining to inspection, sale, and shipment of plant materials shall be met. Plants shall show good annual growth. Buds shall be plump and well filled for that species.
- D. Plant Quality: Furnish plants which meet the requirements of Mn/DOT Spec 3861. Plants shall be nursery grown, quality plants with normally shaped uniform heavy branching and healthy well-developed root systems. Plants shall be disease-free and exhibit callusing on wounds present at time of digging.
- E. Plant List: List of plants furnished on Drawings is for the convenience of the Contractor. Contractor shall verify quantity by comparing list with plant locations noted on Drawings.
- F. Inspection: Inspections shall be in accordance with "Inspection Guide for Landscape Planting", published by AASHTO, 1973. Contractor shall be responsible for inspection and approval of plant materials that may be required by state, federal, and other authorities, and he shall secure required permits and certificates. Plants shall be subject to inspection and approval by Landscape Architect / Engineer, at place of growth before digging, or upon delivery, for quality, size, and variety. Approval, however, shall not impair the right of rejection at job site during progress of Work, for size, shape, appearance, condition of balls, roots, latent defects or injuries. Remove rejected plants immediately from job site.
- G. Plant Materials: Procedures for selection and handling of plant materials shall be in accordance with the following:
 - 1. Nursery Stock: Plants shall be nursery grown and shall have been transplanted or root-pruned at least once in the 3-year period immediately preceding the current season of growth. Planting stock shall be well formed, healthy, vigorous, free from plant disease, insects or insect eggs, and have healthy, normal, and unbroken root systems.
 - 2. Plant Sizes: Sizes are dimensions of plants as they stand in the nursery, without straightening branches or leaders. Caliper shall be taken 6 inches above ground level up to a 4-inch caliper size. When sizes, dimensions or other plant characteristics are not indicated on the Drawings or Specifications, the current issue of the "American Standard for Nursery Stock", sponsored by the American Association of Nurserymen, Inc. shall govern.
 - 3. Where Grown: Plants shall have been grown under similar climatic conditions to that existent at the site. All plant material shall be grown and dug for shipment in Climatic Zone III as outlined in "Trees for American Gardens" by Donald Wyman.
 - 4. Shrubs: Shrubs shall have well developed symmetrical tops with typical spread of branches or leads for each particular species or variety.
 - 5. Container Grown Plants: Container grown plants shall have sufficient root growth to hold the earth intact when removed from containers, but shall not be root bound.

2.02 MISCELLANEOUS MATERIALS

- A. Planting Soil: Planting soil shall consist of a mixture of 80% topsoil and 20% peat moss by volume, to which is added one pound of commercial fertilizer per cubic yard for spring planted shrubs. Topsoil shall be a natural fertile, friable loam, containing not less than 20% organic matter with a pH of between 5.4 and 7.0 and meeting the compositional limitations of Mn/DOT Spec 3877. Contractor shall submit both a mechanical and horticulture analysis of soils, along with samples for approval by the Landscape Architect / Engineer.
- B. Peat Moss: Hypnum, sphagnum, or reed-sedge type, free of wood and other extraneous matter. Peat moss shall be furnished air-dried and meet requirements of Mn/DOT Spec. 3880. No humus or peat muck is acceptable.
- C. Commercial Fertilizer: Commercial fertilizer for additional plant application shall be standard formula 10-6-4 (10 percent Nitrogen, 6 percent phosphoric acid and 4 percent potash) and shall contain minor trace elements. Formula shall be in accordance with applicable state fertilizer laws. Fertilizer shall be uniform in composition, dry and free-flowing, and shall be delivered to job site in original, unopened containers, each bearing manufacturer's guaranteed analysis. Fertilizer which becomes caked or damaged shall not be used.
- D. Shredded Hardwood Mulch: Double shredded hardwood mulch shall be used for mulching planting areas.
- E. Water: Contractor shall obtain water from sources as approved by Landscape Architect/Engineer. Provide all means and measures necessary to adequately water all plantings. Construct temporary above ground irrigation systems, consisting of piping, heads, valves, etc., as required adequately water landscape areas. All costs associated with watering, including temporary irrigation systems, shall be borne by the Contractor.
- F. Steel Edger: Sure-loc steel edging or equal.
 - 1. Height: 4"
 - 2. Thickness: 3/16"
 - 3. 6 stakes per section minimum

PART 3 - EXECUTION

3.01 DIGGING AND HANDLING

- A. General Requirements: Precautions customary in good trade practice shall be taken in preparing plants for transplanting, in accordance with American Standard for Nursery Stock. Workmanship that fails to meet the highest standards shall be rejected.
- B. Planting Pits: Pits shall be essentially circular with a diameter 1 foot greater than diameter of the container. Depth of pit shall be enough to accommodate the ball or roots of the plant when the plant is set to finish grade, allowing for 6 inches of prepared, compacted planting soil below roots of plant.
- C. Setting of Plants: Set plant material in the planting pit to proper grade and alignment. Place plants at such a level the natural relationship between original grade at which plant grew and present grade shall be the same or 2" - 3" above finished grade. Set the plants upright, plumb and oriented for desired effect as directed by Landscape Architect/Engineer. Tamp planting soil under and around base of each ball to fill voids, in 6 to 8 inch layers, each thoroughly puddled. Shallow basins or saucers, a little larger than the diameter of the ball, shall be formed around shrubs to hold additional water.
- D. Space herbaceous and ground cover plants in accordance with indicated dimensions.
- E. Pruning: Neatly prune plants after planting in accordance with the best standard practices. Prune each plant to preserve its natural form and character and in a manner appropriate to its particular requirements. Pruning shall be done with clean, sharp tools. Cuts over 1/2-inch in diameter shall be immediately covered with an approved plant paint having an asphaltic base.

3.02 EDGING INSTALLATION

- A. Install edging flush with turf, at manufacturer recommended spacing (approximately 3' on center).

3.03 TEMPORARY STORAGE AND HEELING-IN

- A. General Requirements: When temporary storage or heeling-in is required, Contractor shall provide and prepare a suitable heeling ground or heeling-in nursery conveniently located near the planting site prior to shipment of plant material from the growing nursery or other source. Immediately heel-in or transport plant material to site and plant. Material left out of ground overnight or left with its roots bare to the sun, or otherwise unprotected during transit, unloading, or storage shall be rejected by Landscape Architect/Engineer, if in his judgment, such lack of protection has caused damage to roots of plant or in any other way injured the plant material.

3.04 PLANT ESTABLISHMENT AND MAINTENANCE

- A. Upon completion of the initial planting operations, Contractor shall maintain the work and care for plants installed until he has been relieved of this responsibility, the duration of which shall be known as the plant establishment period. The plant establishment period shall end one year from plant installation or until project substantial completion, whichever is later.
- B. After starting plant operations and until expiration of plant establishment period, Contractor shall keep plants in healthy growing condition, using good horticultural practices performed during growing season.
- C. The plant establishment work shall consist of fertilizing and maintaining adequate soil moisture at all times; repairing, adjusting or replacing as necessary the staking and guying, mulch material, planting soil, rodent protection and other incidental items; applying insecticide spray as necessary; furnishing and installing replacement plants as needed, including new mulch and planting soil; maintaining the plants in an upright position; and removing all weed growth in mulched areas. Contractor shall inspect and maintain the new plantings on a minimum basis of every 15 days or additionally as may become necessary. All cost of plant establishment work shall be at the Contractor's expense, including the costs of any replacement materials required.

3.05 INSPECTION AND ACCEPTANCE

- A. Inspection: Inspection of this Work will be made by the Landscape Architect / Engineer at the conclusion of the plant establishment period upon written notice by the Contractor at least 5 days prior to anticipated date. Condition of plants will be noted and recorded for reference at end of warranty period.
- B. Notice of Deficiencies: After inspection, Contractor will be notified in writing by the Landscape Architect / Engineer of all deficiencies in the Work.
- C. Acceptance by Owner: Planting must be totally complete before acceptance by Owner or starting of warranty period. The warranty period will not begin on any plantings until replacement plantings, identified by the Notice of Deficiencies by the Landscape Architect / Engineer, are installed. Plants will not be considered planted until they are properly staked, mulched, pruned, and watered.

3.06 CLEANING

- A. General Requirements: Collect and remove, from site, excess materials, containers, packaging, branches, trimmings, and other debris left over from planting operations. Restore ground areas disturbed as a result of planting operations to their original condition or to the desired new appearance.

END OF SECTION 32 93 00