

PROJECT MANUAL FOR
**WAYNFLETE LOWER SCHOOL
RENOVATION AND ADDITION
PORTLAND, MAINE**

Volume 2 - Divisions 21 thru 39



ISSUED FOR BID

JANUARY 12, 2017

ARCHITECT

SCOTT SIMONS ARCHITECTS
75 York Street
Portland, ME 04101

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By Construction Manager

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WAYNFLETE LOWER SCHOOL
ADDITION AND RENOVATION

January 12, 2017

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SECTION 211000 - FIRE-SUPPRESSION SPRINKLER SYSTEM

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. The fire protection system shall be an automatic sprinkler system arranged to properly protect the building and shall meet NFPA 13 and Maine State Fire Marshall requirements.
- B. This Section includes fire-suppression sprinklers, piping, and equipment.
- C. The sprinkler entrance in Founders provides sprinkler coverage for the adjacent Sills Gym building. Demolition of the Lower School will interrupt this coverage. Phasing or other provisions such as a temporary fire hose shall be provided to maintain coverage.
- D. If a temporary fire hose is used, provisions shall be made to protect it from freezing.
- E. The Sprinkler Contractor shall place the sprinkler system in service and hand over the sprinkler system to the General Contractor for care and maintenance.
- F. Performance and Design Criteria: Provide products and systems complying with specific performance and design criteria indicated.

1.3 SYSTEM PERFORMANCE REQUIREMENTS

- A. Design sprinklers and obtain approval from authorities having jurisdiction. The design of the automatic sprinkler system shall be complete with all necessary accessories for proper operation.
- B. The system shall be hydraulically calculated in accordance with all provisions of the Contract Documents and any authority having jurisdiction.
- C. The contract documents do not include a fire pump. The city water supply is marginal (see tag below), provide over-sized piping as required to meet required system hydraulics. Contractor shall review the civil plans, the existing site and existing fire flow data. If the contractor or authority with jurisdiction determines that a fire pump is required: Provide in accordance with NFPA 20, "Stationary Pumps for Fire Protection," for fire pumps, drivers, controllers, accessories, and their installation.

PUMP ON _____ OFF _____ LOW PRESSURE ON _____ OFF _____

tyco
SimplexGrinnell

THIS AREA EQUIPPED WITH:

WET SYS. DELUGE VALVE
 DRY SYS. RATE OF RISE VALVE
 X2 Close by stairs ANTI-FREEZE THERMAL CONTROL VALVE
 PRE-ACTION VALVE OTHER TYPE VALVE

VALVE SERIAL NO. 4" 5/6 Riser

	1st	2nd	3rd	4th
STATIC WATER P.S.I.	45	45	46	45
RESIDUAL WATER P.S.I.	41	39	37	38
DID ALARMS OPERATE?	YES	YES	YES	YES
AIR PRESSURE	N/A	N/A	N/A	N/A
AIR PRESSURE TRIP POINT			N/A	N/A
TRIP TIME (SEC.)			N/A	N/A
WATER FLOW TIME (SEC.)	30	26	28	22
LOW POINTS DRAINED	N/A	N/A	N/A	N/A
WATER SUPPLY & VALVE LEFT OPEN	YES	YES	YES	YES

NO. LOW POINTS TO BE DRAINED:

INSPECTION MADE AND WITNESSED BY		
DATE & INSP #	MADE BY	WITNESSED BY
8-6-2015	N.T.A #730	G.R.C
12-21-2015	G.R.C #7	G.R.C
4-19-2016	G.R.C #699	Pat B.
6-13-2016	G.R.C #7	



- D. Design sprinkler piping according to the following and obtain approval from authorities having jurisdiction:
 - 1. Include a 5 percent margin of safety for available water flow and pressure.
 - 2. Include losses through water-service piping, valves, and backflow preventers.

- E. Sprinkler Occupancy Hazard Classifications:
 - 1. Light Hazard:
 - a. Office and Public Areas
 - b. Classrooms

 - 2. Ordinary Hazard, Group 1:
 - a. General Storage Areas
 - b. Rooms with Denlar kitchen hoods
 - c. Innovation Room
 - d. Art Room
 - e. Mechanical Equipment Rooms
 - f. Electrical Equipment Rooms

- F. Minimum Density for Automatic-Sprinkler Piping Design shall be in accordance with NFPA 13. Maximum Protection Area per Sprinkler shall be in accordance with NFPA 13.

1.4 GENERAL REQUIREMENTS

- A. Components and Installation: Capable of producing piping systems with 175-psig minimum working-pressure rating, unless otherwise indicated.

- B. Protect all systems from freezing.

- C. Bundled/Grouped wired in concealed spaces: Non-combustible spaces having 15 or more non-plenum-rated wires grouped together shall be fully sprinklered.

- D. Seismic Performance: If required by the authority with jurisdiction, fire-suppression piping shall be capable of withstanding the effects of earthquake motions determined according to NFPA 13.

- E. Elevators: Provide sprinkler protection in accordance with authority with jurisdiction requirements.

- F. Coordinate fire department connection type and location with local fire department.

- G. The sprinkler contract starts inside the sprinkler valve room with a connection to the water entry. Coordinate with the site contractor.

- H. Contractor shall obtain and pay for required permits.

1.5 SUBMITTALS

- A. Shop Drawings: Submit working plans, prepared according to NFPA 13, and hydraulic calculations with cross reference to applicable drawings, water supply data, and equipment schedule with ratings for the system to the Owner's Representative, Insurance Underwriter, and other authorities having jurisdiction.
- B. Product Data: Catalog sheets, specifications, and installation instructions. Indicate UL or FM approval for each product. Include the following additional information:
 - 1. Pipe and fitting materials and methods of joining for sprinkler piping.
 - 2. Pipe hangers and supports.
 - 3. Piping seismic restraints.
 - 4. Valves, including specialty valves, accessories, and devices.
 - 5. Alarm devices. Include electrical data.
 - 6. Electrical Devices: Complete description of intended use, wiring diagrams, data plate information and, in the case of switching devices, whether normally on or normally off. Include motor test data.
 - 7. Mechanical Devices: Complete description of intended use, including normal operating capacities and working pressures.
 - 8. Enclosures: Dimensions, materials, gages of metals; type of door hinges and locks, and methods of securing the enclosure members to the building construction.
 - 9. Hose Threads: Verify that hose threads on fire department connections match threads on equipment used by the local or servicing fire department.
- C. Design Data: The portions of the sprinkler system not sized on the Contract Drawings shall be sized in accordance with NFPA requirements for Hydraulically Designed Systems. Submit drawings and hydraulic calculations for approval.
- D. Delegated-Design Submittal: In addition to Shop Drawings, Product Data, and other required submittals, submit three copies of a statement, signed and sealed by the responsible sprinkler system design professional. Indicate that products and systems comply with performance and design criteria in the Contract Documents.
 - 1. Certification: Submit Contractor's NICET certification and number or PE license number.
- E. Field Test Reports and Certificates: Indicate and interpret test results for compliance with performance requirements and as described in NFPA 13. Include "Contractor's Material and Test Certificate for Aboveground Piping" and "Contractor's Material and Test Certificate for Underground Piping."
- F. Maintenance Data: For each type of sprinkler specialty to include in maintenance manuals specified in Division 1.

1.6 QUALITY ASSURANCE

A. Sprinkler Contractor

1. Installer Qualifications: An experienced installer who has designed and installed fire-suppression piping similar to that indicated for this Project and obtained design approval and inspection approval from authorities having jurisdiction.
2. Engineering Responsibility: Preparation of working plans, calculations, and field test reports by a qualified sprinkler designer. Base calculations on results of fire hydrant flow test. Sprinkler designer shall be legally qualified and licensed to practice in jurisdiction where Project is located and who is experienced in providing engineering services of the kind indicated. Engineering services are defined as those performed for installations of fire-suppression piping that are similar to those indicated for this Project in material, design, and extent.
3. Contractor shall be a licensed fire sprinkler contractor.

B. Manufacturer Qualifications:

1. Firms whose equipment, specialties, and accessories are listed by product name and manufacturer in UL's "Fire Protection Equipment Directory" and FM's "Fire Protection Approval Guide" and that comply with other requirements indicated.
2. Sprinkler Components: Listing/approval stamp, label, or other marking by a testing agency acceptable to authorities having jurisdiction.
3. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction.
4. Factory Mutual Engineering Corporation (FM) Approval Guide

1.7 COORDINATION

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

1.8 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. Sprinkler Cabinets: Finished, wall-mounting steel cabinet and hinged cover, with space for a minimum of six spare sprinklers plus sprinkler wrench. Include the number of sprinklers required by NFPA 13 and wrench for sprinklers. Include separate cabinet with sprinklers and wrench for each type of sprinkler on Project.

PART 2 - PRODUCTS

2.1 PIPING

- A. Pipe and fittings shall conform to the requirements of NFPA 13. Pipe shall be listed by UL and be FM approved, and installed per its listing and approval.

2.2 Sprinkler piping shall be black steel schedule 40, 2 inch and smaller, and thinwall 2 ½ inch and larger. C factor 120.

- A. System piping shall be substantially supported to the building structure. The installation of hangers and supports shall adhere to the requirements set forth in N.F.P.A. 13. Materials used in the installation or construction of hangers and supports shall be listed and approved for such application.

2.3 JOINING MATERIALS

- A. Furnish in accordance with NFPA 13.
- B. Transition Couplings: AWWA C219, sleeve type, or other manufactured fitting the same size as, with pressure rating at least equal to, and with ends compatible with piping to be joined.

2.4 SPRINKLERS

- A. Fire sprinklers shall be of one manufacturer throughout the building. No mixing of sprinkler brands shall be permitted. Sprinklers shall be of all brass frame construction with a quick response frangible bulb type fusible element.
- B. Automatic Sprinklers: With heat-responsive element complying with the following:
 - 1. UL 199, for applications except residential.
 - 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.
 - 1. Kiln Room: High temperature
- D. Provide quick response sprinklers.
- E. Sprinkler Escutcheons: Materials, types, and finishes of sprinklers. Escutcheons for concealed, flush, and recessed-type sprinklers are specified with sprinklers.
- F. Sprinkler Guards: Wire-cage type, including fastening device for attaching to sprinkler.

2.5 SPRINKLER SPECIALTY FITTINGS

- A. Sprinkler specialty fittings shall be UL listed or FMG approved, with 175-psig minimum working-pressure rating, and made of materials compatible with piping.
- B. Sprinkler Drain and Alarm Test Fittings: Cast- or ductile-iron body; with threaded or locking-lug inlet and outlet, test valve, and orifice and sight glass.
- C. Sprinkler Branch-Line Test Fittings: Brass body with threaded inlet, capped drain outlet, and threaded outlet for sprinkler.
- D. Sprinkler Inspector's Test Fitting: Cast- or ductile-iron housing with threaded inlet and drain outlet and sight glass.
- E. Drop-Nipple Fittings: UL 1474, adjustable with threaded inlet and outlet, and seals.
- F. Dry-Pipe-System Fittings: UL listed for dry-pipe service.

2.6 VALVES

- A. Valves shall be UL listed and FMG approved
- B. System Control Valve: The wet system control valve shall be a listed indicating type valve. Control valve shall be UL Listed and Factory Mutual Approved for fire protection installations. System control valve shall be rated for normal system pressure but in no case less than 175 PSI.

2.7 WATERFLOW ALARMS

- A. Flow of water equal to or greater than that from a single automatic sprinkler (smallest orifice in system) shall result in an audible alarm on the premises within 5 minutes after such flow begins and until such flow stops.
- B. The alarm apparatus shall consist of a listed alarm check valve or other listed waterflow-indicating device with the necessary attachments to give an alarm.
- C. The apparatus for a dry pipe system shall consist of alarm attachments to the dry pipe valve.

2.8 FIRE DEPARTMENT CONNECTION

- A. The existing FD connection can be re-used in acceptable to the PFD.
- B. If replacement is requires, provide a new fire department connection in accordance with N.F.P.A. 13, Standard for Installation of Sprinkler Systems. Fire department connection shall be constructed of a brass body with an integral clapper assembly to separate flow between inlets. Fire department connection shall be installed in an area accessible for the first response unit. Fire department connection shall be UL Listed and Factory Mutual Approved for fire protection use.

2.9 BACKFLOW PREVENTION

- A. Provide in accordance with manufacturers recommendations, re-use existing if hydraulically feasible. See photo below; existing entrance for reference:



- B. Provide in accordance with NFPA 13. Provide a permanent means of testing the backflow preventer in accordance with NFPA 13 requirements.
- C. Backflow preventer types; provide as required by the Portland Water District.
1. Double check: Watts Series 709DCDA or 774DCDA detector check fire service applications; or approved equal.
 2. RPZ: Watts Series 909RPDA or 994RPDA, detector check fire service applications; or approved equal. Provide proper drainage.

PART 3 - EXECUTION

3.1 EARTHWORK

- A. Refer to Division 31 for excavating, trenching, and backfilling.

3.2 FIRE-SUPPRESSION DEMOLITION

- A. Disconnect, demolish, and remove fire-suppression systems, equipment, and components as required.

3.3 PREPARATION

- A. The nature of the work requires coordination with other trades. Shop fabrication shall be done at the Contractor's risk. Relocation of piping and components to avoid obstructions may be necessary. Relocation, if required, shall be done at the Contractor's expense. The installation shall be performed in a workmanlike manner as determined by the Owner's Representative and in accordance with the Contract Documents, manufacturer's printed installation instructions, and submitted and Owner's Representative reviewed drawings.
- B. Existing Sprinkler System Shutdown:
 - 1. Follow NFPA 13 recommendations.
 - 2. Before shutting down the sprinkler system to perform the Work, notify the Owner's Representative in writing, and the local fire department that the system is to be shut down temporarily. Give schedule which states date and time of proposed shut down and the approximate length of time that the system will be out of service. Request instructions for precautions that should be taken during the shut down period.
 - 3. Do not shut down the system until schedule is approved by the Owner's Representative.
 - 4. Return the existing system to pre-shutdown operation immediately after the Work has been completed. Give written notice to the Director's Representative that the system has been returned to pre-shutdown operation.

3.4 SPRINKLER APPLICATIONS

- A. General: Use sprinklers according to the following applications:
 - 1. Rooms/spaces without Ceilings: Upright sprinklers.
 - 2. All occupied rooms with Finished Ceilings: Recessed Pendent.
 - 3. Provide sprinkler guards for heads in mechanical and storage spaces, less than 8 ft. above finished floor subject to mechanical damage.
 - 4. Low ceilings (under 8 feet): Concealed
 - 5. Attics: attic sprinklers.
 - 6. Wall Mounting: Sidewall sprinklers.
 - 7. Spaces Subject to Freezing: Upright; pendent, dry-type; and sidewall, dry-type sprinklers.
 - 8. Special Applications: Use extended-coverage, flow-control, and quick-response sprinklers where indicated.
- B. Finishes
 - a. Unfinished spaces not exposed to view: rough bronze.
 - b. Recessed Sprinklers: White
 - c. Wood ceiling: color as selected by Architect.
 - d. Provide escutcheons with matching color for finished spaces.

3.5 SYSTEM INSTALLATIONS

- A. Earthquake Protection: Install piping according to NFPA 13 to protect from earthquake damage.
- B. Water supply control valves shall be electrically supervised and mechanically locked for proper position. Water flow and supervisory circuits shall be in accordance with the requirements of electrical specifications. Electric connections to sprinkler system shall be by Division 26. Furnish wiring diagrams for all equipment.
- C. Fire Department Connection: Coordinate with local fire department.
- D. A sprinkler head wrench of each style and model installed shall be provided to the owner at the completion of the project. A representative sampling of each sprinkler head style and model shall be provided to the owner and housed in a sprinkler head cabinet at or near the sprinkler riser. The number of sprinkler heads provided to the owner shall be in accordance with NFPA 13.
- E. Install "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13

3.6 SPRINKLER INSTALLATION

- A. Install sprinklers in suspended ceiling in center of all ceiling tiles.
- B. Do not install pendent or sidewall, wet-type sprinklers in areas subject to freezing. Use dry-type sprinklers with water supply from heated space.
- C. Install sprinkler piping with drains for complete system drainage.
- D. Hangers and Supports: Comply with NFPA 13 for hanger materials.

3.7 LABELING AND IDENTIFICATION

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

3.8 FIELD QUALITY CONTROL

- A. Flush, test, and inspect sprinkler piping according to NFPA 13, "System Acceptance" Chapter.
- B. Verify that specialty valves, trim, fittings, controls, and accessories are installed and operate correctly.
- C. Verify that specified tests of piping are complete.
- D. Verify that damaged sprinklers and sprinklers with paint or coating not specified are replaced with new, correct type.

- E. Verify that sprinklers are correct types, have correct finishes and temperature ratings, and have guards as required for each application.
- F. Verify that potable-water supplies have correct types of backflow preventers.
- G. Verify that fire department connections have same type compatible with local fire department equipment.
- H. Replace piping system components that do not pass test procedures and retest to demonstrate compliance. Repeat procedure until satisfactory results are obtained.
- I. Fill wet-pipe sprinkler piping with water.
- J. Energize circuits to electrical equipment and devices.
- K. Coordinate with fire alarm tests. Operate as required.

3.9 CLEANING

- A. Clean dirt and debris from sprinklers.
- B. Remove and replace sprinklers having paint other than factory finish.

3.10 PAINTING

- A. Painting of fire-suppression systems, equipment, and components is specified in Division 9.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.11 PROTECTION

- A. Protect sprinklers from damage until Substantial Completion.

END OF SECTION 210000

SECTION 220500 – COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230500, common work results for plumbing are included in this section.

END OF SECTION 220500

SECTION 220516 – BRAIDED EXPANSION LOOPS AND FITTINGS FOR PLUMBING PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230516, braided expansion loops and fittings for plumbing piping are specified in this Section.

END OF SECTION 220516

SECTION 220519 – THERMOMETERS AND PRESSURE GAUGES FOR PLUMBING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230519 for thermometer and pressure gauges for plumbing.

END OF SECTION 220519

SECTION 220529 - HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230529 for hangers and supports for plumbing piping and equipment.

END OF SECTION 220529

SECTION 220553 – IDENTIFICATION FOR PLUMBING PIPING & EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230553 for identification for plumbing piping and equipment.

END OF SECTION 220553

SECTION 220700 - PLUMBING INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Refer to Section 230700 for plumbing insulation.

END OF SECTION 220700

SECTION 221116 - DOMESTIC WATER PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 22 Section "Common Work Results for Plumbing"
 - 2. Division 22 Section "Hangers and Supports"
 - 3. Division 22 Section "Plumbing Specialties" for water distribution piping specialties.

1.2 SUMMARY

- A. This Section includes domestic water piping from locations indicated to fixtures and equipment inside the building.
- B. Drawings show the general layout of piping and accessories but do not show all required fittings and offsets that may be necessary to connect piping to equipment and to coordinate with other trades. Fabricate piping based on field measurements. Provide all necessary fittings and offsets.
- C. General layout shown, provide piping to fixtures as required by the Maine Plumbing Code. A licensed master plumber shall perform or supervise the work and provide layouts, piping, and fittings as required by code.

1.3 SUBMITTALS

- A. Product Data: For the following products:
 - 1. Specialty valves.
 - 2. Transition fittings.
 - 3. Dielectric fittings.
 - 4. Flexible connectors.
 - 5. Escutcheons.
 - 6. Sleeves and sleeve seals.
 - 7. Water penetration systems.
- B. LEED Submittal: Product Data for Credit EQ 4.1: For solvent cements and adhesive primers, including printed statement of VOC content.
- C. Field quality-control reports.

1.4 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with the UPC 2009 edition, subject to the exclusions and amendments set forth by the Maine Plumbers Examining Board.
- C. Qualify brazing processes for copper and copper alloy pipe and tube according to ANSI/AWS C3.4.
- D. Comply with NFPA 24, "Installation of Private Fire Service Mains and Their Appurtenances," and NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for combined fire-protection and domestic water service piping to building.
- E. Comply with NSF 61, "Drinking Water System Components-Health Effects; Sections 1 through 9," for potable domestic water piping and components.
- F. Water line components shall be lead-free.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

- A. Refer to Part 3 "Piping Applications" Article for applications of pipe, tube, fitting, and joining materials.
- B. Transition Couplings for Aboveground Pressure Piping: Coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.
- C. Transition Couplings for Underground Pressure Piping: AWWA C219, metal, sleeve-type coupling or other manufactured fitting the same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.2 DUCTILE-IRON PIPING

- A. From inside face of exterior wall to a distance of approximately 5 feet outside of building (coordinate with Division 2). Provide flanged and anchored connection to interior piping. Materials shall be approved by the local water utility.
- B. Ductile iron pipe shall meet requirements of AWWA Standard C-151 (latest revision) and be cement lined and seal coated to meet AWWA Standard C-104 (latest revision). Joints shall meet requirements of AWWA C-111 (latest revision). Interior seal coated, bituminous paint oil cut, emulsion not acceptable, thickness minimum of 2 mils dry film thickness. Exterior bituminous coated with minimum of 2 mils dry film thickness. Class 52 wall thickness, 4-inch diameter through 12-inch diameter inclusive. Mechanical joint pipe to be furnished with gland, gaskets and Cor-Ten bolts and nuts.

- C. Ductile Iron Fittings Including Bends, Reducers, Off-Sets, Tees And Sleeves: Material shall be ASTM A536 latest, grade 70-50-05, in accordance with AWWA C153 (latest revision). Fittings shall be cement lined AWWA C104 (latest revision) or fusion bonded epoxy coated with a 5 mil nominal thickness per AWWA C550 and C116. Interior seal coated AWWA C104 with minimum of 4 mils dry film thickness. Exterior bituminous coated, 4 mils minimum dry film thickness or fusion bonded epoxy coated with a 5 mil nominal thickness per AWWA C550 and C116. Mechanical joint with accessories furnished: D.I. glands, gaskets, Cor-Ten T-bolts and nuts. Pressure Rating: Class 350 pressure rating in accordance with AWWA C153.

2.3 COPPER TUBING

- A. Soft Copper Tube: ASTM B 88, Types K and L, water tube, annealed temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
- B. Hard Copper Tube: ASTM B 88, Types L and M, water tube, drawn temper.
 - 1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
 - 2. Bronze Flanges: ASME B16.24, Class 150, with solder-joint end. Furnish Class 300 flanges if required to match piping.
 - 3. Copper Unions: MSS SP-123, cast-copper-alloy, hexagonal-stock body, with ball-and-socket, metal-to-metal seating surfaces and solder-joint or threaded ends.
 - 4. Copper, Grooved-End Fittings: ASTM B 75 copper tube or ASTM B 584 bronze castings.
 - 5. Copper-Tubing, Keyed Couplings: Copper-tube dimensions and design similar to AWWA C606. Include ferrous housing sections, gasket suitable for hot water, and bolts and nuts.
- C. Mechanically formed copper or steel tee connections are not acceptable.

2.4 AQUATHERM PIPING

- A. Pipe shall be Aquatherm Greenpipe, or Greenpipe Faser, available from Aquatherm, Inc. Domestic hot water shall contain a fiber layer (faser) to restrict thermal expansion. As proof of Aquatherm's demanding quality standards, all properly installed Aquatherm pipe systems carry a 10-year warranty for property damage liability coverage of up to \$15 million per damage event. This warranty covers the pipes, the fittings, and any incidental damage caused by material failure. The policy also provides an additional \$15 million for personal injury.
- B. Pipe shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The pipe shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All pipe shall be made in a three layer extrusion process. Domestic hot

water shall contain a fiber layer (faser) to restrict thermal expansion. All pipe shall comply with the rated pressure requirements of ASTM F 2389. All pipe shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.

- C. Fittings shall be manufactured from a PP-R resin meeting the short-term properties and long-term strength requirements of ASTM F 2389. The fittings shall contain no rework or recycled materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material. All fittings shall be certified by NSF International as complying with NSF 14, NSF 61, and ASTM F 2389 or CSA B137.11.
- D. Where indicated on the drawings that a Plenum-rated Piping System is needed, then the pipe shall be pre-insulated or field insulated, and when tested with standard un-insulated fittings per CAN/ULC-S102.2-03 or ASTM E84, the system consisting of wrapped or coated pipe and bare fittings shall have a Flame Spread Classification of less than 25 and Smoke Development rating of less than 50.
- E. Where indicated on the drawings that the pipe will be exposed to direct UV light for more than 30 days, it shall be provided with a Factory applied, UV-resistant coating or alternative UV protection.
- F. If heat tracing is specified for the piping, it should be installed on the pipe interior or exterior, and it must be suitable for use with plastic piping and self-regulating to ensure the surface temperature of the pipe and fittings will not exceed 70°C (158°F).
- G. Where up to 1 inch of standard insulation is indicated in Section 220700, a factory installed, thermal (radiant, conductive, and convective) and vapor barrier insulation shall be provided. Where more than 1 inch of standard insulation is indicated in Section 220700, additional overlap of factory installed, thermal (radiant, conductive, and convective) and vapor barrier insulation shall be provided to ensure equivalent thermal resistance. The thick wall, self-insulating fittings do not require an additional vapor barrier for the piping system to meet this performance level. The thermal barrier is UV resistant, CFC-free, non-porous, non-fibrous, and resist mold growth. The pipe with the integral thermal barrier with standard unprotected fittings shall meet the ASTM E84 and the CAN/ULC S102.2 requirements for a Flame Spread Rating of 25 and Smoke Development rating of 50.
- H. Manufacturer shall warrantee pipe and fittings for 10 years to be free of defects in materials or workmanship. Warranty shall cover labor and material costs of repairing and/or replacing defective materials and repairing any incidental damage caused by failure of the piping system do to defects in materials or workmanship.

2.5 PEX DOMESTIC WATER PIPING

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following. PEX-a manufacturer system warranty shall cover tubing for a duration of 30 years from the date of installation.
 - 1. Uponor Wirsbo hePEX (Basis of Design)
 - 2. Rehau
 - 3. Mr. PEX

B. Code approved:

1. International Code Conference (ICC) – International Plumbing Code (IPC)
2. Uniform Plumbing Code (UPC)
3. Comply with ANSI/NSF Standard 14.
4. Comply with ANSI/NSF Standard 61
5. Certification of flame spread/smoke development rating of 25/50 in accordance with ASTM E84 provided the installation meets one of the following requirements.
 - a. Tubing spacing is a minimum of 18 inches apart for the following sizes: 3/8” through 3/4”.
 - b. Tubing is wrapped with 1/2” fiberglass insulation with a flame spread of not more than 20 and a smoke-developed rating of not more than 30 and a nominal density of 4.0 to 4.5 pcf. Tubing can run with three tubes separated by zero inches and then 18 inches between the next group of three tubes for the following sizes: 3/8” through 2”.

C. Tubing

1. Material: Crosslinked polyethylene (PEX) manufactured by PEX-a or Engel method
2. Type: Wirsbo AQUAPEX
3. Material Standard: Manufactured in accordance with ASTM F876 and ASTM F877 and tested for compliance by an independent third party agency
4. Standard grade hydrostatic design and pressure ratings from PPI
5. Fire-rated assembly listings in accordance with ANSI/UL 263
 - a. UL Design No. L557 — 1-hour wood frame floor/ceiling assemblies
 - b. UL Design No. K913 — 2-hour concrete floor/ceiling assemblies
 - c. UL Design No. U372 — 1-hour wood stud/gypsum wallboard wall assemblies
 - d. UL Design No. V444 — 1-hour steel stud/gypsum wallboard wall assemblies
6. Minimum Bend Radius (cold bending): No less than six times the outside diameter. Use a bend support as supplied by the PEX tubing manufacturer for tubing with a bend radius less than stated.
7. Nominal Inside Diameter: Provide tubing with nominal inside diameter, in accordance with ASTM F876 as indicated.

D. Fittings

1. Material: Fitting assembly is manufactured from material listed in paragraph 5.1 of ASTM F1960.
2. Material Standard: Comply with ASTM F1960.
3. Type: PEX-a cold expansion fitting. Assembly consists of the appropriate ProPEX insert with a corresponding ProPEX Ring.

E. Manifolds

1. Material
 - a. Type L copper body with UNS 3600 series brass ProPEX outlet connections
 - b. Engineered Plastic (EP) body with ProPEX outlet connections

2. Manifold Type
 - a. Uponor ProPEX 1" Copper Manifold
 - b. Uponor engineered plastic (EP) Manifold
3. All manifolds manufactured with the appropriate-sized ProPEX fittings on the manifold supply inlets.

F. Accessories

1. Angle stops and straight stops that are compatible with PEX tubing are supplied by the PEX tubing manufacturer.
2. Bend supports designed for maintaining tight radius bends are supplied by the PEX tubing manufacturer.
3. ProPEX expander tool to install the ASTM F1960 compatible fittings are supplied by the PEX tubing manufacturer.
4. The tubing manufacturer provides clips and/or PEX rails for supporting tubing runs.
5. All horizontal tubing hangers and riser clamps are epoxy-coated material.

2.6 VALVES

A. Ball Valves

1. The valve body and adapter shall be constructed using Lead Free brass. Lead Free ball valves shall comply with state codes and standards, where applicable, requiring reduced lead content.
2. ½" to 2" ball valves: 2-piece full port Lead Free brass ball valves: The valve must have a blowout proof pressure retaining 316 stainless steel stem, 316 stainless steel ball, virgin PTFE seats, seals, stem packing seal and thrust washer. Valve must have adjustable packing. Valves with O-ring stem seal only are not acceptable. Pressure rating no less than 600psi WOG non-shock, 150psi WSP. Valve shall be manufactured to the MSS-SP-110 standard and shall be a Watts Series LFB6080 (threaded) or LFB6081 (solder).
3. Valve sizes 2-1/2" to 4" threaded, shall be rated to 400psi WOG non-shock and 125psi WSP. Valve sizes 2-1/2" to 3" solder shall be rated to 400psi WOG non-shock and 125psi WSP. Valve shall be a Watts Series LFFBV-3C (threaded) or LFFBVS-3C (solder).
4. Provide locking handle where indicated.
5. Aquatherm Greenpipe: Valves shall be manufactured in accordance with the manufacturer's specifications and shall comply with the performance requirements of ASTM F 2389 or CSA B137.11. The valves shall contain no rework or recycled thermoplastic materials except that generated in the manufacturer's own plant from resin of the same specification from the same raw material.
6. Comply with MSS SP-110.

B. Swing check valves:

1. Construct pressure containing parts of Valves as follows: Bronze Valves: 125 or 150 psi: ANSI/ASTM B 62; Iron Body Valves: ANSI/ASTM A-126, Grade B.
2. Check valves shall be lead free.

3. Comply with the following standards for design, workmanship, material and testing:
Bronze Valves: MSS SP – 80; Cast Iron Valves: MSS SP – 71
4. Construct valves of pressure casting free of any impregnating materials. Construct disc and hanger as one piece. Support hanger pins by removable side plug.
5. Threaded Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc.
6. Soldered Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc.
7. Flanged Ends 2-1/2" and Larger: Class 125, iron body, bronze mounted, horizontal swing, cast-iron disc.

C. Refer to Division 22 Section "Plumbing Specialties" for balancing and drain valves.

PART 3 - EXECUTION

3.1 EXCAVATION

A. Refer to Division 31 for excavating, trenching, and backfilling.

3.2 PIPING APPLICATIONS

A. Transition and special fittings with pressure ratings at least equal to piping rating may be used in applications below, unless otherwise indicated.

B. Flanges may be used on aboveground piping, unless otherwise indicated.

C. Mechanically formed tee-branch outlets and brazed joints shall not be used.

D. Underground Domestic Water Service Piping: Use any of the following piping materials for each size range:

1. NPS 2 and Smaller: PE pipe; insert fittings for PE pipe; and banded or crimp-ring joints.
2. NPS 2-1/2 and larger: ductile-iron pipe; mechanical- or push-on-joint, ductile-iron fittings; and restrained, gasketed joints.

E. Aboveground Domestic Water or Non-Potable Water Piping: Use the following piping materials for each size range:

1. NPS 2 and Smaller: Type L copper, PEX, or Aquatherm.
2. NPS 2.5 to 3: Type L copper, or Aquatherm.

3.3 VALVE APPLICATIONS

A. Drawings indicate valve types to be used. Where specific valve types are not indicated, the following requirements apply:

1. Shutoff Duty: Use bronze ball valves for piping NPS 3 and smaller. Use cast-iron butterfly valves with flanged or grooved ends for piping NPS 4 and larger. Aquatherm: ball valves.

2. Throttling Duty: Use bronze ball or globe valves for piping NPS 3 and smaller. Use cast-iron butterfly valves with flanged ends for piping NPS 4 and larger.
3. Hot-Water-Piping, Balancing Duty: Calibrated, memory-stop balancing valves.
4. Drain Duty: Hose-end drain valves.

3.4 VALVE INSTALLATION

- A. Install sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment.
- B. Install shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops.
- C. Install hose end drain valves for equipment, at base of each water riser, at low points in horizontal piping, and where required to drain water piping.
- 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. Refer to Division 22 Section "Plumbing Specialties" for calibrated balancing valves.

3.5 PIPING INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping installation.
- B. Extend domestic water service piping to exterior water distribution piping in sizes and locations indicated.
- C. Install underground ductile-iron piping according to AWWA C600 and NFPA 24.
- D. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Common Work Results for Plumbing" for wall penetration systems.
- E. Install shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside building at each domestic water service.
- F. Provide dielectric fittings as specified in Section 230500.
- G. Install water-pressure regulators downstream from shutoff valves. Refer to Division 22 Section "Plumbing Specialties" for water-pressure regulators.
- H. Install aboveground domestic water piping level and plumb.
- I. Provide firestopping as per Section 230500 "Common Work Results for HVAC".
- J. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.

- K. Perform the following steps 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. Remove plugs used during testing of piping and plugs used for temporary sealing of piping during installation.
 - 5. Remove and clean strainer screens. Close drain valves and replace drain plugs.
- L. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.
- M. Check plumbing specialties and verify proper settings, adjustments, and operation.
- N. Water-Pressure Regulator: Set outlet pressure at 80 psig maximum.

3.6 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
- B. Soldered Joints: Use ASTM B 813, water-flushable, lead-free flux; ASTM B 32, lead-free-alloy solder; and ASTM B 828 procedure, unless otherwise indicated.
- C. Fusion Welded Aquatherm Joints:
 - 1. Install fittings and joints using socket-fusion, electrofusion, or butt-fusion as applicable for the fitting type. All fusion-well joints shall be made in accordance with the pipe and fitting manufacturer's specifications and product standards.
 - 2. Fusion-weld tooling, welding machines, and electrofusion devices shall be as specified by the pipe and fittings manufacturer.
 - 3. Prior to joining, the pipe and fittings shall be prepared in accordance with F 2389 and the manufacturer's specifications.
 - 4. Joint preparation, setting and alignment, fusion process, cooling times and working pressure shall be in accordance with the pipe and fitting manufacturer's specifications.

3.7 PEX PIPING INSTALLATION

- A. Install PEX tubing in accordance with the tubing manufacturer's recommendations and as indicated in the installation handbook.
- B. Do not install PEX tubing within 6 inches of gas appliance vents or within 12 inches of any recessed light fixtures.
- C. Do not solder within 18 inches of PEX tubing in the same waterline. Make sweat connections prior to making PEX connections.
- D. Do not expose PEX tubing to direct sunlight for more than 30 days.

- E. Ensure no glues, solvents, sealants or chemicals come in contact with the tubing without prior permission from the tubing manufacturer.
- F. Use grommets or sleeves at the penetration for PEX tubing passing through metal studs.
- G. Protect PEX tubing with sleeves where abrasion may occur.
- H. Use strike protectors where PEX tubing penetrates a stud or joist and has the potential for being struck with a screw or nail.
- I. Use tubing manufacturer-supplied bend supports where bends are less than six times the outside tubing diameter.
- J. PEX-a Piping Hanger Spacing: Install hangers for PEX-a piping with the following maximum spacing:
 - 1. 1 inch and below: Maximum span, 32 inches.
 - 2. 1¼ inch and above: Maximum span, 48 inches.
 - 3. PEX-a Piping Hanger Spacing with PEX-a Support Channel: Install hangers for PEX-a piping with horizontal support channel in accordance with local jurisdiction and manufacturer's recommendations, with the following maximum spacing: Maximum span, 8 feet.
- K. PEX-a Riser Supports: Install CTS riser clamps at the base of each floor and at the top of every other floor. Install mid-story guides between each floor.
- L. Pipe Joint Construction: PEX-a Connections: Install per manufacturer's recommendations. Use manufacturer-recommended cold-expansion tool for F1960 connections.
- M. Pressurize PEX tubing with air in accordance with applicable codes or in the absence of applicable codes to a pressure of 25 psi above normal working pressure of the system.
- N. Comply with safety precautions when pressure testing, including use of compressed air, where applicable. Do not use water to pressurize the system if ambient air temperature has the possibility of dropping below 32°F.
- O. Through-penetration Firestop
 - 1. Ensure compliance of one- and two-hour rated through penetration assemblies in accordance with ASTM E814.
 - 2. A list of firestop manufacturers that list PEX tubing with their firestop systems is available from the PEX tubing manufacturer.
- P. Related Products Installation: Refer to other sections listed in Related Sections paragraph herein for related products installation.

3.8 FLEXIBLE CONNECTOR INSTALLATION

- A. Install flexible connectors in suction and discharge piping connections to each domestic water pump. Domestic water temperature maintenance pumps do not require flexible connectors.

3.9 HANGER AND SUPPORT INSTALLATION

- A. Hanger, support, and anchor devices are specified in Division 22 Section "Hangers and Supports."

3.10 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 service piping with shutoff valve, and extend and connect to the equipment and fixtures as shown on the plans.
- E. Connect water piping in sizes indicated, but not smaller than sizes of unit connections.
- F. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.11 FIELD QUALITY CONTROL

- A. Follow local code requirements.
- B. Inspect domestic water piping as follows:
 - 1. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
 - 2. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction:
 - a. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - b. Final Inspection: Arrange for final inspection by 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 test or inspection, make required corrections and arrange for reinspection.
 - 4. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- C. Test domestic water piping as follows:
 - 1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.

2. Leave uncovered and unconcealed new, altered, extended, or replaced domestic water piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Cap and subject piping to static water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 4. Repair leaks and defects with new materials and retest piping or portion thereof until satisfactory results are obtained.
 5. Prepare reports for tests and required corrective action.
- D. Adjust balancing valves in hot-water-circulation return piping to provide adequate flow. Manually adjust ball-type balancing valves in hot-water-circulation return piping to provide flow of hot water in each branch. Adjust calibrated balancing valves to flows indicated.

3.12 CLEANING

- A. Clean interior of domestic water piping system. Remove dirt and debris as work progresses. Clean and disinfect domestic water piping per code requirements or administrative authority requirements. Sample procedure as indicated:
1. Purge new piping and parts of existing domestic water piping that have been altered, extended, or repaired before using.
 2. Use purging and disinfecting procedures prescribed by authorities having jurisdiction or, if methods are not prescribed, procedures described in either AWWA C651 or AWWA C652 or as described below:
 - a. Flush piping system with clean, potable water until dirty water does not appear at outlets.
 - b. Fill and isolate system according to either of the following: 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. 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.

END OF SECTION 221116

SECTION 221119 - PLUMBING SPECIALTIES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 22 Section "Common Work Results for Plumbing"

1.2 SUMMARY

- A. This Section includes plumbing specialties.

1.3 PERFORMANCE REQUIREMENTS

- A. Provide components and installation capable of producing piping systems with following minimum working-pressure ratings, unless otherwise indicated:
 - 1. Domestic Water Piping: 125 psig.
 - 2. Sanitary Waste and Vent Piping: 10-foot head of water.
 - 3. Storm Drainage Piping: 10-foot head of water.

1.4 ACTION SUBMITTALS

- A. Product Data: Include rated capacities and shipping, installed, and operating weights. Indicate materials, finishes, dimensions, required clearances, and methods of assembly of components; and piping and wiring connections.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data
- B. Field test reports.

1.6 QUALITY ASSURANCE

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

- B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- C. Comply with local building and plumbing codes.
- D. ASME Compliance: Comply with ASME B31.9, "Building Services Piping," for piping materials and installation.
- E. Water line components shall be lead-free.
- F. NSF Compliance: Comply with NSF 14, "Plastics Piping Components and Related Materials," for plastic domestic water piping components. Include marking "NSF-PW" on plastic potable-water piping and "NSF-DWV" on plastic drain, waste, and vent piping. Comply with NSF 61, "Drinking Water System Components--Health Effects, Sections 1 through 9," for potable domestic water plumbing specialties.

PART 2 - PRODUCTS

2.1 ACCESS PANELS

- A. Provide access panels to concealed valves, cleanouts, and components that require service access. All components shall have proper access in accordance with manufactures' recommendations. Refer to Section 220500.

2.2 BACKFLOW PREVENTERS

- A. Manufacturers:
 - 1. Ames Co., Inc.
 - 2. Cla-Val Co.
 - 3. Apollo
 - 4. CMB Industries, Inc.; Febco Backflow Preventers.
 - 5. Conbraco Industries, Inc.
 - 6. Watts Industries, Inc.; Water Products Div.
 - 7. Zurn Industries, Inc.; Wilkins Div.
- B. General: ASSE standard, backflow preventers.
 - 1. NPS 2 and Smaller: Bronze body with threaded ends.
 - 2. NPS 2-1/2 and Larger: Bronze, cast-iron, steel, or stainless-steel body with flanged ends.
 - 3. Interior Components: Corrosion-resistant materials. AWWA C550 or FDA-approved
 - 4. Exterior Finish: manufacturer's standard.
 - 5. Strainer: On inlet, lead-free.
 - 6. Lead free.
 - 7. Backflow preventers for hot water over 110F shall be a listed type for that application.
- C. Atmospheric-Type Vacuum Breakers: ASSE 1001, with floating disc and atmospheric vent.

- D. Hose-Connection Vacuum Breakers: Watts Series 8FR; ASSE 1011, nickel plated, with non-removable and manual drain features, and ASME B1.20.7, garden-hose threads on outlet. Units attached to rough-bronze-finish hose connections may be rough bronze.
- E. Double-Check Backflow Prevention Assemblies:
 - 1. Watts Series LF007 (2-1/2" and smaller)
 - 2. Watts Series LF709 (3" and larger)
 - 3. ASSE 1015, suitable for continuous pressure application. Include shutoff valves on inlet and outlet, and strainer on inlet; test cocks; and two positive-seating check valves. Pressure Loss: 5 psig maximum, through middle 1/3 of flow range.
 - 4. Lead-free
- F. Reduced-Pressure-Principle Backflow Preventers: ASSE 1013, suitable for continuous pressure application. Include ball or gate valves on inlet and outlet, and strainer on inlet; test cocks; and pressure-differential relief valve with ASME A112.1.2 air-gap fitting located between two positive-seating check valves. Pressure Loss: 12 psig maximum, through middle 1/3 of flow range.
 - 1. Provide lead-free construction.
 - 2. Provide air gap fitting.
 - 3. Provide lead-free bronze strainer/
 - 4. Watts Series LF909 or LF994

2.3 DOMESTIC WATER SUB METERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Badger Meter, Inc.
 - 2. Sensus Metering Systems.
 - 3. Onicon
- B. Master Sub Meter Basis of Design: Badger Recordall Compound Series Meter, size 2". The standard register is a straight-reading, permanently sealed magnetic drive register. Dirt, moisture, tampering and lens fogging problems are eliminated. The register has a six-odometer wheel totalization display, 360° test circle with center sweep hand, and flow finder to detect leaks. Register gearing is made of self-lubricating engineered polymer, which minimizes friction and provides long life. The multi-position register simplifies meter installation and reading.

Compound Series Model	2" (50 mm)
Meter Flanges, Class 150	2" elliptical or round
	(50 mm)
Typical Operating Range	0.5...200 gpm
(100% ± 1.5%)	(0.1...45 m³/h)
Low Flow Registration (95% minimum)	0.25 gpm (0.06 m³/h)
Maximum Continuous Flow	170 gpm (38.3 m³/h)
Pressure Loss at Maximum Continuous Flow	5.4 psi at 170 gpm
	(0.38 bar at 38.3 m³/h)
Crossover Flow Rate, Typical	12 gpm
Pressure Loss at Crossover	3.5 psi (0.24 bar)
Minimum Crossover Accuracy	97%
Maximum Operating Pressure	
Maximum Operating Temperature	

- C. Irrigation Sub Meter Basis of Design: Badger E-Series Ultrasonic water meter, totally encapsulated and weatherproof. Equipped with an easy to read, 9-digit LCD display, the ultrasonic meter reports consumption, rate of flow, reverse-flow indication, and alarms. No moving parts improves the reliability and has greater extended flow accuracy.

2.4 WATER PRESSURE REGULATORS

A. Manufacturers:

1. Zurn Industries, Inc.; Wilkins Div.
2. Cashco, Inc.
3. Cla-Val Co.
4. Conbraco Industries, Inc.
5. FLOMATIC Corp.
6. Honeywell Braukmann.
7. IMI Cash Valve.
8. Watts Industries, Inc.; Water Products Div.

- B. The water pressure reducing valve shall be Lead Free, certified to NSF/ANSI 372 and ASSE Listed 1003, with an integral strainer, direct acting integral by-pass and balance piston actuator. The main body shall be low lead cast bronze (ASTM B 584) alloy. The bell shall be composite plastic. The cartridge shall be NSF Listed acetal and incorporate an integral seat. The seat disc elastomer shall be NSF Listed EPDM. The assembly shall be accessible for maintenance without removing the device from the line. The water pressure reducing valve shall be a Zurn Wilkins Model NR3XL or equal.

2.5 THERMOSTATIC WATER MIXING VALVE PACKAGE

A. Manufacturers:

- a. Armstrong International, Inc.
- b. Lawler Manufacturing Company, Inc.
- c. Leonard Valve Company.
- d. Powers; a division of Watts Water Technologies, Inc.
- e. Symmons Industries, Inc.

B. Basis of Design: Leonard Megatron Model 2NB-LF complete water temperature control station.



C. Furnished complete with:

1. Wetted surface area of this product contains less than one quarter of one percent (0.25%) of lead by weight
2. 3/4" bottom inlet connections (copper tube)
3. 1" top outlet connection (copper tube)
4. 3/4" return line size with piping method #2.
5. Thermostatic water mixing valve with DURA-trol solid bimetal thermostat (with Extended 7 Year Limited Warranty) directly linked to hot and cold valve porting, adjustable high temperature limit stop set for 120°F, color-coded dial: C-H, locking temperature regulator, integral checkstops.
6. Full port ball valve, pressure gauge on mixed water outlet piping of large mixing valve.
7. Dial thermometer (range: 0 to 140°F and pressure gauge on mixed water outlet of the system.
8. Outlet Test Connection with ball valve and 3/4" hose connection with cap
9. Full port ball valve mounted downstream of test connection on mixed water outlet of the system
10. Inlet piping manifold with full port ball valves and dial thermometers (20 to 240°F on hot supply, 0 to 140F cold supply) on hot and cold supply inlets

11. Return piping, with aquastat, circulator, dial thermometer (0 to 140°F), balancing valve (with positive shutoff) to balance system, and check valve
 12. Aquastat with temperature differential of 5 to 30F.
 13. Circulator wiring box to include a GFCI switch, red and green lights. The GFCI switch will be used to turn the circulator on or off for setup. Green light will indicate when circulator is running and red light will indicate when circulator is not running because of a temperature rise.
 14. Bypass piping, with check valve and isolation ball valve to bottom port of small mixing valve
 15. System mounted on strut, galvanized. Strut shall be assembled with three hole flat angle plate on corners, four hole tee plates or two hole flat plate connectors on all other support pieces using 3/8" grip lock nuts and 3/8"x 1" hex head cap screws, washers and lock washers.
 16. Factory pre-assembled and tested as a complete system
 17. Contractor shall provide field-required electrical connections.
- D. Circulator Pump shall be designed specifically for Hot Water Recirculation applications. Pump shall be by Grundfos, Wilo, Taco, or Bell & Gossett. Provide the following features:
1. Refer to plumbing pump schedule on the plans.
 2. Automatic Operation - Pulse mode, the Taco SmartPlus circulator will run for 150 seconds every 10 minutes to maintain hot water temperature.
 3. LED Display
 4. Remote Sensor Included
 5. 6' Line Cord
 6. Field Replaceable Cartridge
 7. Provide an integral flow check
 8. Materials of Construction:
 - a. Casing (Volute): Stainless Steel
 - b. Stator Housing: Steel
 - c. Cartridge: Stainless Steel
 - d. Impeller: Non-Metallic
 - e. Shaft: Ceramic
 - f. Bearings: Carbon
 - g. O-Ring & Gaskets: EPDM



2.6 STRAINERS FOR DOMESTIC WATER PIPING

- A. 3" and smaller: Y-type strainer shall be domestically manufactured, and conform to MIL-S-16293, and be ANSI 3rd party certified to comply with states' lead plumbing law 0.25% maximum weighted average lead content requirement. The main body shall be low lead bronze (ASTM B 584), the access cover shall be yellow brass (ASTM B 16) or cast bronze (ASTM B 584), the strainer screen shall be 300 series stainless steel, 20 mesh. Screens shall be accessible for cleaning without removing the device from the line. The "Y" type strainer shall be a WILKINS Model YBXL. Drain: Pipe plug.
- B. 4" and larger: The lead-free cast iron "Y" type strainer shall be in compliance with MIL-S-16293F Type 2. The main body and access cover shall be cast iron (ASTM A 126 Class B) and coated with a FDA approved epoxy coating inside and out. The integral strainer screen shall be accessible for cleaning without removing the device from the line. The Cast Iron "Y" type strainer shall be a WILKINS Model FSC-DOM. Pressure/temperature: 200 psi @ 150°F WOG; End connections: Flanged Class 125 lb. Drain: Factory-installed, hose-end drain valve.

2.7 OUTLET BOXES

- A. Manufacturers:
1. Watts
 2. Oatey.
 3. Symmons Industries, Inc.
 4. Zurn Industries, Inc.; Jonespec Div.
- B. General: Outlet boxes with supply fittings complying with ASME A112.18.1M. Include box with faceplate, services indicated for equipment connections, and fire-retardant-treated-wood blocking between studs.

- C. **WVB-1** Clothes Washer Outlet Boxes: with hot- and cold-water hose connections, drain, and the following:
1. Box and Faceplate: White Powder Coat on Cold Rolled Steel
 2. Surface-mounted for concrete or CMU walls, recess for stud walls.
 3. Shutoff Fitting: Combination, single lever.
 4. Supply Fittings: Two NPS 1/2 ball valves and NPS 1/2 copper, water tubing.
 5. Drain: NPS 2 standpipe, P-trap, and direct waste connection to drainage piping.
- D. Provide braided hose connectors, Watts Series FS-CWM-S "FloodSafe" Flexible Braided Stainless Steel Water Supply Connectors, designed specifically for washing machine hookups. They shall include a shutoff device on the inlet side to protect against catastrophic water damage. There are no mechanical moving parts during normal operation and no power source shall be required. FloodSafe connectors shall consist of PVC tubing jacketed with braided stainless steel, and permanently attached, brass, compression end fittings.
1. Length: 60".
 2. UPC listed
 3. Connector shall be pressure rated to 125psi
 4. Supplied with standard brass female hose bibb fittings at each end of the flexible connector.

2.8 HYDRANTS AND HOSE BIBBS

- A. Manufacturers:
1. Josam Co.
 2. Murdock, Inc.
 3. Simmons Manufacturing Co.
 4. Smith, Jay R. Mfg. Co.
 5. Tyler Pipe; Wade Div.
 6. Watts Industries, Inc.; Drainage Products Div.
 7. Woodford Manufacturing Co.
 8. Zurn
 9. MAPA Products
- B. General: ASME A112.21.3M, key-operation hydrant with pressure rating of 125 psig.
1. Inlet: NPS 3/4 or NPS 1 threaded or solder joint.
 2. Outlet: ASME B1.20.7, garden-hose threads.
 3. Operating Keys: One with each key-operation hydrant.
- C. Non-freeze Concealed-Outlet Wall Hydrants: Zurn Z1322-EZ encased Ecolotrol anti-siphon; ASSE 1019, 3/4" pipe connection; automatic draining with flush-mounting box with cover, integral non-removable hose-connection backflow preventer, casing and operating rod to match wall thickness, concealed outlet, and wall clamp. Provide nickel bronze box and hinged cover with operating key lock and "WATER" cast on cover.
- D. Hose Bibbs: Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS 3/4 threaded or solder-joint inlet, of design suitable for

pressure of at least 125 psig; integral non-removable, drainable hose-connection vacuum breaker; and garden-hose threads complying with ASME B1.20.7 on outlet.

1. Finish for Equipment Rooms: Rough bronze.
2. Finish for Finished Rooms: Chrome or nickel plated.
3. Operation for Equipment Rooms: Wheel handle.
4. Operation for Finished Rooms: Operating key.
5. Include operating key with each operating-key hose bibb.
6. Include integral wall flange with each chrome- or nickel-plated hose bibb.

2.9 WATER HAMMER ARRESTORS

- A. Lead-free 0.25% maximum weighted average lead content requirement, consist of a copper body with a low lead brass hexagonal male pipe threaded inlet, an acetal, polycarbonate or low lead brass piston with Buna Nitrile or EPDM O-rings and lead free solder; ASSE® Listed 1010, ANSI A112.26.1. The device shall be pre-charged and sealed at the factory. The Water Hammer Arrester shall be a WILKINS Model 1250XL.

2.10 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

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

B. Deep-Seal Traps:

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

C. Floor-Drain, Trap-Seal Primer Fittings:

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

D. Expansion Joints:

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

2.11 AIR-GAP FITTINGS

- A. Small AC condensate drain into sink trap: Airgap International, Inc. Drain Boa; Inlet port directly accepts 3/8" poly tubing. Dual plumbing code listed sink tailpiece fitting. Listed by NSF® and UPC®.
- B. Fixed Air-Gap Fittings: Zurn Z1024/Z1025 or Precision Plumbing Products ; manufactured cast-iron or bronze drainage fitting with semi-open top with threads or device to secure drainage inlet piping in top and bottom spigot or threaded outlet larger than top inlet. Include design complying with ASME A112.1.2 that will provide fixed air gap between installed inlet and outlet piping.

2.12 DRAIN VALVES

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

2.13 CLEANOUTS

- A. Manufacturers
 - 1. Zurn
 - 2. Smith, Jay R. Mfg. Co.
 - 3. Josam Co.
 - 4. Tyler Pipe, Wade Div.
 - 5. Watts Industries, Inc., Drainage Products Div.
 - 6. Mifab
- B. Cleanouts shall be easily accessible and shall be gastight and watertight. Provide a minimum clearance of 24 inches for the rodding. Size of cleanout shall be same as pipe size through 4". Pipes 4" and larger shall have 4" cleanouts.
- C. Floor Cleanouts: Mifab C1000 Series floor cleanout with heavy-duty nickel-bronze or stainless steel adjustable top.
 - 1. Compliance: ANSI/ASME A112.36.2M.
 - 2. Load Rating: Up to 7,499 pounds.

3. Body: A1, 8-inch diameter body. Lacquered, ASTM A 48, Class 25 cast iron body with anchor flange. O-ring secondary gasket seal. 4-inch; 4" NPS machined integral body threads.
 4. Combined Access Cover and Plug Top Assembly: Heavy-duty, round, 5-inch diameter; square, 5-inch by 5-inch (for tile insertion), adjustable, Type 304 stainless steel top assembly with No. 4 satin finish. Neoprene primary gasket seal. Vandal-resistant stainless steel screws.
 5. When a waterproof membrane is used in the floor system, provide clamping collars on the cleanouts.
 6. In carpeted areas, provide carpet cleanout markers.
- D. Cleanouts shall consist of "Y" fittings and (1/8 inch) bends with brass or bronze screw plugs.
- E. Provide cleanouts at or near the base of the vertical stacks with the cleanout plug located approximately 24 inches above the floor. If there are no fixtures installed on the lowest floor, the cleanout shall be installed at the base of the stack. Cleanout shall consist of sanitary tees. . Extend the cleanouts to the wall access cover; Mifab 1400 Series.
- F. In horizontal runs above grade, cleanouts shall consist of cast brass tapered screw plug in fitting or caulked/no hub cast iron ferrule. Plain end (no-hub) piping in interstitial space or above ceiling may use plain end (no-hub) blind plug and clamp.

2.14 FLOOR DRAINS

- A. Manufacturers
1. Zurn Industries, Inc
 2. Jay R. Smith Mfg. Co.
 3. Tyler Pipe, Wade Div.
 4. Watts Industries, Inc
 5. Mifab
- B. Floor drains shall comply with ASME A112.21.1M.
- C. Provide outlet type as required by piping system used.
- D. Provide 1/2" trap primer connection.
- E. Smith #2010 Series, Zurn ZN415B; Dura-coated cast iron body, Flashing collar, adjustable 6" round nickel bronze top. Provide vandal secured top.

2.15 TRAP SEAL PRIMER VALVES

- A. Manufacturers:
1. Precision Plumbing Products, Inc.
 2. Josam Co.
 3. Watts Industries, Inc.; Water Products Div.
 4. Zurn Industries, Inc.; Jonespec Div.

- B. **TP-1** Electronic Trap Primer Basis of Design: PPP Model MP-500-115V mini-prime electronic trap priming manifold; UL and UPC listed.
1. Primer shall be an electronically activated trap priming device. Primer functions at a pre-selected time, delivering potable water across an air gap funnel.
 2. The device shall be mounted higher than the drains it serves. Trap supply lines shall be sloped to discharge point.
 3. A preset timer energizes a normally closed electronic solenoid valve. Potable water flows across the air gap and is distributed via trap primer feed lines. The timer then de-energizes the solenoid allowing it to close until the next operational cycle.
- C. **TP-2** Water-saver trap primer designed to be used in conjunction with a 1-1/4" sink outlet, to divert drain water, Basis of Design: Zurn Z1021, chrome-plated polished cast brass body with cleanout, ground joint elbow with 1-1/2" NPT outlet, 1-1/2" slip nuts and washers, flexible primer tubing and compression fitting, and escutcheons.

2.16 SOLIDS INTERCEPTOR

- A. **SI-1** Solids Interceptor Basis of Design: ZURN Z-1180 Acid Resistant Composite Interceptor, in lieu of fixture 'P' trap, for on-floor installation, with removable PVC sediment bucket having a removable 3/32" diameter perforated flow defusing/intercepting PVC screen, with top access gasketed secured cover, stainless steel draw latches and hardware with an ABS handle for easy removal of sediment bucket and screen. Provide with 2" threaded low inlet and high outlet. Install with manufacturer's recommended clearance for maintenance under art sink counter. Coordinate location with architect and casework layout.



2.17 ROOF DRAINS

- A. Roof Drains: Comply with ASME A112.21.2M.
- B. Manufacturers
1. MIFAB
 2. Josam Co.
 3. Froet Industries
 4. Smith, Jay R. Mfg. Co.
 5. Watts
 6. Zurn

- C. **RD-1** Roof Drain Basis of Design: Zurn Z100, 15" diameter main roof drain with low silhouette cast iron dome. Dura coated cast iron body with combination membrane flashing clamp/gravel guard.



- D. **RD-2** Small Area Roof Drain Basis of Design: Zurn ZRB181 6" diameter by 2" high cornice drain, dura coated cast iron body, plain bronze dome and membrane flashing clamp. Bottom outlet.



- RD-3** Small Area Roof Drain Basis of Design: Zurn Z158, 10" square top prom-deck drain with heel proof grate and rotatable frame. Dura coated cast iron body with square promenade frame with seepage openings, frame clamps and light duty heel proof vandal proof secured, polished nickel bronze grate.



PART 3 - EXECUTION

3.1 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 hydronic 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.
 - 4. Access shall be provided for testing, maintenance and repair. Locate backflow preventer between 2 feet and 5 feet above floor.
 - 5. Test of Backflow Prevention Assemblies: Backflow prevention assembly shall be tested using gauges specifically designed for the testing of backflow prevention assemblies. Gauges shall be tested annually for accuracy in accordance with the University of Southern California's Foundation of Cross Connection Control and Hydraulic Research or the American Water Works Association Manual of Cross Connection (Manual M-14). Report form for each assembly shall include, as a minimum, the following:
 - a. Data on Device Data on Testing Firm
 - b. Type of Assembly Name
 - c. Manufacturer Address
 - d. Model Number Certified Tester
 - e. Serial Number Certified Tester No.
 - f. Size Date of Test
 - g. Location
 - h. Test Pressure Readings Serial Number and Test Data of Gauges
 - i. If the unit fails to meet specified requirements, the unit shall be repaired and retested.
- C. Install air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.
- D. Install pressure regulators with inlet and outlet shutoff valves and balance valve bypass. Install pressure gages on inlet and outlet.
- E. Install strainers on supply side of each control valve, pressure regulator, and solenoid valve.
- F. Trap primers:
 - 1. Install floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection.

- a. Exception: Fitting may be omitted if trap has trap-seal primer connection.
 - b. Size: Same as floor drain inlet.
2. Install trap seal primers in accordance with manufacturer's instructions.
 3. Cycle trap seal primers a minimum of 6 times to ensure optimum performance.
 4. Ensure flux and other debris is removed.
 5. Use only Teflon tape around threads. Do not use pipe dope or paste.
 6. Do not solder fittings directly onto inlet or outlet of primer.
 7. Do not install trap seal primers closer than 40 feet apart when using same potable water supply line.
 8. Mount trap seal primers in a vertical position 1 foot above finished floor for every 20 feet of floor drain trap make-up water line.
 9. Install union connection above trap seal primers.
 10. Install line shut-off valve upstream of trap seal primers to shut off water supply when performing maintenance on trap seal primers.
 11. Avoid direct installation to prevent foreign material from entering directly into trap seal primers.
- G. Cleanouts:
1. Install cleanouts in aboveground piping and building drain piping according to the following, unless otherwise indicated: Size same as drainage piping up to NPS 4. Use NPS 4 for larger drainage piping unless larger cleanout is indicated. Locate at each change in direction of piping greater than 45 degrees. Locate at minimum intervals of 50 feet for piping NPS 4 and smaller and 100 feet for larger piping. Locate at base of each vertical soil and waste stack.
 2. Install cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
 3. Install cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.
 4. Install flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.
- H. Install floor drains in accordance with manufacturer's instructions at locations indicated on the drawings.
1. Protect installed floor drains from damage during construction.
 2. Install floor drains at low points of surface areas to be drained.
 3. Install floor drains plumb, level, and to correct elevation.
 4. Ensure top of floor drains are flush with top of finished floor.
 5. Install floor drains using manufacturer's supplied hardware.
 6. Coordinate depressed/pitched slab with concrete contractor.
 7. Install floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
 8. Install individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

- I. Roof Drains:
 - 1. Coordination:
 - a. Roof drains installed and flashed by roofing contractor.
 - b. Roof drains furnished, insulated, and connected to piping by Division 22.
 - 2. Examine areas to receive roof drains. Notify Architect of conditions that would adversely affect installation or subsequent use. Do not proceed with installation until unsatisfactory conditions are corrected.
 - 3. Install roof drains in accordance with manufacturer's instructions at locations indicated on the drawings.
 - 4. Install roof drains plumb, level, and to correct elevation.
 - 5. Install roof drains using manufacturer's supplied hardware.
 - 6. Protect installed roof drains from damage during construction.
- J. Install interceptors, including trapping, venting, and flow-control fitting, according to authorities having jurisdiction and with clear space for servicing. Set unit in accordance with manufacturer's recommendations. Install cleanout immediately downstream from interceptors not having integral cleanout on outlet.
- K. Install grease recovery units on floor. Install trap, vent, and flow-control fitting according to authorities having jurisdiction. Install control panel adjacent to unit, unless otherwise indicated.
- L. Fasten wall-hanging plumbing specialties securely to supports attached to building substrate if supports are specified and to building wall construction if no support is indicated.
- M. Fasten recessed-type plumbing specialties to reinforcement built into walls.
- N. Install wood-blocking reinforcement for wall mounting and recessed-type plumbing specialties.
- O. Install individual shutoff valve in each water supply to plumbing specialties. Install shutoff valves in accessible locations.
- P. Install air vents at piping high points. Include ball valve in inlet.
- Q. Install traps on plumbing specialty drain outlets.
- R. Water hammer arrestors shall be installed at flush valve water closets, as shown on the plans, and as recommended by Plumbing & Drainage Institute Standard PDI-WH-201. Locate units at the end of branch lines, between the last two fixtures served. Size units based on fixture unit total of branch. All branch pipes serving flush valve water closets shall have water hammer arrestors.
- S. 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.

3.2 ROUGHING-IN FOR UTILITY WATER METERS

- A. Pay all required fees.
- B. Install water meters, piping, and specialties according to AWWA M6 and utility's requirements.

3.3 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. Connect plumbing specialties to piping specified in other Division 22 Sections.
- D. Connect plumbing specialties and devices that require power according to Electrical Specification Sections.

3.4 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 each day or when work stops.

END OF SECTION 221119

SECTION 221316 – PLUMBING SANITARY AND STORM PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 22 Section "Common Work Results for Plumbing"
 - 2. Division 22 Section "Plumbing Specialties" for soil, waste, and vent piping systems specialties.

1.2 SUMMARY

- A. This Section includes soil and waste, sanitary drainage and vent piping inside the building and to locations indicated.
- B. This Section includes storm-drainage piping inside the building and to locations indicated.
- C. Drawings show the general layout of piping and accessories but do not show all required fittings and offsets that may be necessary to connect piping to equipment and to coordinate with other trades. Fabricate piping based on field measurements. Provide all necessary fittings and offsets.
- D. General layout shown, provide piping to fixtures as required by the Maine Plumbing Code. A licensed master plumber shall perform or supervise the work and provide layouts, piping, and fittings as required by code.

1.3 PERFORMANCE REQUIREMENTS

- A. Comply with the utility requirements for the connection of to the municipal utility services. Obtain and pay for all necessary permits from the applicable municipal department. Obtain authority to connect to their existing mains.
- B. Provide components and installation capable of producing piping systems with working-pressure ratings per local plumbing code.

1.4 SUBMITTALS

- A. Product Data: For pipe, tube, fittings, and couplings.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.5 QUALITY ASSURANCE

- A. Piping materials shall bear label, stamp, or other markings of specified testing agency.
- B. Comply with the UPC 2009 edition, subject to the exclusions and amendments set forth by the Maine Plumbers Examining Board.
- C. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components. Include marking with "NSF-DWV" for plastic drain, waste, and vent piping; "NSF-drain" for plastic drain piping; "NSF-tubular" for plastic continuous waste piping; and "NSF-sewer" for plastic sewer piping.

PART 2 - PRODUCTS

2.1 PIPING MATERIALS

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

2.2 CAST-IRON SOIL PIPING

- A. Hubless
 - 1. Hubless Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A-888 and CISPI Standard 301. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute.
 - 2. Hubless couplings shall conform to CISPI Standard 310 for standard couplings or ASTM C-1540 for heavy duty couplings where indicated. Gaskets shall conform to ASTM C-564. All pipe and fittings to be produced by a single manufacturer and are to be installed in accordance with manufacturer's recommendations and local code requirements. Couplings shall be installed in accordance with the manufacturer's band tightening sequence and torque. Tighten bands with a properly calibrated torque limiting device.
- B. Hub and Spigot Cast Iron Soil Pipe and Fittings:
 - 1. Hub and Spigot Cast Iron pipe and fittings shall be manufactured from gray cast iron and shall conform to ASTM A-74. All pipe and fittings shall be marked with the collective trademark of the Cast Iron Soil Pipe Institute. Pipe and fittings to be Service (SV) Extra Heavy (XH)
 - 2. Joints can be made using a compression gasket manufactured from a neoprene elastomer meeting the requirements of ASTM C-564 or lead and oakum. All pipe and fittings to be produced by a single manufacturer and are to be installed in accordance with manufacturer's recommendations and local code requirements. The system shall be hydrostatically tested after installation to 10 ft. of head (4.3 psi maximum).

2.3 PVC DRAINAGE PIPING

- A. Pipe and fittings shall be manufactured from PVC compound with a cell class of 12454 per ASTM D-1784 and conform with National Sanitation Foundation (NSF) standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM D-1785 and ASTM D-2665. Fittings shall conform to ASTM D-2665.
- B. All pipe and fittings to be produced by a single manufacturer and to be installed in accordance with manufacturer's recommendations and local code requirements. Solvent cements shall conform to ASTM D-2564, primer shall conform to ASTM F-656. The system to be manufactured by Charlotte Pipe and Foundry Co. or approved equal; and shall be intended for non-pressure drainage applications where the temperature will not exceed 140°F.

2.4 ABS PIPING

- A. ABS Pipe: ASTM D 2661, Schedule 40, solid wall. ABS Socket Fittings: ASTM D 2661, made to ASTM D 3311, drain, waste, and vent patterns.

PART 3 - EXECUTION

3.1 EXCAVATION

- A. Comply with requirements for excavating, trenching, and backfilling specified in Division 31.

3.2 PIPING APPLICATIONS

- A. Transition and special fittings with pressure ratings at least equal to piping pressure ratings may be used in applications below, unless otherwise indicated.
- B. Flanges may be used on aboveground pressure piping, unless otherwise indicated.
- C. Aboveground and Underground, Soil, Waste, and Vent Piping: Use any of the following piping materials for each size range:
 - 1. Cast iron
 - a. Boiler room drains – within 40 feet of boiler drains
 - 2. PVC or Cast iron
 - a. Under slab
 - b. Concealed
 - c. Vents
- D. Vent Piping through roof/exposed above roof: Use any of the following piping materials for each size range:
 - 1. Cast iron
 - 2. Schedule 40 PVC DWV
 - 3. ABS

- E. Elevator sump pump discharge piping: Type L sweated copper.
- F. Storm Drain Piping:
 - 1. Cast iron
 - 2. Schedule 40 PVC DWV

3.3 PIPING INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping installation.
- B. Provide firestopping as per Section 230500 "Common Work Results for HVAC".
- C. Install cast-iron soil piping according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings."
- D. Install PVC soil and waste drainage and vent piping according to ASTM D 2665.
- E. Install underground PVC soil and waste drainage piping according to ASTM D 2321.
- F. Make changes in direction for soil and waste drainage and vent piping using appropriate branches, bends, and long-sweep bends. Sanitary tees and short-sweep 1/4 bends may be used on vertical stacks if change in direction of flow is from horizontal to vertical. Use long-turn, double Y-branch and 1/8-bend fittings if 2 fixtures are installed back to back or side by side with common drain pipe. Straight tees, elbows, and crosses may be used on vent lines. Do not change direction of flow more than 90 degrees. Use proper size of standard increasers and reducers if pipes of different sizes are connected. Reducing size of drainage piping in direction of flow is prohibited.
- G. Lay buried building drainage piping beginning at low point of each system. Install true to grades and alignment indicated, with unbroken continuity of invert. Place hub ends of piping upstream. Install required gaskets according to manufacturer's written instructions for use of lubricants, cements, and other installation requirements. Maintain swab in piping and pull past each joint as completed.
- H. Install drainage and vent piping at the minimum slopes as required by the local plumbing code.
- I. Do not enclose, cover, or put piping into operation until it is inspected and approved by authorities having jurisdiction.
- J. Install cleanouts at grade and extend to where building drains connect to site piping. Sleeves are not required for cast-iron soil piping passing through concrete slabs-on-grade if slab is without membrane waterproofing.
- K. Install wall penetration system at each service pipe penetration through foundation wall. Make installation watertight. Refer to Division 22 Section "Common Work Results for Plumbing" for wall penetration systems.

3.4 JOINT CONSTRUCTION

- A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping joint construction.
- B. Cast-Iron, Soil-Piping Joints: Make joints according to CISPI's "Cast Iron Soil Pipe and Fittings Handbook," Chapter IV, "Installation of Cast Iron Soil Pipe and Fittings." Gasketed Joints: Make with rubber gasket matching class of pipe and fittings. Hubless Joints: Make with rubber gasket and sleeve or clamp.

3.5 VALVE INSTALLATION

- A. Shutoff Valves: Install full-port ball valve on each pump discharge.
- B. Check Valves: Install swing check valve, downstream from shutoff valve, on each pump discharge.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Hanger, support, and anchor devices are specified in Division 22 Section "Hangers and Supports."

3.7 CONNECTIONS

- A. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Connect interior drainage piping to exterior drainage piping.
- C. Use transition fitting to join dissimilar piping materials.
- D. Connect drainage and vent piping to fixtures and equipment as shown on the plans.
- E. Connect drainage piping in sizes indicated, but not smaller than required by plumbing code.

3.8 FIELD QUALITY CONTROL

- A. During installation, notify authorities having jurisdiction at least 24 hours before inspection must be made. Perform tests specified below in presence of authorities having jurisdiction.
 - 1. Roughing-in Inspection: Arrange for inspection of piping before concealing or closing-in after roughing-in and before setting fixtures.
 - 2. Final Inspection: Arrange for final inspection by authorities having jurisdiction to observe tests specified below and to ensure compliance with requirements.
- B. Test piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:

1. Test for leaks and defects in new piping and parts of existing piping that have been altered, extended, or repaired. If testing is performed in segments, submit separate report for each test, complete with diagram of portion of piping tested.
 2. Leave uncovered and unconcealed new, altered, extended, or replaced drainage and vent piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 3. Roughing-in Plumbing Test Procedure: Test piping on completion of roughing-in. Close openings in piping system and fill with water to point of overflow, but not less than 10-foot head of water. From 15 minutes before inspection starts to completion of inspection, water level must not drop. Inspect joints for leaks.
 4. Finished Plumbing Test Procedure: After plumbing fixtures have been set and traps filled with water, test connections and prove they are gastight and watertight. Plug vent-stack openings on roof and building drains where they leave building. Introduce air into piping system equal to pressure of 1-inch wg. Use U-tube or manometer inserted in trap of water closet to measure this pressure. Air pressure must remain constant without introducing additional air throughout period of inspection. Inspect plumbing fixture connections for gas and water leaks.
 5. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
- C. Test force-main piping according to procedures of authorities having jurisdiction or, in absence of published procedures, as follows:
1. Leave uncovered and unconcealed new, altered, extended, or replaced force-main piping until it has been tested and approved. Expose work that was covered or concealed before it was tested.
 2. Cap and subject piping to static-water pressure of 50 psig above operating pressure, without exceeding pressure rating of piping system materials. Isolate test source and allow to stand for four hours. Leaks and loss in test pressure constitute defects that must be repaired.
 3. Repair leaks and defects with new materials and retest piping, or portion thereof, until satisfactory results are obtained.
- D. Re-inspection: If authorities having jurisdiction find that piping will not pass test or inspection, make required corrections and arrange for re-inspection.
- E. Reports: Prepare inspection reports and have them signed by authorities having jurisdiction.
- 3.9 CLEANING
- A. Clean interior of piping. Remove dirt and debris as work progresses.
 - B. Protect drains during remainder of construction period to avoid clogging with dirt and debris and to prevent damage from traffic and construction work.
 - C. Place plugs in ends of uncompleted piping at end of day and when work stops.

END OF SECTION 221316

SECTION 221429 – ELEVATOR SUMP PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following: Division 22 Section "Common Work Results for Plumbing"

1.2 SUMMARY

- A. This Section includes sump pumps for elevator sump pits.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
- B. Wiring Diagrams: For power, signal, and control wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps and controls, to include in operation and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings indicate size, profiles, connections, and dimensional requirements of pumps and are based on specific manufacturer types and models indicated. Other manufacturers' pumps with equal performance characteristics may be considered.
- 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.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Retain shipping flange protective covers and protective coatings during storage.
- B. Protect bearings and couplings against damage.

- C. Comply with pump manufacturer's rigging instructions for handling.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Weil Pump Co.
 - 2. Little Giant Pump Co.
 - 3. Weil Pump Co.
 - 4. Zoeller Pump Co.
 - 5. Liberty Pumps.
 - 6. Myers
 - 7. Stancor

2.2 ELEVATOR SUMP PUMP

- A. The OilTector control system shall be designed and approved for the safe operation of pumping, alarming and monitoring of elevator sump pits. The OilTector shall activate a pump to remove water from elevator pits in accordance with ASME A17.1.
- B. Components required for the repair of the pump shall be shipped within a period of 24 hours.
- C. The castings shall be constructed of Class 25 cast iron. The motor housing shall be oil filled to dissipate heat. Air filled motors shall not be considered equal since they do not properly dissipate heat from the motor. All mating parts shall be machined and sealed with a Buna-N O-ring. All fasteners exposed to the liquid shall be stainless steel. The motor shall be protected on the top side with sealed cord entry plate with molded pins to conduct electricity eliminating the ability of water to enter internally through the cord. The motor shall be protected on the lower side with a unitized ceramic/carbon seal with stainless steel housings and spring or engineered double lip seal with stainless steel springs. The pump shall be furnished with stainless steel handle. The exterior of the casting shall be protected with powder coat paint. The pump shall have cast iron support legs, enabling it to be a free standing unit.
- D. The submersible pump shall be supplied with a 25 feet of multiconductor power cord. It shall be cord type YELLOW UL 16-3 SJEOOW 300V 105°C, capable of continued exposure to the pumped liquid. The power cord shall be sized for the rated full load amps of the pump in accordance with the National Electric Code. The power cable shall not enter the motor housing directly but will conduct electricity to the motor by means of a water tight compression fitting cord plate assembly, with molded pins to conduct electricity. This will eliminate the ability of water to enter internally through the cord, by means of a damaged or wicking cord.
- E. Single phase motors shall be oil filled, permanent split capacitor, Class B insulated NEMA B design, rated for continuous duty. At maximum load the winding temperature shall not exceed 130 degrees C unsubmerged. Since air filled motors are not capable of dissipating heat they shall

not be considered equal. The pump motor shall have an integral thermal overload switch in the windings for protecting the motor. The capacitor circuit shall be mounted internally in the pump.

- F. An upper sleeve and lower ball bearing shall be required. The lower ball bearing shall be a single ball / race type bearing. Both bearings shall be permanently lubricated by the oil, which fills the motor housing. The motor shaft shall be made of 300 or 400 series stainless steel.
- G. The pump shall have a unitized carbon / ceramic seal with stainless steel housings and spring, or engineered double lip seal with stainless steel springs. The motor plate / housing interface shall be sealed with a Buna-N O-ring. The impeller shall be vortex style made of an engineered polymer, with pump out vanes on the back shroud to keep debris away from the seal area. It shall be threaded to the motor shaft.
- H. The pump shall have a ground continuity check and the motor chamber shall be Hi-potted to test for electrical integrity, moisture content and insulation defects. The motor and volute housing shall be pressurized, and an air leak decay test is performed to ensure integrity of the motor housing. The pump shall be run, voltage current monitored, and the tester checks for noise or other malfunction.
- I. Controls:
 - 1. The OilTector shall stop the pump before oil or other harmful substances enter our water supply. Indicator lights will illuminate on the control panel for the following: power, pump running, high water, and high oil. The panel has a set of auxiliary contacts that activate on power loss or high Oil/Water conditions. These contacts can be connected to the OilTector remote panel which contains audio/visual alarming along with auxiliary contacts for connection to Building Automation System.
 - 2. The control unit has three probes and a float ball switch. The pump will activate when the middle probe contacts water, and will remain on until the first, longest probe no longer is in contact with water. A high water alarm is activated when third or shortest probe contacts water. The system will ignore a small film of oil, however larger volumes of oil will be detected when the alarm probe does not detect water and the float ball activates. The system will continue to operate, removing water not oil from the vault even when oil has been detected.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in of plumbing piping systems to verify actual locations of piping connections before pump installation.

3.2 CONCRETE

- A. Concrete for pits and sumps is specified in Division 3. Coordinate pit size with Division 3. The minimum sump size shall be 20" x 20" x 30" deep.

3.3 INSTALLATION

- A. Install pumps according to manufacturer's written instructions.
- B. Install pumps and arrange to provide access for maintenance, including removal of motors, impellers, couplings, and accessories.
- C. Support piping so weight of piping is not supported by pumps.
- D. Coordinate location of GFI 3-prong grounded electrical receptacles, extension cords are not permitted.
- E. Pit must be cleaned of debris after installation.

3.4 CONNECTIONS

- A. Install swing check valve on each pump discharge.
- B. Install electrical connections for power, controls, and devices. Connect pump, level switch, and alarm panel to GFCI outlets.

3.5 STARTUP SERVICE

- A. Perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.

3.6 ADJUSTING

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

3.7 DEMONSTRATION

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

END OF SECTION 221429

SECTION 223300 - ELECTRIC WATER HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes heat pump water heaters and accessories.

1.3 SUBMITTALS

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

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain same type of electric water heaters through one source from a single manufacturer.
- B. Product Options: Drawings indicate size, profiles, and dimensional requirements of electric water heaters and are based on the specific system indicated
- C. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1-2007.
- E. ASME Compliance: Where indicated, fabricate and label commercial water heater storage tanks to comply with ASME Boiler and Pressure Vessel Code: Section VIII, Division 1.
- F. Comply with NSF 61, "Drinking Water System Components - Health Effects; Sections 1 through 9," for all components that will be in contact with potable water.

- G. Hydrostatically test water heater storage tanks before shipment to minimum of one and one-half times pressure rating.

1.5 COORDINATION

- A. Coordinate size and location of concrete bases. Refer to Division 22 Section "Common Work Results for Plumbing".

PART 2 - PRODUCTS

2.1 HEAT PUMP WATER HEATERS

- A. The water heater shall be Accelera® E air-to-water heat pump manufactured by Stiebel Eltron or approved equal. Water heater shall have 3 adjustable rubber feet for leveling unit that shall also provide sound/vibration isolation.
- B. Tank shall be 80 gallons with interior of hygienic glass enameled surface and an impressed current anode. Tank insulation shall be 3" polyurethane foam insulation.
 - 1. Tank insulation R-value shall be R14 minimum. If the manufacturer supplied insulation is not R14, provide an additional blanket insulation wrap.
- C. Heat pump thermal capacity shall be 1.7 kW and cooling capacity 1.0 kW, with thermal losses less than 600kWh/24h at 45 K temp difference. There shall be a single electric resistance element of 1.5 kW. Heat pump shall be fitted with a safety pressure switch at 348 PSI.
- D. Operation temperature limit shall be 107.6°F to 42.8°F. Unit shall be equipped with automatic defrost via fan-driven ambient air and shall have a fast pressure equalization to prevent cycling compressor after power outage. Defrost cycle is engineered to not interrupt heat pump operation for greater efficiency. A filter is unnecessary because the evaporator self-cleans during defrost mode due to its optimal fin spacing and hydrophobic coating.
- E. Housing shall be hot dip power painted galvanized sheet metal without welding and have salt air impervious screws.
- F. Refrigerant circuit (R134a) shall have corrosion protection via a stainless steel expansion valve and a coated evaporator salt mist tested to ASTM B 287-74/G84-95 200 hrs. Compressor shall be a high efficiency reliable rotary compressor with thermal overload switch. Refrigerant circuit shall be stainless steel parts and silver alloy brazed copper tubing with recuperator tubing.
- G. Water connections shall be NPT.

2.2 ACCESSORIES

- A. Provide field installed accessories:
 - 1. Heat Trap Fittings: Inlet type in cold-water inlet and outlet type in hot-water outlet to prevent thermo-siphoning.

2. Relief Valve: ASME rated and stamped and complying with ASME PTC 25.3 for combination temperature and pressure relief valves. Include relieving capacity at least as great as heat input, and include pressure setting less than water heater working-pressure rating.
- B. Compression Tanks: Steel pressure-rated tank constructed with welded joints and factory-installed butyl-rubber diaphragm. Include air pre-charge to minimum system-operating pressure at tank.
1. Manufacturers:
 - a. AMTROL Inc.
 - b. Armstrong Pumps, Inc.
 - c. Taco, Inc.
 - d. Wessels Co.
 2. Construction:
 - a. Tappings: Factory-fabricated steel, welded to tank before testing and labeling. Include ASME B1.20.1, pipe thread.
 - b. Interior Finish: Comply with NSF 61 barrier materials for potable-water tank linings, including extending finish into and through tank fittings and outlets.
 - c. Air-Charging Valve: Factory installed.
 3. Capacity and Characteristics: As shown on the plans.

PART 3 - EXECUTION

3.1 WATER HEATER INSTALLATION

- A. Install water heaters level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.
- B. Do not install with the air exhaust pointing at a wall or any surface closer than 6 feet away. Do not install with the air intake pointing to a wall or any surface closer than 2 feet away.
- C. Water heaters shall be supported and restrained by the specified supports.
- D. Install combination temperature and pressure relief valves in top portion of storage tanks. Use relief valves with sensing elements that extend into tanks. Extend water-heater relief-valve outlet, with drain piping same as domestic water piping in continuous downward pitch, and discharge by positive air gap onto closest floor drain.
- E. Plumb the return line of the recirculation loop back in through the T&P valve port of the appliance. The T&P valve may not be omitted so a Tee must be used in this configuration. Be sure that the T&P valve probe is submerged sufficiently. Pipe the 3/4" T&P valve to 6" AFF.

- F. Install hose-end drain valves at low points in water piping for water heaters that do not have tank drains. Refer to Division 22 Section "Plumbing Specialties" for hose-end drain valves.
- G. Pipe the condensate drain connection to the floor drain.
- H. Install plumbing specialties as shown on the plans and in accordance with manufactures' recommendations.
- I. Fill water heaters with water.
- J. Charge compression tanks with air.

3.2 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Install piping adjacent to water heaters to allow service and maintenance. Arrange piping for easy removal of water heaters.
- C. Ground equipment according to electrical specifications.
- D. Connect wiring according to electrical specifications.

3.3 FIELD QUALITY CONTROL

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

END OF SECTION 223300

SECTION 224000 - PLUMBING FIXTURES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 22 Section "Common Work Results for Plumbing"
 - 2. Section 221116 - Domestic Water Piping: Material and installation of piping systems, valves, and piping specialties.
 - 3. Division 22 Section "Plumbing Specialties" for backflow preventers and specialty fixtures not in this Section.

1.2 SUMMARY

- A. This Section includes Plumbing Fixtures.

1.3 SUBMITTALS

- A. Product Data: Include selected fixture and trim, fittings, accessories, appliances, appurtenances, equipment, and supports and indicate materials and finishes, dimensions, construction details, and flow-control rates for each type of fixture indicated.
- B. Maintenance Data: For plumbing fixtures to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Source Limitations: Obtain plumbing fixtures, faucets, and other components of each category through one source from a single manufacturer. 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. Comply with local building and plumbing codes.
- C. Regulatory Requirements: Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; about 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. Water line components shall be lead-free.

1.5 COORDINATION

- A. Coordinate roughing-in and final plumbing fixture locations, and verify that fixtures can be installed to comply with original design and referenced standards.

PART 2 - PRODUCTS

2.1 GENERAL

- A. Common Plumbing Fixture Requirements
 1. Fixtures shall be water conservation type in accordance with local, state, and federal requirements.
 2. Vitreous china, nonabsorbent, hard-burned, and vitrified throughout the body shall be provided. Porcelain enameled ware shall have specially selected, acid-resisting enamel coating evenly applied on surfaces. No fixture will be accepted that shows cracks, crazes, blisters, thin spots, or other flaws.
 3. Fixture color shall be white except as specified herein.
 4. Provide combinations of fixtures and trim, faucets, fittings, and other components that are compatible.
 5. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings.
 6. Each fixture and piece of equipment requiring connections to the drainage system shall be equipped with a trap.
 7. Brass expansion or toggle bolts capped with acorn nuts shall be provided for supports, and polished chromium-plated pipe, valves, and fittings shall be provided where exposed to view.
 8. Fixtures with the supply discharge below the rim shall be equipped with backflow preventers.
 9. Fixture supports for off-the-floor fixtures shall be of the chair-carrier type. The carrier shall provide the necessary means of mounting the fixture, with a foot or feet to anchor the assembly to the floor slab. Adjustability shall be provided to locate the fixture at the desired height and in proper relation to the wall. Support plates, in lieu of chair carrier, shall be fastened to the wall structure only where it is not possible to anchor a floor-mounted chair carrier to the floor slab.
 10. Provide access panels to concealed valves and components. All components shall have proper access in accordance with manufactures' recommendations. Refer to Section 220500.
 11. Mounting heights: Refer to Architectural Plans.

2.2 TANK TYPE WATER CLOSET

A. Manufacturers:

1. American Standard
2. Kohler
3. Toto
4. Gerber

B. Tank Type Toilets - Common Requirements:

1. Comply with ASME A112.19.2 – Ceramic Plumbing Fixtures
2. Comply with ADA, see plans for trip lever side of tank.
3. Toilet shall be EPA Water Sense Certified.
4. Material: Vitreous china, white.
5. Type: Siphon jet.
6. Rim Contour: Elongated.
7. MaP Rating: 1,000 grams minimum.
8. Supply Fittings:
 - a. Standard: ASME A112.18.1/CSA B125.1.
 - b. Supply Piping: Chrome-plated-brass pipe or chrome-plated-copper tube matching water-supply piping size. Include chrome-plated wall flange.
 - c. Stop: Chrome-plated-brass, one-quarter-turn, ball-type or compression stop with inlet connection matching water-supply piping type and size.
 - d. Operation: Wheel handle.
 - e. Riser Size: NPS 3/8; Material: ASME A112.18.6, braided- or corrugated-stainless-steel flexible hose riser.
9. Provide neoprene or graphite felt waste outlet seal for back outlet per manufacturer's recommendation for P-1A. Provide wax ring, bolt caps, gaskets, and accessories for a complete code-compliant installation for P-1B and P-1C.
10. Toilet Seats:
 - a. Standard: IAPMO/ANSI Z124.5.
 - b. Material: Solid polypropylene.
 - c. Provide a permanent surface that inhibits the growth of stain and odor causing bacteria, mold and mildew on the surface
 - d. Type: Commercial (Heavy duty).
 - e. Shape: Elongated rim, open front.
 - f. Hinge: Check.
 - g. Seat Cover: Not required.
 - h. Color: White.

- C. **P-1A** Basis of Design: American Standard Yorkville Flowise Elongated Pressure Assisted Toilet 1.1 GPF, back outlet, Model 2876.100. For use in Toilet 118.



- D. **P-1B** Basis of Design: American Standard Cadet 3 Flowise Elongated 10" rough in complete Toilet 1.128 GPF, Model 3379.128ST. For use in Toilet 110 and non ADA toilets.



- E. **P-1C** Basis of Design: American Standard Cadet Pro Right Height Elongated Toilet 1.128 GPF, Model 215AA.104. For adult ADA toilets.



2.3 MOP SERVICE BASIN

- A. Mop Basin Manufacturers:

1. Zurn
2. Fiat
3. Stern William

- B. Faucet Manufacturers:
1. Zurn
 2. Chicago Faucet
- C. Provide check valves at HW and CW connections.
- D. **P-2** Basis of Design: 24 x 24 x 10" H Mop Service Basin: Zurn Z1996-24. Molded high density molded stone basin; PVC drain body, stainless steel strainer, and 3" gasketed outlet connection. Certifications: Meets ANSI Z124.6, CSA listed, and IAPMO listed under file # 3561.
1. Wall Guard (-WG) Provide 20 gage type 304 stainless steel bumpers used to protect walls adjacent to mop basin. Two panels shall be supplied for corner installation
 2. Mop holder (-MH): Stainless steel 24" long x 3" wide with three rubber tool grips
 3. Bumper Guards (-BS) Provide 20 gage type 304 stainless steel bumper guards to protect top edge of basin.
 4. Basis of Design P-2 Faucet: Service Sink Faucet – Zurn Model Z1996-SF. Chrome plated service faucet, complete with vacuum breaker, integral stops, adjustable wall brace, pail hook, four-arm hot and cold handles and 3/4 hose thread on spout.



2.4 LAVATORIES

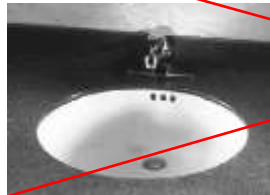
- A. Lavatory Manufacturers:
1. American Standard
 2. Kohler
 3. Toto
- B. Faucet Manufacturers
1. Chicago
 2. American Standard
 3. Sloan
 4. Moen
 5. Toto
- C. Lavatories – Common Requirements:
1. Standard: ASME A112.19.2/CSA B45.1; ADA.
 2. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.

3. Faucet-Hole Punching: Match faucet, coordinate hole locations.
4. Mounting Material: Chair carrier.
5. Provide a permanent surface that inhibits the growth of stain and odor causing bacteria, mold and mildew on the surface
6. Provide overflow.
7. Provide 304 stainless steel grid drain unless noted otherwise.
8. Risers: Supply line: supplied by fixture manufacturer, or by McGuire or Brasscraft. Shall be lead-free, loose key standard stop lavatory supply kit, two polished chrome, solid brass angle stops with loose key handles, two 12" flexible chrome-plated lavatory risers complete with two forged brass with set screw flanges; connections: 1/2" sweat x 3/8" OD.
9. Waste Fittings: Standard: ASME A112.18.2
10. Drain: Stainless steel grid type with NPS 1-1/4 offset and straight tailpiece.
11. Trap: NPS 1-1/2 by NPS 1-1/4; Material: Chrome-plated, two-piece, cast-brass trap and swivel elbow with 0.032-inch- thick brass tube to wall; and chrome-plated, brass or steel wall flange.
12. Provide ADA trim kits for exposed piping.

D. Lavatory Faucets Common Requirements:

1. Standard: ASME A112.18.1/CSA B125.1.
2. Body Material: Commercial, solid brass.
3. Finish: Polished chrome plate.
4. Mounting Type: Deck.

- E. ~~P-3A~~ Basis of Design: American Standard Ovalyn Universal Access Undercounter lavatory, Model 9482.000, rear overflow.



1. Faucet Basis of Design: Electronic, sensor-operated lavatory faucet; American Standard Model # 6053.105 Selectronic PWRX; shall feature a programmable, multi-function sensor and an electronically operated self-cleaning solenoid valve. Shall also feature a vandal resistant all brass body with single inlet and in-line strainer. Shall meet ANSI A112.18.1 and ANSI 117.1 codes. Long Life Battery System: 480,000 cycles (10 years @ 4,000 cycles per month). Advanced battery & electronics reduce the downtime and maintenance costs associated with changing batteries. Safety Circuitry prevents overheating in case of short circuit and protects the electronics from damage. Provide a 0.35 GPM Vandal-Resistant Multi-Laminar Spray VO35.



2. Provide optional mixing valve 605XTMV1070, set to deliver 105 degrees F.
- F. **P-3B** Basis of Design: American Standard Murro Universal Design Wall hung lavatory with Everclean, Model 0955.001, center hole with overflow.



1. Provide 0062.00EC Acrylic Shroud to conceal both pipes and faucet controller.
2. Faucet Basis of Design: Same as P-3A. ~~SEE SECTION 2.E.1 AND 2.E.2.~~

2.5 STAINLESS STEEL SINKS

- A. Sink Manufacturers:
1. Just Manufacturing Co.
 2. Elkay Manufacturing Co.
 3. Kindred
 4. Advance Tabco
- B. Faucet Manufacturers
1. American Standard
 2. Chicago
 3. Moen
- C. Stainless Steel Sink – Common Requirements:
1. Sinks are listed with IAPMO as meeting the applicable requirements of the Uniform Plumbing Code and the International Plumbing Code
 2. Standard: ASME A112.19.3/CSA B45.4.
 3. NSF Standard: Comply with NSF/ANSI 61 Annex G, "Drinking Water System Components - Health Effects," for faucet materials that will be in contact with potable water.
 4. Faucet-Hole Punching: Match faucet, coordinate hole locations.
 5. Supply line: supplied by fixture manufacturer, or by McGuire or Brasscraft. Shall be lead-free, loose key standard stop lavatory supply kit, two polished chrome, solid brass angle stops with round wheel handles, two 12" flexible chrome-plated lavatory risers complete with two forged brass with set screw flanges; connections: 1/2" sweat x 3/8" OD.
 6. Drain: type 304 stainless grid drain.

- A. **P-4A** Basis of Design: ADA Compliant Classroom Sink, Faucet Ledge – Side, less bubbler hole. Seamless die-drawn construction of 18 gauge type 304 stainless steel. Interior and top surfaces polished to a non-porous Hand Blended Just Finish. Fully coated underside insulates for sound and reduces condensation. Straight sided compartment with 1-3/4” radius corners provides greater capacity. Self-rimming top mount with Grip-Rim Plus stainless steel mounting channels. Drain punched for Just J-35-SSF drain. Certified to ASME/CSA B45.4; UPC; IPC.
1. See Architectural Elevations for orientation of faucet for hole punching prior to ordering fixtures, NO BUBBLER.
 2. Just CRA-ADA-2225-A-GR; 19” X 16” inside bowl dimensions.
 3. ADA bowl depth: 6 1/2”.
 4. Drain Opening: 3-1/2” center.
 5. Provide a solids interceptor. Watts Drainage SI-742 floor mounted epoxy coated cast aluminum sediment interceptor with removable stainless steel sediment basket, gasketed cover, and 2" IPS threaded connections.
 6. Basis of Design Sink Faucet: American Standard Monterrey, two handle widespread faucet with convertible rigid/swivel gooseneck spout with 8” reach and flexible underbody. Model 6540.278.



- B. **P-4B** Basis of Design: Classroom Sink, Faucet Ledge – Side, less bubbler hole. Seamless die-drawn construction of 18 gauge type 304 stainless steel. Interior and top surfaces polished to a non-porous Hand Blended Just Finish. Fully coated underside insulates for sound and reduces condensation. Straight sided compartment with 1-3/4” radius corners provides greater capacity. Self-rimming top mount with Grip-Rim Plus stainless steel mounting channels. Drain punched for Just J-35-SSF drain. Certified to ASME/CSA B45.4; UPC; IPC.
1. See Architectural Elevations for orientation of faucet for hole punching prior to ordering fixtures, NO BUBBLER.
 2. Just CRA-2225-A-GR; 19” X 16” inside bowl dimensions.
 3. Bowl depth: 7-1/2”.
 4. Drain Opening: 3-1/2” center location.
 5. Provide a solids interceptor. Watts Drainage SI-742 floor mounted epoxy coated cast aluminum sediment interceptor with removable stainless steel sediment basket, gasketed cover, and 2" IPS threaded connections.
 6. Basis of Design Sink Faucet: same as P-4A.
- C. **P-4C** Basis of Design: ADA Compliant Classroom Sink with integral flow 16 gauge. Seamless die-drawn construction of 16 gauge type 304 stainless steel. Interior and top surfaces polished to a non-porous Hand Blended Just Finish. Fully coated underside insulate for sound and reduces condensation. Straight sided compartment with 1-3/4” radius corners provides greater capacity.

Self-rimming top mount with Grip-Rim Plus with stainless steel mounting channels. Drain punched for Just J-35-SSF drain. Certified to ASME A112.19.3/CSA B45.4; UPC; IPC.

1. See Architectural Elevations for orientation of faucet for hole punching prior to ordering fixtures.
2. Just CRAF-ADA-1923-16-GR; 16" X 14" inside bowl dimensions.
3. ADA bowl depth: 5 1/2".
4. Drain Opening: 4-1/2" center location.
5. Basis of Design Sink Faucet: American Standard Monterrey, two handle widespread faucet with convertible rigid/swivel gooseneck spout with 5" reach and flexible underbody. Model 6542.170.
6. Basis of Design Bubbler: Chicago Faucets Model 748-665TBABCP, single hole, vandal proof metering push handle.



- D. **P-4D** Basis of Design: Single Blow drop in sink, 18 gauge stainless steel sink with faucet ledge and integral flow system.

1. Just SL-ADA-2017-A-GR; 14" X 14" inside bowl dimensions.
2. ADA bowl depth: 6 1/2".
3. Drain Opening: 4-1/2" rear center location.
4. Basis of Design Sink Faucet: same as P-4C.



2.6 SHOWERS

- A. **P-5** Future

2.7 LAUNDRY BASIN

- A. Mop Basin Manufacturers:

1. Zurn
2. Fiat
3. Stern William

- B. Faucet Manufacturers:
1. Zurn
 2. Chicago Faucet
- C. **P-6** Basis of Design: Single compartment, multi-purpose sink. Molded polypropylene, seamless corners and edges, floor mounted equipped with coated steel, self leveling legs.
1. Basis of Design P-2 Faucet: Zurn Model 826B1-XL-140. Chrome plated, integral shank, quarter turn ceramic disc cartridges and a centerline swing gooseneck spout, 2.2 GPM pressure compensating aerator, vandal resistant color coded metal lever handles, mounting hardware and stainless steel flex connection hoses. Restricted 140 degree spout has a 5 3/8" throat.



2.8 BOTTLE FILLING STATION

- A. Manufacturers
1. Halsey Taylor.
 2. Elkay Manufacturing Co.
 3. Haws Corporation.
- B. **EWC-1** Basis of Design: Unit shall include electric water cooler with bottle filling station. Elkay Model LZS8WS shall deliver 8 GPH of 50°F drinking water at 90°F ambient and 80°F inlet water. Lower unit shall have push bar activation. Bottle filling unit shall include an electronic sensor for touchless activation with auto 20-second shut-off timer. Shall include Green Ticker™ displaying count of plastic bottles saved from waste. Bottle filler shall provide 1.1-1.5 gpm flow rate with laminar flow to minimize splashing. Shall include the WaterSentry® Plus 3000-gallon capacity filter, certified to NSF/ANSI 42 and 53, with visual monitor to indicate when replacement is necessary. Shall include integrated silver ion anti-microbial protection in key areas.
1. Unit shall meet ADA guidelines.
 2. Unit shall be a lead-free design which is certified to NSF/ANSI 61 and 372 and meets Federal and State low-lead requirements.
 3. Unit shall be certified to UL399 and CAN/CSA 22.2 No. 120 & is FCC compliant.
 4. Electrical 115/1/60, 4.2FLA.



2.9 EMERGENCY PLUMBING FIXTURES

A. Manufacturers

1. Bradley Corporation
2. Encon Safety Products
3. Guardian Equipment Co.
4. Haws Corporation.
5. Speakman Co.
6. Chicago Faucets

B. ANSI Standard: Comply with ANSI Z358.1-2009, "Emergency Eyewash and Shower Equipment." Comply with requirements in ICC A117.1, "Accessible and Usable Buildings and Facilities"; Public Law 90-480, "Architectural Barriers Act"; and Public Law 101-336, "Americans with Disabilities Act"; for plumbing fixtures for people with disabilities.

C. In an emergency situation one's vision may be impaired. Therefore, emergency equipment requires what ANSI describes as a "highly visible sign." This signage shall be provided in close proximity to the emergency equipment for quick identification. Provide signage per ANSI Z358 requirements.

D. **DH-1** Deck Mount Hand-Held Hose Spray – Bradley Model S19-460EFW



1. Quick-access emergency eye/face spray features soft-flow dual spray-heads for flooding large areas as well as eyes only. Self-coiling hose retracts for easy storage while allowing instant extension in emergency situations. Hand-held hose sprayhead shall contain an antimicrobial agent to protect the sprayhead. Operating range is 30–90 psi. Flow rate is 3.9–5.9 GPM.
2. Eye/Face Spray: Perforated sprayhead is ABS plastic and features soft-flow sprayhead for flooding large areas as well as eyes only. Includes protective sprayhead cover. Integral flow control assures safe, steady flow under varying water supply conditions.
3. Valve: Chrome-plated brass with extended handle stays open once handle is squeezed.
4. Drench Hose: 8' yellow reinforced thermoplastic hose has 3/8" NPT male thread. Burst strength is 450 PSI.

E. Thermostatic Mixing Valves (TMV)

1. Tepid flushing fluid is considered necessary in all types of emergency equipment applications. Tepid is defined in ANSI Z358 as a flushing fluid temperature conducive to promoting a minimum 15-minute irrigation period. A suitable range is 60°F to 100°F. Generally, temperatures higher than 100 degrees Fahrenheit may cause chemical interactions with the skin and result in further damage. At 60 degrees Fahrenheit and below hypothermia becomes a concern. The Owner's safety/ health advisor shall provide a determination of the best temperature parameters; absent this information, set the temperature at 85°F.
2. Provide a liquid-filled unit-mounted dial thermometer, providing tepid, potable water, maintaining temperature at plus or minus 5°F for required 15-minute test period, and in case of unit failure to continue cold-water flow, with associated corrosion-resistant housing and fittings.
3. TMV #-01: Thermostatic Mixing Valve for Eyewash and Eye/Face Wash Units: Basis of Design Manufacturer/Model: Bradley, Navigator Emergency Thermostatic Mixing Valve S19-2000 EFX-8. Supply Connections: 1/2" hot and cold water. Flow Capacity: 7 gpm at 30 psi. Finish: Rough bronze

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine roughing-in for water soil and for waste piping systems and supports to verify actual locations and sizes of piping connections and that locations and types of supports match those indicated, before plumbing fixture installation. Use manufacturer's roughing-in data if roughing-in data are not indicated.
- B. Examine walls, floors, and cabinets for suitable conditions where fixtures are to be installed.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FIXTURE INSTALLATION - GENERAL

- A. Assemble and support fixtures, trim, fittings, and other components according to manufacturers' written instructions.

- B. Install fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.
- C. Install water-supply piping with stop on each supply to each fixture to be connected to water distribution piping. Attach supplies to supports or substrate within pipe spaces behind fixtures. Install stops in locations where they can be easily reached for operation.
- D. Install traps on fixture outlets as required.
- E. Install escutcheons at piping wall ceiling penetrations in exposed, finished locations and within cabinets and millwork. Use deep-pattern escutcheons if required to conceal protruding fittings. Refer to Division 22 Section "Common Work Results for Plumbing" for escutcheons.
- F. Set shower receptors, and mop service basins in leveling bed of cement grout. Refer to Division 22 Section "Common Work Results for Plumbing" for grout.
- G. Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to fixture color.

3.3 WATER CLOSET & URINAL INSTALLATION

- A. Water-Closet Installation:
 - 1. Install level and plumb according to roughing-in drawings.
 - 2. Install floor-mounted water closets on bowl-to-drain connecting fitting attachments to piping or building substrate.
 - 3. Install accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.
- B. Support Installation:
 - 1. Install supports, affixed to building substrate, for floor-mounted, back-outlet water closets.
 - 2. Use carrier supports with waste-fitting assembly and seal.
 - 3. Install floor-mounted, back-outlet water closets attached to building floor substrate, onto waste-fitting seals; and attach to support.
 - 4. Install wall-mounted, back-outlet water-closet supports with waste-fitting assembly and waste-fitting seals; and affix to building substrate.
- C. Flushometer-Valve Installation:
 - 1. Install flushometer-valve, water-supply fitting on each supply to each water closet.
 - 2. Attach supply piping to supports or substrate within pipe spaces behind fixtures.
 - 3. Install lever-handle flushometer valves for accessible water closets with handle mounted on open side of water closet.
 - 4. Install actuators in locations that are easy for people with disabilities to reach.
 - 5. Install fresh batteries in battery-powered, electronic-sensor mechanisms.
- D. Install toilet seats on water closets.

- E. Wall Flange and Escutcheon Installation:
 - 1. Install wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork.
 - 2. Install deep-pattern escutcheons if required to conceal protruding fittings.
- F. Joint Sealing:
 - 1. Seal joints between water closets and walls and floors using sanitary-type, one-part, mildew-resistant silicone sealant.
 - 2. Match sealant color to water-closet color.
 - 3. Comply with sealant requirements specified in Division 9.

3.4 SINKS AND LAVATORIES

- A. Install faucet-spout fittings with specified flow rates and patterns in faucet spouts if faucets are not available with required rates and patterns. Include adapters if required.

3.5 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Use chrome-plated brass or copper tube, fittings, and valves in locations exposed to view. Plain copper tube, fittings, and valves may be used in concealed locations.
- C. Supply and Waste Connections to Plumbing Fixtures: Connect fixtures with water supplies, stops, risers, traps, and waste piping. Use size fittings required to match fixtures. Connect to plumbing piping.
- D. Provide plumbing hookups to Fixtures and Equipment Specified in Division 11 "Residential Appliances". Connect fixtures and equipment with water supplies Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

3.6 FIELD QUALITY CONTROL

- A. Verify that installed fixtures are categories and types specified for locations where installed.
- B. Check that fixtures are complete with trim, faucets, fittings, and other specified components.
- C. Inspect installed fixtures for damage. Replace damaged fixtures and components.
- D. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.
- E. Water-Cooler Testing: After electrical circuitry has been energized, test for compliance with requirements. Test and adjust controls and safeties. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

- F. Install fresh batteries in sensor-operated mechanisms.

3.7 ADJUSTING

- A. Operate and adjust fixtures. Replace damaged and malfunctioning fixtures.
- B. Adjust water pressure to produce proper flow and stream.
- C. Emergency plumbing fixtures: adjust to approximately 85°F temperature.
- D. Replace washers and seals of leaking and dripping faucets and stops.
- E. Water coolers: Adjust fixture flow regulators for proper flow and stream height. Adjust water-cooler temperature settings.

3.8 CLEANING

- A. After completing fixture installation, inspect unit. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. Clean fixtures and other fittings with manufacturers' recommended cleaning methods and materials. Remove faucet spouts and strainers, remove sediment and debris, and reinstall strainers and spouts. Remove sediment and debris from drains.
- C. Clean fixtures, on completion of installation, according to manufacturer's written instructions.

3.9 PROTECTION

- A. Provide protective covering for installed fixtures and fittings.
- B. Do not allow use of fixtures for temporary facilities unless allowed in Division 1.

END OF SECTION 224000

SECTION 230500 – COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. This section applies to Division 21, 22, & 23 sections.
- C. Division 1 - Sustainable Design Requirements - LEED for New Construction and Major Renovations. Provide general requirements and procedures for compliance with certain USGBC LEED prerequisites and credits needed.

1.2 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.
- F. This contractor will be responsible to carry out the commissioning requirements specified. Refer to Division 1 for additional requirements. The following systems will be commissioned:
 - 1. ERV
 - 2. Variable Refrigerant Flow systems
 - 3. Unit Heaters
 - 4. Fans
 - 5. CO2 demand control ventilation and VAV boxes

6. Elevator sump pump
7. The CxA shall verify that the HVAC DDC interface and sequences functions properly
8. Domestic hot water and recirculation temperature maintenance

1.3 EFFICIENCY MAINE

- A. This project intends to pursue Efficient Maine prescriptive and/or custom incentives. The contractor shall participate in the activities associated with Efficiency Maine incentive approval process including but not limited to; preparation and submission of required incentive applications and the tracking and submission of measure specific invoices to Efficiency Maine within 60 days of the completion of the work.
- B. The contractor shall also:
 1. Become familiar with the Efficiency Maine Business Program including available incentives and the application and review process.
 2. Review plans and specifications for compliance with Efficiency Maine standards for applicable systems and technologies.
 3. Review plans and specifications for any and all incentive opportunities.
- C. The project schedule shall reflect and accommodate the time required to achieve application pre-approval from Efficiency Maine (EM). No equipment shall be purchased until pre-approval is received from EM.
- D. All invoices shall be forwarded to EM within 60 days of the completion of work. This deliverable shall be shown on the project schedule as a milestone date and coordinated with all contractors to assure compliance with this requirement.
- E. Efficiency Maine is available to assist in the application process and can be reached at 866-376-2463. Contractor must contact EM prior to submittals to review the project equipment and scope. <http://www.energymaine.com/at-work/ci-prescriptive-incentive-program/>

- F. As a minimum, seek to obtain rebates for the following:



Effective 1/1/17 - 3/31/17

Variable Refrigerant Flow Systems

\$0.50/sq. ft.

VFDs for HVAC

\$ 400-\$2,300 per unit
(incentive varies by
system horsepower)

1.4 DEFINITIONS

- A. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.
- B. "Install": Operations at Project site including unloading, temporarily storing, unpacking, assembling, erecting, placing, anchoring, applying, working to dimension, finishing, curing, protecting, cleaning, and similar operations.
- C. "Provide": Furnish and install, complete and ready for the intended use.
- D. "Shall": The word shall is used to indicate mandatory requirements strictly to be followed in order to conform to the standard and procedures and from which no deviation is permitted.
- E. Finished Spaces: Spaces other than mechanical and electrical equipment rooms, furred spaces, pipe and duct shafts, unheated spaces immediately below roof, spaces above ceilings, unexcavated spaces, crawlspaces, and attics.
- F. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

- G. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.
- H. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.
- I. 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.
- J. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

1.5 SUBMITTALS

- A. Provide in accordance with Division 1 of the specifications.

1.6 SUBSTITUTIONS

- A. Provide in accordance with Division 1 of the specifications.

1.7 QUALITY ASSURANCE

- A. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications.
- B. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
- C. Steel Support Welding: Qualify processes and operators according to AWS D1.1, "Structural Welding Code--Steel."
- D. Steel Pipe Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications." Comply with provisions in ASME B31 Series, "Code for Pressure Piping." Certify that each welder has passed AWS qualification tests for welding processes involved and that certification is current.
- E. Electrical Characteristics for Equipment: Equipment of higher electrical characteristics may be furnished provided such proposed equipment is approved in writing and connecting electrical services, circuit breakers, and conduit sizes are appropriately modified. If minimum energy ratings or efficiencies are specified, equipment shall comply with requirements.
- F. The Contractor shall hold a license to perform the work as issued by the local jurisdiction.
- G. Plumbing work shall be performed by, or under, the direct supervision of a licensed master plumber.
- H. Electrical work shall be performed by, or under, the direct supervision of a licensed electrician.

- I. Compatibility of Options: If Contractor is given option of selecting between two or more products for use on Project, product selected shall be compatible with products previously selected, even if previously selected products were also options.
 - 1. Each contractor is responsible for providing products and construction methods compatible with products and construction methods of other contractors.
 - 2. If a dispute arises between contractors over concurrently selectable but incompatible products, Engineer will determine which products shall be used.

1.8 PRODUCT DELIVERY, STORAGE, AND HANDLING

- A. Provide in accordance with Division 1 - Product Requirements.
- B. Piping:
 - 1. Pipe and tube required by the applicable standard to be cleaned and capped shall be delivered to the job site with factory-applied end-caps. Maintain end-caps through shipping, storage, and handling to prevent pipe-end damage and prevent entrance of dirt, debris, and moisture.
 - 2. Protect stored pipe and tube from moisture and dirt. Elevate above grade. When stored inside, do not exceed the structural capacity of the floor.
 - 3. Protect fittings, flanges, and piping specialties from moisture and dirt.
 - 4. Store plastic pipes protected from direct sunlight. Support to prevent sagging and bending.

1.9 COORDINATION

- A. Coordinate use of project space and sequence of installation of mechanical and electrical work, which is indicated diagrammatically on drawings. Follow routings shown for pipes, ducts, and conduits as closely as practicable, with due allowance for available physical space; make runs parallel with lines of building. Utilize space efficiently to maximize accessibility for other installations, for maintenance, and for repairs.
- B. Coordinate use of project space and sequence of installation of work.
- C. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for installations. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.
- D. Access panels shall be provided for concealed valves and controls, or any item requiring inspection or maintenance. Access panels shall be of sufficient size and located so that the concealed items may be serviced, maintained, or replaced. Access panels and doors are specified in Division 8.

1.10 TEST ADJUST AND BALANCE READINESS

- A. The Contractor shall provide and coordinate the services of qualified, responsible sub-contractors, 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.
- B. 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.
- C. 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.
- D. 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.
- E. 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).
2. 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.
 3. Automatic 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 Contractor prior to the TAB beginning.

1.11 RENOVATION PROJECTS

- A. 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.
- B. 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.
- C. 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. Refer to “General Conditions of the Contract for Construction” for temporary facilities for additional contract requirements. Schedules for various phases of contract work shall be coordinated with all other trades and with Owner’s Representative. Provide, as part of contract, temporary plumbing and mechanical and electrical connections and relocations as required to accomplish the above.
- D. 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.

PART 2 - PRODUCT

2.1 PRODUCT CRITERIA

- A. Standard Products: Material and equipment shall be the standard products of a manufacturer regularly engaged in the manufacture of the products for at least 3 years. See other specification sections for any exceptions.
- B. Equipment Service: Products shall be supported by a service organization that maintains a complete inventory of repair parts and is located reasonably close to the site.
- C. Multiple Units: When two or more units of materials or equipment of the same type or class are required, these units shall be products of one manufacturer.
- D. Assembled Units: Manufacturers of equipment assemblies, which use components made by others, assume complete responsibility for the final assembled product.
- E. Nameplates: Nameplate bearing manufacturer's name or identifiable trademark shall be securely affixed in a conspicuous place on equipment, or name or trademark cast integrally with equipment, stamped or otherwise permanently marked on each item of equipment.
- F. Asbestos products or equipment or materials containing asbestos shall not be used.

2.2 PIPE JOINING MATERIALS

- A. Refer to individual Division 22 and 23 piping Sections for pipe, tube, and fitting materials and joining methods. Refer to individual piping Sections for special joining materials not listed below.
- B. Pipe Threads: ASME B1.20.1 for factory-threaded pipe and pipe fittings.
- C. 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. Full-Face Type: For flat-face, Class 125, cast-iron and cast-bronze flanges. 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.
- D. Flange Bolts and Nuts: ASME B18.2.1, carbon steel, unless otherwise indicated.
- E. Mechanical Coupling Gasket Materials: Suitable for the chemical and thermal conditions of the piping system contents and exterior environment. Gasket design shall be such that the entire

coupling housing is isolated from the system contents to prevent galvanic action and inhibit galvanic corrosion.

- F. Plastic, Pipe-Flange Gasket, Bolts, and Nuts: Type and material recommended by piping system manufacturer, unless otherwise indicated.
- G. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.
- H. Brazing Filler Metals: AWS A5.8, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated; and AWS A5.8, BAgl, silver alloy for refrigerant piping, unless otherwise indicated.
- I. Welding Filler Metals: Comply with AWS D10.12 for welding materials appropriate for wall thickness and chemical analysis of steel pipe being welded.
- J. Solvent Cements for Joining Plastic Piping: CPVC Piping: ASTM F 493. PVC Piping: ASTM D 2564. Include primer according to ASTM F 656.

2.3 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. Underground Piping NPS 1-1/2 and Smaller: Manufactured fitting or coupling. Underground Piping NPS 2 and Larger: AWWA C219, metal sleeve-type coupling. Aboveground Pressure Piping: Pipe fitting.
- 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. Flexible Transition Couplings for Underground Non-pressure Drainage Piping: ASTM C 1173 with elastomeric sleeve; ends same size as piping to be joined, and corrosion-resistant metal band on each end.

2.4 DIELECTRIC FITTINGS

- A. Provide where copper tubing and ferrous metal pipe are joined.
- B. Fittings shall match piping specifications. Threaded dielectric union, ANSI B16.39. Watts Series LF3000 (lead free) or approved equal. Flange union with dielectric gasket and bolt sleeves, ANSI B16.42. Dielectric flange fittings: Watts Series LF3100.

2.5 MECHANICAL SLEEVE SEALS

- A. Description: Modular sealing element unit, designed for field assembly, to fill annular space between pipe and sleeve; Thunderline Link-Seal, or approved equal.
 - 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: Glass-reinforced nylon.
3. Connecting Bolts and Nuts: Stainless steel, of length required to secure pressure plates to sealing elements.

2.6 ESCUTCHEONS

- A. Escutcheons shall be manufactured from nonferrous metals and shall be chrome-plated. Metals and finish shall conform to ASME A112.19.2. Escutcheons shall be one-piece type where mounted on chrome-plated pipe or tubing, and one-piece of split-pattern type elsewhere. ID shall closely fit around pipe, tube, and insulation of insulated piping and an OD that completely cover the opening.
- B. All escutcheons shall have setscrews for maintaining a fixed position against a surface.

2.7 GROUT

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

2.8 ROOFING

- A. Coordinate roofing with Division 7.

2.9 MOTORS

- A. Motor Characteristics
 1. Motors 1/2 HP and Larger: Three phase.
 2. Motors smaller than 1/2 HP: Single phase.
 3. Frequency Rating: 60 Hz.
 4. Voltage Rating: NEMA standard voltage selected to operate on nominal circuit voltage to which motor is connected.
 5. Service Factor: 1.15 for open drip proof motors; 1.0 for totally enclosed motors.
 6. Duty: Continuous duty at ambient temperature of 105 deg F and at altitude of 3300 feet above sea level.
 7. 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.
 8. Enclosure: as specified.

B. Polyphase Motors

1. Description: NEMA MG 1, Design B, medium induction motor.
2. Efficiency: Premium efficiency ratings shall meet or exceed the NEMA Premium qualifying efficiencies. Efficiencies shall be eligible for utility rebates. For example, 1800-RPM ODP minimum required efficiency for a 7.5 HP motor is 91.0%
3. Stator: Copper windings, unless otherwise indicated. Multispeed motors shall have separate winding for each speed.
4. Rotor: Squirrel cage, unless otherwise indicated.
5. Bearings: Double-shielded, pre-lubricated ball bearings suitable for radial and thrust loading.
6. Temperature Rise: Match insulation rating, unless otherwise indicated.
7. Insulation: Class F, unless otherwise indicated.
8. Motors Used with Reduced-Inrush Controllers: Match wiring connection requirements for controller with required motor leads. Provide terminals in motor terminal box, suited to control method.

C. Single-Phase Motors

1. Type: One of the following, to suit starting torque and requirements of specific motor application: Permanent-split capacitor, Split-phase start, capacitor run, Capacitor start, capacitor run.
2. Shaded-Pole Motors: For motors 1/20 hp and smaller only.
3. 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.
4. Bearings: Ball type for belt-connected motors and other motors with high radial forces on motor shaft; sealed, pre-lubricated-sleeve type for other single-phase motors.

D. Motors Used with Variable Frequency Controllers: Ratings, characteristics, and features coordinated with and approved by controller manufacturer.

1. Provide AEGIS® Shaft Grounding Ring (SGR) on either DE or NDE of motor to divert current away from the bearings and protect bearings in attached equipment.
2. 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.
3. Energy- and Premium-Efficient Motors: Class B temperature rise; Class F insulation.
4. Inverter-Duty Motors: Class F temperature rise; Class H insulation.
5. Thermal Protection: Comply with NEMA MG 1 requirements for thermally protected motors.

2.10 VIBRATION ISOLATION

- A. All equipment shall be isolated to prevent vibration transmission to the building structure.

PART 3 - EXECUTION

3.1 DEMOLITION AND REMOVALS

- A. Refer to Division 1 for general demolition requirements and procedures.
- B. Disconnect, demolish, and remove plumbing and mechanical systems, equipment, and components indicated to be removed.

3.2 COMMON REQUIREMENTS

- A. Install piping, ductwork, and equipment to allow maximum possible headroom unless specific mounting heights are indicated. Install equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.
- B. Install equipment to facilitate service, maintenance, and repair or replacement of components. Connect equipment for ease of disconnecting, with minimum interference to other installations. Extend grease fittings to accessible locations.
- C. Coordinate location of piping, sleeves, inserts, hangers, ductwork and equipment. Locate piping, sleeves, inserts, hangers, ductwork and equipment clear of windows, doors, openings, light outlets, and other services and utilities. Follow manufacturer's published recommendations for installation methods not otherwise specified.
- D. Any structural member weakened or impaired by cutting, notching, or otherwise shall be reinforced, repaired, or replaced so as to be left in safe structural condition in accordance with the local building code requirements.
- E. Install piping and ductwork in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.
- F. 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.
- G. Install systems above accessible ceilings to allow sufficient space for ceiling panel removal.
- H. Install piping to permit valve servicing.
- I. Install equipment and other components to allow right of way for piping installed at required slope.
- J. Install free of sags and bends.

- K. Provide unions or flanges at connections to equipment.
- L. Install fittings for changes in direction and branch connections.
- M. Make allowances for application of insulation.
- N. Select system components with pressure rating equal to or greater than system operating pressure.
- O. Verify final equipment locations for roughing-in.
- P. Protection and Cleaning: Equipment and materials shall be carefully handled, properly stored, and adequately protected to prevent damage before and during installation, in accordance with the manufacturer's recommendations. Damaged or defective items shall be replaced. Protect all finished parts of equipment. Close duct and pipe openings with caps or plugs during installation. Tightly cover and protect fixtures and equipment against dirt, water, chemical, or mechanical injury. At completion of all work thoroughly clean fixtures, exposed materials and equipment.

3.3 PIPING JOINT CONSTRUCTION

- A. Join pipe and fittings according to the following requirements and the relevant specification section specifying piping systems.
- B. Ream ends of pipes and tubes and remove burrs. Bevel or groove 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. Only brazing alloys having a liquid temperature above 1000°F shall be used.
- 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: Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.
- G. Welded Joints: Construct joints according to AWS D10.12, using qualified processes and welding operators according to Part 1 "Quality Assurance" Article.
- H. Flanged Joints: Select appropriate gasket material, size, type, and thickness for service application. Install gasket concentrically positioned. Use suitable lubricants on bolt threads.

- I. Plastic Piping Solvent-Cement Joints: Clean and dry joining surfaces. Join pipe and fittings according to the following:
 - 1. Comply with ASTM F 402 for safe-handling practice of cleaners, primers, and solvent cements.
 - 2. CPVC Piping: Join according to ASTM D 2846/D 2846M Appendix.
 - 3. PVC Pressure Piping: Join schedule number ASTM D 1785, PVC pipe and PVC socket fittings according to ASTM D 2672. Join other-than-schedule-number PVC pipe and socket fittings according to ASTM D 2855.
 - 4. PVC Non-pressure Piping: Join according to ASTM D 2855.
- J. Plastic Pressure Piping Gasketed Joints: Join according to ASTM D 3139.
- K. Plastic Non-pressure Piping Gasketed Joints: Join according to ASTM D 3212.

3.4 PIPE PENETRATIONS

- A. Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed.
- B. Refer to Section 230700 "Mechanical Insulation".
- C. Sleeve Clearance: Sleeve through floors, walls, partitions, and beam flanges shall be one inch greater in diameter than external diameter of pipe. Sleeve for pipe with insulation shall be large enough to accommodate the insulation.
- D. Install sleeves for pipes passing through concrete and masonry walls and concrete floor and roof slabs. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.
 - 1. Cut sleeves to length for mounting flush with both surfaces.
 - 2. Install sleeves in new walls and slabs as new walls and slabs are constructed.
 - 3. Install steel pipe sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation.
 - 4. Sleeves are not required in drywall construction.
 - 5. Sleeves are not required for core-drilled holes. Piping through concrete or masonry shall not be subject to any load from the building construction.
- E. Exterior-Wall Pipe Penetrations:
 - 1. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at service piping entries into building.
 - 2. Select type, size, and number of sealing elements required for piping material and size and for sleeve ID or hole size. Position piping in center of sleeve. Center piping in penetration, assemble sleeve-seal system components, and install in annular space between piping and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make a watertight seal.
- F. Escutcheons: Provide for penetrations in finished spaces where pipes are exposed.

- G. Plastic and copper piping penetrating framing members, and within one-inch of the framing, shall be protected with 10-gauge steel nailing plates. The steel plate shall extend along the framing member a minimum of 1.5” beyond the OD of the pipe or tubing.

3.5 PIPING CONNECTIONS

- A. Make connections according to the following, unless otherwise indicated: Install unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment. Install flanges or Victaulic couplings, in piping NPS 2-1/2 and larger, adjacent to flanged or grooved-ended valves and at final connection to each piece of equipment. Provide dielectric fittings at connection between copper and ferrous metal.

3.6 ERECTION OF WOOD SUPPORTS AND ANCHORAGES

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

3.7 GROUTING

- A. Provide in accordance with Division 3.
- B. Mix and install grout for equipment base bearing surfaces, pump and other equipment base plates, and anchors. Clean surfaces that will come into contact with grout. Provide forms as required for placement of grout. Avoid air entrapment during placement of grout. Place grout, completely filling equipment bases. Place grout on concrete bases and provide smooth bearing surface for equipment. Place grout around anchors. Cure placed grout.

3.8 ERECTION OF METAL SUPPORTS AND ANCHORAGES

- A. Provide in accordance with Division 5.
- B. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor materials and equipment. Field Welding: Comply with AWS D1.1.

3.9 FIRESTOPPING

- A. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with fire stop materials. Refer to Division 7 for materials. Seal all penetrations through fire-or smoke-rated wall, partition, ceiling, or roof assemblies with firestopping system. Refer to Architectural plans for location of rated assemblies. Refer to Division 7 for firestopping systems.

3.10 PAINTING

- A. Painting of plumbing and mechanical systems, equipment, and components is specified in Division 9.
- B. Damage and Touchup: Repair marred and damaged factory-painted finishes with materials and procedures to match original factory finish.

3.11 CONCRETE HOUSEKEEPING PADS

- A. Provide in accordance with Division 3.
- B. Coordinate size, thickness, doweling, and reinforcing of concrete equipment housekeeping pads and piers with vibration isolation and seismic restraint device manufacturer to ensure adequate space, embedment and prevent edge breakout failures. Construct concrete bases not less than 4 inches larger in both directions than supported unit.
- C. Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors.
- D. Provide 4" high (+/-) housekeeping pads for the following:
 - 1. Domestic water heaters

3.12 ROOFING

- A. Refer to Division 7.
- B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

3.13 PROJECT CLOSEOUT

- A. Provide Demonstration and Training in accordance Division 1.
- B. Provide Project Record Documents in accordance with Division 1.
- C. Follow Closeout procedures as per Division 1.
- D. Provide Operation and Maintenance information in accordance with Division 1.

END OF SECTION 230500

SECTION 230516 - BRAIDED EXPANSION LOOPS AND FITTINGS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Division 23 Section "Common Work Results for Mechanical"

1.2 SUMMARY

- A. This Section includes braided pipe expansion loops.

1.3 PERFORMANCE REQUIREMENTS

- A. Compatibility: Products suitable for piping system fluids, materials, working pressures, and temperatures.

1.4 SUBMITTALS

- A. Product Data: For each type of expansion fitting indicated.
- B. Schedule: Indicate manufacturer's number, size, location, and features for each expansion fitting and loop.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Metraflex Co (Basis of Design).
 - 2. Flex Hose Co., Inc.
 - 3. Flexicraft

2.2 BRAIDED EXPANSION LOOPS

- A. Provide flexible expansion loops of size and type noted on drawings; Metraflex Metraloop expansion joints, or approved equal. Flexible loops shall consist of two flexible sections of hose and braid, two 90° elbows, and a 180° return assembled in such a way that the piping does not change direction, but maintains its course along a single axis. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180° return, and a drain/air release plug.
- B. Flexible loops shall impart no thrust loads to system support anchors or building structure. Loops shall be installed in a neutral, pre-compressed or pre-extended condition as required for the application.
- C. Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings.
- D. Size for 3" movement in all directions.
- E. All piping passing through building seismic joints shall contain a flexible expansion loop designed for seismic movement. Flexible loops shall be located at, or near the building seismic joint. A vertical support hanger, located within 4 pipe diameters, shall be installed on each side of the flexible loop.
- F. Flexible loops attached to fuel gas lines, shall be specifically manufactured for fuel gas applications and certified by the American Gas Association.
- G. Flexible loops for use in domestic water applications shall be NSF approved for potable service and shall be certified lead free.
- H. Flexible loops used for sanitary waste service shall incorporate a cleanout fitting at the base and shall be lined to minimize sediment collection.

2.3 ANCHORS

- A. Metraflex Model PA anchor clamp, or approved equal. Provide light weight anchor for low load; compatible with braided expansion loop manufactures recommendations for "no thrust" expansion joints. Clamps to pipe.

2.4 GUIDES

- A. Metraflex Model PGIV shall be of the radial type employing a heavy wall guide cylinder with weld down or bolt down anchor base. A two section guide spider, having 1/8" maximum diametrical clearance with guide cylinder inside diameter, bolted or welded tight to the carrier pipe which slides through the guide cylinder I.D. Cylinder shall be of sufficient size to clear pipe insulation and long enough to prevent over travel of the spider.

2.5 MISCELLANEOUS MATERIALS

- A. Structural Steel: ASTM A 36/A 36M.
- B. Bolts and Nuts: ASME B18.10 or ASTM A 183, steel, hex head; ASTM F 844, steel, plain, flat washers.
- C. Mechanical Fasteners: Insert-wedge-type stud with expansion plug anchor for use in hardened Portland cement concrete, and tension and shear capacities appropriate for application. Stud: Threaded, zinc-coated carbon steel. Expansion Plug: Zinc-coated steel. Washer and Nut: Zinc-coated steel.
- D. Chemical Fasteners: Insert-type-stud bonding system anchor for use with hardened Portland cement concrete, and tension and shear capacities appropriate for application. Bonding Material: ASTM C 881, Type IV, Grade 3, two-component epoxy resin suitable for surface temperature of hardened concrete where fastener is to be installed. Stud: ASTM A 307, zinc-coated carbon steel with continuous thread on stud, unless otherwise indicated; Washer and Nut: Zinc-coated steel.
- E. Concrete: Portland cement mix, 3000 psi minimum. Refer to Division 3 Section "Cast-in-Place Concrete" for formwork, reinforcement, and concrete.

PART 3 - EXECUTION

3.1 BRAIDED EXPANSION LOOP INSTALLATION

- A. Install expansion fittings according to manufacturer's written instructions.
- B. Install expansion fittings in sizes matching pipe size in which they are installed.
- C. Align expansion fittings to avoid end-loading and torsional stress.
- D. Loops can be installed in a neutral, pre-compressed or pre-extended condition as required for the application.
- E. A pipe guide shall be installed anywhere within 15 pipe diameters on each side of the braided expansion loop. Loops anchored on one side need only one guide on the traveling side. Attach guides to pipe and secure to building structure.
- F. Install pipe anchors according to expansion fitting manufacturer's written instructions.
 - 1. Install anchors at locations to prevent stresses from exceeding those permitted by ASME B31.9 and to prevent transfer of loading and stresses to connected equipment.
 - 2. Steel Anchors: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
 - 3. Concrete Anchors: Attach by fasteners. Follow fastener manufacturer's written instructions.

- G. Each hanger to be transversely and longitudinally braced per local codes. Seismic bracing shall not pass through building seismic joint and shall not connect or tie together different sides or parts of building structure. Flexible loops shall be capable of 4" of movement in the X, Y, and Z planes.

3.2 BRAIDED EXPANSION LOOP APPLICATION SCHEDULE

- A. Domestic Water Service: Copper fittings and sweat ends with bronze hose and braid, NSF Approved, certified lead free.
- B. Hydronic Heating Service (Includes drain pan condensate drain piping): Copper fittings and sweat ends with bronze hose and braid.
- C. Sanitary waste and vent (Metraflex "PoopLoop"): 304SS fittings and flanged ends with 304SS steel hose and braid. Provide long radius elbows and cleanout tee.

END OF SECTION 230516

SECTION 230519 – THERMOMETERS AND PRESSURE GAUGES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section “Common Work Results for Mechanical”
 - 2. Mechanical equipment Sections that specify meters and gauges as part of factory-fabricated equipment.

1.2 SUMMARY

- A. This Section includes thermometers and pressure gauges.

1.3 ACTION SUBMITTALS

- A. Product Data: Include scale range, ratings, and calibrated performance curves for each gauge, fitting, specialty, and accessory specified.

1.4 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ashcroft
 - 2. Weksler
 - 3. Ernst Gauge Co.
 - 4. Terice: H. O. Terice Co.
 - 5. Weiss Instruments, Inc.

2.2 THERMOMETERS

- A. Liquid-In-Glass Industrial Thermometers: shall be a blue reading (Fill Type Spirit: Blue colored, organic) liquid-in-glass adjustable angle type, 9" scale, cast aluminum case with cured polyester powder coating, clear acrylic window and brass separable thermowell. Thermometers will be Trerice BX9 Series or approved equal.
- B. Scale Range: Temperature ranges for services listed are as follows: The proper range will be selected so that the operating temperature of the material being measured will fall approximately in the middle of the scale.
1. Domestic Hot Water: 30 to 180 deg F, with 2-degree scale divisions.
 2. Domestic Cold Water: 0 to 100°F, with 1°F scale divisions.
 3. Heating Hot Water: 30 to 180°F, with 2°F scale divisions.
- C. Thermowells: Provide fitting with protective socket for installation in threaded pipe fitting to hold fixed thermometer stem.
1. Material: Brass, for use in copper piping.
 2. Material: Stainless steel, for use in steel piping.
 3. Where insulation thickness exceeds 2", a longer stem thermometer will be used with an extension neck brass separable thermowell. The extension neck will be at least 2" long.
 4. Thermometers for measuring fluid temperatures will have stems with insertion lengths of roughly half of the pipe diameter; minimum insertion length will be 2".
 5. Cap: Threaded, with chain permanently fastened to socket. Heat-Transfer Fluid: Mixture of graphite and glycerin.

2.3 PRESSURE GAUGES

- A. Pressure gauges shall be 3½" dial size with a flangeless cast aluminum case, stainless steel friction ring and glass window. Movement will be brass with a bronze bourdon tube and brass socket. Dial face will be white with black figures; pointer will be friction adjustable type. Accuracy shall be ±1% of scale range, ASME B40.1 Grade 1A. Pressure gauges will be Trerice No. 600CB approved equal.
1. Connector: Brass, NPT 1/4.
 2. Units of Measure: PSI
 3. Provide silicone-damped movement.
 4. Range: The proper range shall be selected so that the average operating pressure falls approximately in the middle of the scale selected.
 5. Install pressure-gauge needle valve and snubber (Trerice No. 872 pressure snubbers) in piping to pressure gauges; ASME B40.5, NPS 1/4 brass bushing with corrosion-resistant porous-metal disc of material suitable for system fluid and working pressure.
 6. Needle Valves: Trerice 735 Series; NPS 1/4 brass or 316 stainless steel needle type.
- B. Scale Range: Pressure ranges for services listed are as follows: The proper range will be selected so that the operating pressure of the material being measured will fall approximately in the middle of the scale.

1. Domestic Hot Water: 0 to 100 psi
2. Domestic Cold Water: 0 to 100 psi.
3. Heating Hot Water: 0 to 60 psi.

PART 3 - EXECUTION

3.1 GAUGE INSTALLATION, GENERAL

- A. Install according to manufacturer's written instructions for applications where used.

3.2 THERMOMETER INSTALLATION

- A. Install thermometers and adjust vertical and tilted positions.
- B. Install thermowells with extension on insulated piping.
- C. Install separable sockets in vertical position in piping tees.

3.3 PRESSURE-GAUGE INSTALLATION

- A. Install pressure gauges in piping tees with pressure-gauge valve located on pipe at most readable position.
- B. Install valve and snubber in piping for each pressure gage for fluids.

3.4 CONNECTIONS

- A. Piping installation requirements are specified in other Division 22 and 23 Sections. Drawings indicate general arrangement of piping and specialties. Install adjacent to machines and equipment to allow service and maintenance. Connect per manufacturers recommendations.

3.5 ADJUSTING AND CLEANING

- A. Calibrate according to manufacturer's written instructions, after installation.
- B. Adjust faces to proper angle for best visibility.
- C. Clean windows and clean factory-finished surfaces. Replace cracked and broken windows, and repair scratched and marred surfaces with manufacturer's touchup paint.

END OF SECTION 230519

SECTION 220529 - HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for Mechanical"
 - 2. Division 23 Section "Mechanical Insulation"

1.2 SUMMARY

- A. This Section includes hangers and supports for piping and equipment.

1.3 ACTION SUBMITTALS

- A. Submit product data on all hanger and support devices, including shields and attachment methods. Product data to include, but not limited to materials, finishes, approvals, load ratings, and dimensional information.
- B. Shop Drawings: Signed and sealed by a qualified professional engineer. Show fabrication and installation details and include calculations for the following; include Product Data for components:
 - 1. Trapeze pipe hangers.
 - 2. Metal framing systems.
 - 3. Pipe stands.
 - 4. Equipment supports.
- C. Delegated-Design Submittal: For trapeze hangers indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.
 - 1. Detail fabrication and assembly of trapeze hangers.
 - 2. Design Calculations: Calculate requirements for designing trapeze hangers.
 - 3. Welded steel support designs
 - 4. Structural Performance: Hangers and supports for HVAC piping and equipment shall withstand the effects of gravity loads and stresses within limits and under conditions indicated according to ASCE/SEI 7. Design supports for multiple pipes, including pipe stands, capable of supporting combined weight of supported systems, system contents, and test water. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

1.4 QUALITY ASSURANCE

- A. Provide in accordance with MSS SP69 - Manufacturers Standardization Society: Pipe Hangers and Supports- Selection and Application
- B. Steel pipe hangers and supports shall have the manufacturer's name, part number, and applicable size stamped in the part itself for identification.
- C. Pipe Hangers, Supports, and Components: The materials of all pipe hanging and supporting elements shall be in accordance with MSS SP-58.
- D. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Pipe Hangers and Supports:
 - a. B-Line Systems, Inc.
 - b. Carpenter & Patterson, Inc.
 - c. Grinnell Corp.
 - d. Hubbard Enterprises/Holdrite®
 - e. National Pipe Hanger Corp.
 - f. Piping Technology & Products, Inc.
 - g. Unistrut
 - h. Anvil International, Inc.
 - i. Empire

2.2 PIPE HANGERS AND SUPPORTS

- A. Hangers:
 - 1. Uninsulated pipes 2 inch and smaller:
 - a. Adjustable steel swivel ring (band type) hanger, B-Line B3170.
 - b. Adjustable steel swivel J-hanger, B-Line B3690.
 - c. Malleable iron ring hanger, B-Line B3198R or hinged ring hanger, B3198H.
 - d. Malleable iron split-ring hanger with eye socket, B-Line B3173 with B3222.
 - e. Adjustable steel clevis hanger, B-Line B3104 or B3100.

2. Uninsulated pipes 2-1/2 inch and larger:
 - a. Adjustable steel clevis hanger, B-Line B3100.
 - b. Pipe roll with sockets, B-Line B3114.
 - c. Adjustable steel yoke pipe roll, B-Line B3110.
 3. Insulated pipe- Hot piping:
 - a. 2 inch and smaller pipes: use adjustable steel clevis with galvanized sheet metal shield. B-Line B3100 with B3151 series.
 - b. 2-1/2 inch and larger pipes: Adjustable steel yoke pipe roll with pipe covering protection saddle. B-Line B3110 with B3160-B3165 series. Pipe roll with sockets with pipe covering protection saddle, B-Line B3114 with B3160-B3165 series.
 4. Insulated pipe- Cold piping:
 - a. 5 inch and smaller pipes: use adjustable steel clevis with galvanized sheet metal shield. B-Line B3100 with B3151 series.
 - b. 6 inch and larger pipes: Pipe roll with sockets with pipe covering protection saddle, B-Line B3114 with B3160-B3165 series. Adjustable steel yoke pipe roll with pipe covering protection saddle. B-Line B3110 with B3160-B3165 series.
- B. Pipe Clamps: When flexibility in the hanger assembly is required due to horizontal movement, use pipe clamps with weldless eye nuts, B-Line B3140 or B3142 with B3200. For insulated lines use double bolted pipe clamps, B-Line B3144 or B3146 with B3200.
- C. Multiple or Trapeze Hanger
1. Trapeze hangers shall be constructed from 12 gauge roll formed ASTM A1011 SS Grade 33 structural steel channel, 1-5/8 inch by 1-5/8 inch minimum, B-Line B22 strut or stronger as required.
 2. Mount pipes to trapeze with 2 piece pipe straps sized for outside diameter of pipe, B-Line B2000 Series.
 3. For pipes subjected to axial movement:
 - a. Strut mounted roller support, B-Line B3126. Use pipe protection shield or saddles on insulated lines.
 - b. Strut mounted pipe guide, B-Line B2417.
- D. Wall Supports
1. Pipes 4 inch and smaller:
 - a. Carbon steel hook, B-Line B3191.
 - b. Carbon steel J-hanger, B-Line B3690.

2. Pipes larger than 4 inch:
 - a. Welded strut bracket and pipe straps, B-Line B3064 and B2000 series.
 - b. Welded steel brackets, B-Line B3066 or B3067, with roller chair or adjustable steel yoke pipe roll. B-Line B3120 or B3110. Use pipe protection shield or saddles on insulated lines.
- E. Floor Supports: Hot piping under 6 inch and all cold piping: Carbon steel adjustable pipe saddle and nipple attached to steel base stand sized for pipe elevation. B-Line B3093 and B3088T or B3090 and B3088. Pipe saddle shall be screwed or welded to appropriate base stand.
- F. Vertical Supports: Steel riser clamp sized to fit outside diameter of pipe, B-Line B3373.
- G. Copper Tubing Supports
 1. Hangers shall be sized to fit copper tubing outside diameters.
 - a. Adjustable steel swivel ring (band type) hanger, B-Line B3170CT.
 - b. Malleable iron ring hanger, B-Line B3198RCT or hinged ring hanger B3198HCT.
 - c. Malleable iron split-ring hanger with eye socket, B-Line B3173CT with B3222.
 - d. Adjustable steel clevis hanger, B-Line B3104CT.
 2. For supporting copper tube to strut use epoxy painted pipe straps sized for copper tubing, B-Line B2000 series, or plastic inserted vibration isolation clamps, B-Line BVT series.
- H. Plastic Pipe Supports: V-Bottom clevis hanger with galvanized 18-gauge continuous support channel, B-Line B3106 and B3106V, to form a continuous support system for plastic pipe or flexible tubing.
- I. Supplementary Structural Supports: Design and fabricate supports using structural quality steel bolted framing materials as manufactured by Cooper B-Line. Channels shall be roll formed, 12 gauge ASTM A1011 SS Grade 33 steel, 1-5/8 inch by 1-5/8 inch or greater as required by loading conditions. Submit designs for pipe tunnels, pipe galleries, etc., to engineer for approval. Use clamps and fittings designed for use with the strut system.

2.3 UPPER ATTACHMENTS

- A. Beam Clamps
 1. Beam clamps shall be used where piping is to be suspended from building steel. Clamp type shall be selected on the basis of load to be supported, and load configuration.
 2. C-Clamps shall have locknuts and cup point set screws, B-Line B351L, or B3036L. Top flange c-clamps shall be used when attaching a hanger rod to the top flange of structural shapes, B-Line B3034 or B3033. Refer to manufacturer's recommendation for setscrew torque. Retaining straps shall be used to maintain the clamps position on the beam where required.
 3. Center loaded beam clamps shall be used where specified. Steel clamps shall be B-Line B3050, or B3055. Malleable iron or forged steel beam clamps with cross bolt shall be B-Line B3054 or B3291-B3297 Series as required to fit beams.

B. Concrete Inserts

1. Cast in place spot concrete inserts shall be used where applicable; either steel or malleable iron body, B-Line B2500 or B3014. Spot inserts shall allow for lateral adjustment and have means for attachment to forms. Select inserts to suit threaded hanger rod sizes, B-Line N2500 or B3014N series.
2. Continuous concrete inserts shall be used where applicable. Channels shall be 12 gauge, ASTM A1011 SS Grade 33 structural quality carbon steel, complete with styrofoam inserts and end caps with nail holes for attachment to forms. The continuous concrete insert shall have a load rating of 2,000 lbs/ft. in concrete, B-Line B22I, 32I, or 52I. Select channel nuts suitable for strut and rod sizes.

2.4 VIBRATION ISOLATION AND SUPPORTS

- A. For air conditioning and other vibrating system applications, use a clamp that has a vibration dampening insert and a nylon inserted locknut. For copper and steel tubing use B-Line BVT series Vibraclamps, for pipe sizes use BVP series.
- B. For larger tubing or piping subjected to vibration, use neoprene or spring hangers as required.
- C. For base mounted equipment use vibration pads, molded neoprene mounts, or spring mounts as required.
- D. Vibration isolation products as manufactured by B-Line, Vibratrol systems.

2.5 ACCESSORIES

- A. Hanger Rods shall be threaded both ends, or continuous threaded rods of circular cross section. Use adjusting locknuts at upper attachments and hangers. No wire, chain, or perforated straps are allowed.
- B. Shields shall be 180 degree galvanized sheet metal, 12 inch minimum length, 18 gauge minimum thickness, designed to match outside diameter of the insulated pipe, B-Line B3151.
- C. Pipe protection saddles shall be formed from carbon steel, 1/8 inch minimum thickness, sized for insulation thickness. Saddles for pipe sizes greater than 12 inch shall have a center support rib.

2.6 FINISHES

A. Indoor Finishes

1. Hangers and clamps for support of bare copper piping shall be coated with copper colored epoxy paint, B-Line Dura-Copper®. Additional PVC coating of the epoxy painted hanger shall be used where necessary.
2. Hangers for other than bare copper pipe shall be zinc plated in accordance with ASTM B633 OR shall have an electro-deposited green epoxy finish, B-Line Dura-Green®.

3. Strut channels shall be pre-galvanized in accordance with ASTM A653 SS Grade 33 G90 OR have an electro-deposited green epoxy finish, B-Line Dura-Green®.

- B. Outdoor Finishes: Hangers and strut located outdoors shall be hot dip galvanized after fabrication in accordance with ASTM A123. All hanger hardware shall be hot dip galvanized or stainless steel. Zinc plated hardware is not acceptable for outdoor or corrosive use.

2.7 METAL FRAMING SYSTEMS (“UNISTRUT”)

A. MFMA Manufacturer Metal Framing Systems:

1. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - a. Cooper B-Line, Inc.
 - b. Flex-Strut Inc.
 - c. Thomas & Betts Corporation.
 - d. Unistrut Corporation; Tyco International, Ltd.
2. Description: Shop- or field-fabricated pipe-support assembly for supporting multiple parallel pipes.
3. Standard: MFMA-4.
4. Channels: Continuous slotted steel channel with in-turned lips.
5. Channel Nuts: Formed or stamped steel nuts or other devices designed to fit into channel slot and, when tightened, prevent slipping along channel.
6. Hanger Rods: Continuous-thread rod, nuts, and washer made of carbon steel.
7. Coating: Unistrut Perma-green or similar.

2.8 PIPE STANDS

- A. General Requirements for Pipe Stands: 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 or stainless-steel base unit with plastic roller, for roof installation without membrane penetration.
- D. High-Type, Single-Pipe Stand:
 1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration.
 2. Base: Plastic.
 3. Vertical Members: Two or more cadmium-plated-steel or stainless-steel, continuous-thread rods.
 4. Horizontal Member: Cadmium-plated-steel or stainless-steel rod with plastic or stainless-steel, roller-type pipe support.

- E. High-Type, Multiple-Pipe Stand:
 - 1. Description: Assembly of bases, vertical and horizontal members, and pipe supports, for roof installation without membrane penetration.
 - 2. Bases: One or more; plastic.
 - 3. Vertical Members: Two or more protective-coated-steel channels.
 - 4. Horizontal Member: Protective-coated-steel channel.
 - 5. Pipe Supports: Galvanized-steel, clevis-type pipe hangers.
- F. Curb-Mounted-Type Pipe Stands: Shop- or field-fabricated pipe supports made from structural-steel shapes, continuous-thread rods, and rollers, for mounting on permanent stationary roof curb.

PART 3 - EXECUTION

3.1 HANGER AND SUPPORT INSTALLATION

- A. Metal Pipe-Hanger Installation: Comply with MSS SP-69 and MSS SP-89. Provide hangers, supports, clamps, and attachments as required to properly support piping from the building structure.
- B. Metal 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. Pipes of Various Sizes: Support together and space trapezes for smallest pipe size or install intermediate supports for smaller diameter pipes as specified for individual pipe hangers. Field fabricate from ASTM A 36/A 36M, carbon-steel shapes selected for loads being supported. Weld steel according to AWS D1.1/D1.1M.
- C. Metal Framing System Installation: Provide per manufactures recommendations and calculations.
- D. Thermal-Hanger Shield Installation: Provide in pipe hanger or shield for insulated piping.
- E. Fastener System Installation:
 - 1. Provide 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. Provide fasteners according to powder-actuated tool manufacturer's operating manual.
 - 2. Provide mechanical-expansion anchors in concrete after concrete is placed and completely cured. Provide fasteners according to manufacturer's written instructions.
- F. Pipe Stand Installation:
 - 1. Provide per manufactures recommendations and calculations.
 - 2. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane.
 - 3. Curb-Mounted-Type Pipe Stands: Assemble components or fabricate pipe stand and mount on permanent, stationary roof curb.

- G. Provide hangers and supports complete with necessary attachments, inserts, bolts, rods, nuts, washers, and other accessories.
- H. Equipment Support Installation: Fabricate from welded-structural-steel shapes.
- I. Provide 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.
- J. Provide lateral bracing with pipe hangers and supports to prevent swaying.
- K. Provide building attachments within concrete slabs or attach to structural steel. Provide additional attachments at concentrated loads, including valves, flanges, and strainers, NPS 2-1/2 and larger and at changes in direction of piping. Provide concrete inserts before concrete is placed; fasten inserts to forms and install reinforcing bars through openings at top of inserts.
- L. Load Distribution: Provide hangers and supports so that piping live and dead loads and stresses from movement will not be transmitted to connected equipment.
- M. Pipe Slopes: Provide hangers and supports to provide indicated pipe slopes and to not exceed maximum pipe deflections allowed by plumbing code and ASME B31.9 for building services piping.
- N. Insulated Piping:
 - 1. Attach clamps and spacers to piping.
 - a. Piping Operating above Ambient Air Temperature: Clamp may project through insulation.
 - b. Piping Operating below Ambient Air Temperature: Use thermal-hanger shield insert with clamp sized to match OD of insert.
 - c. Do not exceed pipe stress limits allowed by ASME B31.9 for building services piping.
 - 2. Thermal-Hanger Shields: Provide with insulation same thickness as piping insulation.

3.2 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 bearing surface smooth.
- C. Provide lateral bracing, to prevent swaying, for equipment supports.

3.3 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/D1.1M procedures for shielded, metal arc welding; appearance and quality of welds; and methods used in correcting welding work; and with the following:
 - 1. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals.
 - 2. Obtain fusion without undercut or overlap.
 - 3. Remove welding flux immediately.
 - 4. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.4 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.

3.5 PAINTING

- A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. Apply paint by brush or spray to provide a minimum dry film thickness of 2.0 mils.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

3.6 HANGER AND SUPPORT SCHEDULE

- A. Specific hanger and support requirements are 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. Comply with MSS SP-69 for trapeze pipe-hanger selections and applications that are not specified in piping system Sections.
- E. Comply with MFMA-103 for metal framing system selections and applications that are not specified in piping system Sections.

- F. Use powder-actuated fasteners or mechanical-expansion anchors instead of building attachments where required in concrete construction.

3.7 HANGER SPACING

- A. Support piping and tubing not listed below according to MSS SP-69 and manufacturer's written instructions.
- B. Provide hangers for steel piping with the following maximum horizontal spacing and minimum rod sizes:
 - 1. NPS 1/2": Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 2. NPS 3/4 to 1: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/4: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 4. NPS 1-1/2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 5. NPS 2: Maximum span, 10 feet; minimum rod size, 3/8 inch.
 - 6. NPS 2-1/2: Maximum span, 10 feet; minimum rod size, 1/2 inch.
 - 7. NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.
 - 8. NPS 4: Maximum span, 10 feet; minimum rod size, 5/8 inch.
 - 9. NPS 5: Maximum span, 10 feet; minimum rod size, 5/8 inch.
 - 10. NPS 6: Maximum span, 10 feet; minimum rod size, 3/4 inch.
 - 11. NPS 8: Maximum span, 10 feet; minimum rod size, 3/4 inch.
- C. Provide hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:
 - 1. NPS 1/2 and 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
 - 2. NPS 1: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 - 3. NPS 1-1/4: Maximum span, 7 feet; minimum rod size, 3/8 inch.
 - 4. NPS 1-1/2 to 2: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 - 5. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 1/2 inch.
 - 6. Maximum vertical steel and copper pipe attachment spacing: 10 feet.
- D. Piping Hangers for Plastic Piping:
 - 1. Space hangers according to pipe manufacturer's written instructions for service conditions. Avoid point loading. Space and install hangers with the fewest practical rigid anchor points.
 - 2. In systems where large fluctuations in temperature occur, allowances must be made for expansion and contraction of the piping system. Since changes in direction in the system are usually sufficient to allow for expansion and contraction, hangers must be placed so as not to restrict this movement.
 - 3. Hangers shall not compress, distort, cut or abrade the piping. All piping shall be supported at intervals sufficiently close to maintain correct pipe alignment and to prevent sagging or grade reversal. Pipe should also be supported at all branch ends and at all changes of direction.

4. Provide hangers for piping with the following maximum horizontal spacing and minimum rod diameters (pipe temperature 100°F or lower).
 - a. NPS 1 and smaller: 4 feet with 3/8-inch rod.
 - b. NPS 1-1/4 and 1-1/2 and NPS 2: 5 feet with 3/8-inch rod.
 - c. NPS 3: 6 feet with 1/2-inch rod.
 - d. NPS 4: 6.5 feet with 5/8-inch rod.
 - e. NPS 6 and 8: 8 feet with 3/4-inch rod.
 5. Provide supports for vertical piping every 10 feet.
- E. Support vertical piping independently of connected horizontal piping. Support vertical pipes at base and at every floor. Wherever possible, locate riser clamps directly below pipe couplings or shear lugs.
- F. Place a hanger within 12 inches of each horizontal elbow.

END OF SECTION 230529

SECTION 230553 – IDENTIFICATION FOR MECHANICAL

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Division 23 Section "Common Work Results for Mechanical"

1.2 SUMMARY

- A. This Section includes the following mechanical identification materials and their installation.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Valve numbering scheme. Valve Schedules: For each piping system. Furnish extra copies (in addition to mounted copies) to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. ASME Compliance: Comply with ASME A13.1, "Scheme for the Identification of Piping Systems," for letter size, length of color field, colors, and viewing angles of identification devices for piping.

1.5 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 location of access panels and doors.
- C. Install identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.1 EQUIPMENT IDENTIFICATION DEVICES

- A. Equipment Markers: Engraved, color-coded laminated plastic; attach with screws or contact-type, permanent adhesive. Size: 2-1/2" x 1" or as applicable.

1. Terminology: Match schedules as closely as possible.
 2. Data: Name and plan number, equipment service, design capacity, and other design parameters such as pressure drop, entering and leaving conditions, and speed.
- B. Equipment located above the ceiling that requires servicing shall be labeled on the ceiling using a labeling machine.

2.2 PIPING IDENTIFICATION DEVICES

- A. Manufactured Pipe Markers, General: Seton, Brady, or approved equal; preprinted, color-coded, with lettering indicating service, and showing direction of flow.
1. Colors: Comply with ASME A13.1, unless otherwise indicated.
 2. Lettering: Use piping system terms indicated and abbreviate only as necessary for each application length. Size of letters and length of color field per ASME A13.1.
 3. Pipes with OD, Including Insulation; Full-band snap-around pipe markers extending 360 degrees around pipe at each location.
 4. Arrows: Integral with piping system service lettering to accommodate both directions; or as separate unit on each pipe marker to indicate direction of flow.
 5. Minimum length of color field and size of letters shall be in accordance with Uniform Plumbing Code requirements.
- B. Types:
1. Self-adhesive type: Seton Opti-Code.
 2. Snap-around type: Seton Setmark.
 3. Wrap-around type: Seton Ultra-mark; PVF over-laminated polyester construction seals in and protects graphics; suitable for outdoor or harsh environments.

PART 3 - EXECUTION

3.1 APPLICATIONS, GENERAL

- A. Products specified are for applications referenced in other Division 22 or 23 Sections. If more than single-type material, device, or label is specified for listed applications, selection is Installer's option.

3.2 EQUIPMENT IDENTIFICATION

- A. Install equipment markers with permanent adhesive on or near each major item of mechanical equipment. Data required for markers may be included on signs, and markers may be omitted if both are indicated.
1. Letter Size: Minimum 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.
2. Data: Distinguish among multiple units, indicate operational requirements, indicate safety and emergency precautions, warn of hazards and improper operations, and identify units.
 3. Locate markers where accessible and visible. Include markers for the following general categories of equipment:
 - a. All scheduled equipment.
- B. Equipment located above the ceiling that requires servicing shall be labeled on the ceiling using a labeling machine.
1. Ceilings 10 feet and lower: Letters shall be ¼" high, black.
 2. Ceilings higher than 10 feet: Letters shall be 3/8" high, black.
 3. Label all equipment above ceiling that requires servicing or access.
 4. Locate labels on the ceiling grid, adjacent to the ceiling tile that provides the best access to the valve or item that requires servicing.

3.3 PIPING IDENTIFICATION

- A. Piping Identification Types:
1. Piping or Insulation 5-7/8 inch OD or smaller: Snap-around marker or self-adhesive marker.
 2. Piping or Insulation 6 inch OD and Larger: Strap-around with nylon ties or self-adhesive marker.
 3. Provide wrap-around pipe markers for outdoor pipes. Install wrap-around pipe markers completely around pipe.
- B. Install manufactured pipe markers indicating service on each piping system.
1. Install pipe markers to manufacturer's instructions.
 2. Identify piping, concealed or exposed. Include service and flow direction.
 3. Install in clear view and align with axis of piping.
 4. Locate identification at maximum 20 feet centers on straight runs including risers and drops, adjacent to each valve and tee, at each side of penetration of structure or enclosure, and at each obstruction.
 5. At access doors, manholes, and similar access points that permit view of concealed piping.
 6. At least one per room.
- C. Unions covered by insulation: Stencil or label the outside insulation jacket of each union with the word "union." Match size and color of pipe labels.

3.4 ADJUSTING

- A. Relocate mechanical identification materials and devices that have become visually blocked by other work.

3.5 CLEANING

- A. Clean faces of mechanical identification devices.

END OF SECTION 230553

SECTION – 230700 - MECHANICAL INSULATION

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 7 for firestopping materials and requirements for penetrations through fire and smoke barriers.
 - 2. Division 23 Section "Common Work Results for Mechanical"
 - 3. Division 23 Section "Hangers and Supports for Piping and Equipment" for pipe insulation shields and protection saddles.
 - 4. Division 23 Section "Metal Ducts" for duct liner.

1.2 SUMMARY

- A. This Section includes insulation; insulating cements; field-applied jackets; accessories and attachments; and sealing compounds.

1.3 ACTION SUBMITTALS

- A. Product Data: Identify thermal conductivity, Greenguard Certification, thickness, and jackets (both factory and field applied, if any), for each type of product indicated.
- B. LEED Submittals:
 - 1. Product Data for Credit IEQ 4.1: For adhesives and sealants, documentation including printed statement of VOC content.
 - 2. Laboratory Test Reports for Credit IEQ 4: For adhesives and sealants, documentation indicating that products comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

1.4 QUALITY ASSURANCE

- A. Installer Qualifications: Skilled mechanics who have successfully completed an apprenticeship program or another craft training program certified by the U.S. Department of Labor, Bureau of Apprenticeship and Training.
- B. Surface-Burning Characteristics: For insulation and related materials, as determined by testing identical products according to ASTM E 84, by a testing agency acceptable to authorities

having jurisdiction. Factory label insulation and jacket materials and adhesive, mastic, tapes, and cement material containers, with appropriate markings of applicable testing agency.

- C. Insulation Installed Indoors: Flame-spread index of 25 or less, and smoke-developed index of 50 or less. Insulation Installed Outdoors: Flame-spread index of 75 or less, and smoke-developed index of 150 or less.

1.5 DELIVERY, STORAGE, AND HANDLING

- A. Ship insulation materials in containers marked by manufacturer with appropriate ASTM specification designation, type and grade, and maximum use temperature.
- B. All of the insulation materials and accessories covered by this specification shall be delivered to the job site and stored in a safe, dry place with appropriate labels and/or other product identification.
- C. Store tapes, adhesives, mastics, cements, and insulation materials in ambient conditions in accordance with the recommendations of the manufacturer.
- D. Follow manufacturer's recommended handling practices.
- E. The contractor shall use whatever means are necessary to protect the insulation materials and accessories before, during, and after installation. No insulation material shall be installed that has become damaged in any way. The contractor shall also use all means necessary to protect work and materials installed by other trades.
- F. Fiber Glass and Mold: Contractor shall take precaution to protect insulation. Any fiber glass insulation that becomes wet or torn should be replaced at no additional cost. Air handling insulation used in the air stream must be discarded if exposed to water.

1.6 COORDINATION

- A. Coordinate size and location of supports, hangers, and insulation shields. Coordinate clearance requirements with other trades for insulation application.
- B. Schedule insulation application after testing systems. Insulation application may begin on segments of systems that have satisfactory test results.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

3. Owens-Corning
4. John Mansville
5. Armstrong
6. Aeroflex USA
7. Nomaco K-Flex
8. Pabco.

2.2 PIPING INSULATION MATERIALS

A. General

1. Supply fiber glass products that have achieved GREENGUARD Children & Schools Certification.
2. Surface Burning Characteristics: Insulation and related materials shall have surface burning characteristics determined by test performed on identical products per ASTM E 84 mounted and installed as per ASTM E 2231. All testing shall be performed by a testing and inspecting agency acceptable to authorities having jurisdiction. Insulation, jacket materials, adhesives, mastics, tapes and cement material containers shall be labeled with appropriate markings of applicable testing and inspecting agency. Flame-spread index of 25 or less, and smoke-developed index of 50 or less.
3. Supply fiber glass products that are manufactured using a certified 25 % minimum recycled content.

B. Provide thermal hanger shields as specified in Section 230529.

C. Glass Fiber:

1. Knauf 1000° Pipe Insulation with ECOSE Technology meeting ASTM C547 Type IV Grade A, ASTM C585, and ASTM C795; rigid, molded, noncombustible per ASTM E136; k value: ASTM C335, 0.23 at 75°F mean temperature. Maximum Service Temperature: 1000°F, or Johns Manville's Micro-Lok[®] HP meeting ASTM C547, Type I, maximum service temperature of 850°F meeting the other requirements. Vapor Retarder Jacket: ASJ/SSL conforming to ASTM C1136 Type I, secured with self-sealing longitudinal laps and butt strips.
2. PVC Fitting Covers: The Proto Fitting Cover System or Johns Manville Zeston[®] polyvinyl chloride (PVC) parts shall consist of one piece and two piece pre-molded high impact UV-resistant PVC fitting covers with fiberglass inserts and accessories, which include elbows, tee/valves, end caps, mechanical line couplings, and specialty fittings. Fittings shall be made of Zeston[®] or LoSMOKE[®] grade PVC, 25/50 rated per ASTM E-84. Thermal Value of fiberglass insert: K value of 0.26 at 75°F; resistance to fungi and bacteria. (ASTM G 21, ASTM G 22): does not promote growth of fungi or bacteria.

D. Flexible Elastomeric Insulation: Closed-cell, sponge- or expanded-rubber materials. Comply with ASTM C 534, Type I for tubular materials.

1. For indoor applications, adhesive shall have a VOC content of 50 g/L or less when calculated according to 40 CFR 59, Subpart D (EPA Method 24).
2. Adhesive shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."

3. Materials shall have a maximum thermal conductivity of 0.27 Btu-in/h-ft²- °F at a 75°F mean temperature when tested in accordance with ASTM C 177 or ASTM C 518, latest revisions.
4. Materials shall have a maximum water vapor transmission of 0.08 perm-inches when tested in accordance with ASTM E 96, Procedure-A, latest revision.
5. Materials shall have a flame spread index of less than 25 and a smoke developed index of less than 50 when tested in accordance with ASTM E 84, latest revision.
6. Provide Armaflex WB finish for outdoor exposed piping.

2.3 DUCTWORK INSULATION MATERIALS

- A. Flexible Fiber Glass Blanket: Johns Manville's Microlite[®] XG Duct Wrap or Knauf Friendly Feel[®] Duct Wrap with ECOSE Technology meeting ASTM C553 Types I, II and III, and ASTM C1290; GREENGUARD certified; flexible, limited combustible; k value: ASTM C177, 0.29 at 75°F mean temperature. Maximum Service Temperature: faced: 250°F; unfaced: 350°F. Vapor Retarder Jacket: FSK conforming to ASTM C1136 Type II. Installation: Maximum allowable compression is 25%. Securement: Secured in place using outward cinching staples in combination with appropriate pressure-sensitive aluminum foil or PSK tape, or in combination with glass fabric and vapor retarder mastic. Density: concealed areas: Minimum 0.75 PCF; exposed areas: Minimum 1.0 PCF.

2.4 FIELD-APPLIED JACKETS FOR PIPING

- A. General: ASTM C 921, Type 1, unless otherwise indicated.
- B. PVC: Johns Manville's Zeston[®] PVC fittings, jacketing, and accessories or Proto Corporation 25/50 or Indoor/Outdoor, UV-resistant fittings, jacketing and accessories, white. Fitting cover system consists of pre-molded, high-impact PVC materials with fiber glass inserts. Fiber glass insert has a thermal conductivity (k value) of 0.26 at 75° F mean temperature. Closures: stainless steel tacks, matching PVC tape, or PVC adhesive per manufacturer's recommendations.
- C. Aluminum Jacket: Factory cut and rolled to required size. Comply with ASTM B 209, 3003 alloy, and H-14 temper. Finish and Thickness: Corrugated finish, 0.010 inch thick. Moisture Barrier: 1-mil- thick, heat-bonded polyethylene and Kraft paper. Elbows: Preformed, 45- and 90-degree, short- and long-radius elbows; same material, finish, and thickness as jacket.

2.5 EXTERIOR DUCTWORK

- A. Provide Armacell ArmaTuff or equal. Durable cladding laminated to the insulation eliminates jacketing; white embossed laminate surface does not require painting. Provide self-adhesive backing. Heavy-duty durability and puncture-resistant cladding reduces need for repairs. The Armaflex insulation with the laminated cladding provides zero permeability. The complete, easy-to-install, outdoor insulation with a factory-applied cladding providing durability, UV resistance, low maintenance, and reliable protection against condensation, mold and energy loss Armaflex with heavy-duty 12 mil white laminate.

1. Thermal Conductivity: $\text{Btu} \cdot \text{in.}/\text{h} \cdot \text{ft}^2 \cdot ^\circ\text{F}$, 75°F Mean Temperature = 0.25.
 2. Water vapor permeability = 0
 3. 3" Thickness (R10 minimum is required)
- B. Rigid roof insulation board, 2" thickness; with high-performance jacketing: VentureClad-1577, or approved equal; high performance jacketing product shall perform well over a wide temperature range; -30°F to $+300^\circ\text{F}$ service temperature.
1. Zero permeability, absolute vapor barrier
 2. High puncture and tear resistance
 3. Contain tested and approved mold inhibiting agents
 4. A 5-ply self-adhesive material shall install easily with no off-site fabrication required
 5. The cold weather acrylic adhesive shall apply easily at temperatures as cold as -10°F .
 6. Flame spread/smoke developed: 10/20 (UL 723)
 7. 6-mil thickness (PSTC-133)
 8. Exceeds standard building design requirements (UL 723 10/20 Flame Spread/Smoke Rating). Meets requirements of FSIS Directive 5000.1, 9 CFR, Part 416 for USDA and FDA facilities and Department of Health and Human Services Construction Guide for Food Facilities
 9. Provide in natural aluminum stucco embossed finish.

2.6 ACCESSORY MATERIALS

- A. Accessory materials installed as part of insulation work under his section shall include (but not be limited to):
1. Closure Materials - Butt strips, bands, wires, staples, mastics, adhesives; pressure-sensitive tapes.
 2. Adhesive: As recommended by insulation material manufacturer. Materials shall be compatible with insulation materials, jackets, and substrates and for bonding insulation to itself and to surfaces to be insulated
 3. Support Materials - Hanger straps, hanger rods, saddles, support rings
- B. All accessory materials shall be installed in accordance with manufacturer's instructions.
- C. Mastics: Materials recommended by insulation material manufacturer that are compatible with insulation materials, jackets, and substrates.

2.7 ELECTRICAL HEAT TRACING SYSTEM

- A. Systems shall meet requirements of the National Electrical Code (NEC), Section 427.
- B. The heating cable shall be XL-Trace cable as manufactured by Raychem Corporation, or approved equal. Voltage: 120/1/60.
1. The self-regulating heating cable shall consist of two (2) 16 AWG nickel-copper bus wires embedded in parallel in a self-regulating polymer core that varies its power output to respond to temperature all along its length, allowing the heating cable to be cut to length in the field. The heating cable shall be covered by a radiation-cross-linked,

- modified polyolefin dielectric jacket. To provide a ground path and to enhance the heating cable's ruggedness, the heating cable shall have a braid of tinned copper and an outer jacket per section 427-23 of the NEC-1996.
2. All heating-cable components shall be UL Listed for use as part of the system to provide pipe freeze protection. Component enclosures shall be rated NEMA 4X to prevent water ingress and corrosion. Installation shall not require the installing contractor to cut into the heating-cable core to expose the bus wires. Connection systems that require the installing contractor to strip the bus wires or that use crimps or terminal blocks, shall not be acceptable. All components that make an electrical connection shall be re-enterable for servicing. No component shall use silicone to seal the electrical connections. An exception will be made in areas where a conduit transition is required.
- C. Provide sufficient cable, as recommended by the manufacturer, to keep the surface at 40°F minimum at -10°F winter outdoor design temperature.
1. Roof Gutter Drain : 8 watts/foot
 2. Rayclic-PC power connection and end seal
 3. Rayclic fast connection system
 4. DigiTrace 1pt controller
 5. RTD with 10 ft flexible armor
 6. Electric Traced Label
 7. Glass tape

PART 3 - EXECUTION

3.1 EXAMINATION & PREPARATION

- A. Examine substrates and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of insulation application. Verify that systems to be insulated have been tested and are free of defects. Verify that surfaces to be insulated are clean and dry.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.
- C. Before starting work under this section, carefully inspect the site and installed work of other trades and verify that such work is complete to the point where installation of materials and accessories under this section can begin.
- D. Ensure that all pipe and fitting surfaces over which insulation is to be installed are clean and dry. Ensure that insulation is clean, dry, and in good mechanical condition with all factory-applied vapor or weather barriers intact and undamaged. Wet, dirty, or damaged insulation shall not be acceptable for installation. Ensure that pressure testing of piping and fittings has been completed prior to installing insulation.

3.2 GENERAL APPLICATION REQUIREMENTS

- A. Provide insulation materials, accessories, and finishes according to the manufacturer's written instructions; with smooth, straight, and even surfaces; free of voids throughout, including the length of ducts and fittings, valves, and specialties.
- B. Provide insulation materials, vapor barriers or retarders, jackets, and thicknesses required for each system as specified in insulation system schedules.
- C. Provide accessories compatible with insulation materials and suitable for the service. Provide accessories that do not corrode, soften, or otherwise attack insulation or jacket in either wet or dry state.
- D. Provide insulation with longitudinal seams at top and bottom of horizontal pipe runs and equipment.
- E. Provide 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. Seal joints and seams with vapor-retarder mastic on insulation indicated to receive a vapor retarder.
- H. Keep insulation materials dry during application and finishing.
- I. Provide insulation with tight longitudinal seams and end joints. Bond seams and joints with adhesive recommended by the insulation material manufacturer.
- J. Provide insulation over fittings, valves, and specialties, with continuous thermal and least number of joints practical.
- K. Where vapor barrier is indicated, seal joints, seams, and penetrations in insulation at hangers, supports, anchors, and other projections with vapor-barrier mastic.
 - 1. Install insulation continuously through hangers and specialties 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.
- L. Apply adhesives, mastics, and sealants at manufacturer's recommended coverage rate and wet and dry film thicknesses.

- M. Provide insulation with factory-applied jackets as follows:
 - 1. Draw jacket tight and smooth.
 - 2. Cover circumferential joints with 3-inch- wide strips, of same material as insulation jacket. Secure strips with adhesive and outward clinching staples along both edges of strip, spaced 4 inches o.c.
 - 3. Overlap jacket longitudinal seams at least 1-1/2 inches. Clean and dry surface to receive self-sealing lap. Staple laps with outward clinching staples along edge at 2 inches o.c. For below ambient services, apply vapor-barrier mastic over staples.
 - 4. Cover joints and seams with tape, according to insulation material manufacturer's written instructions, to maintain vapor seal.
 - 5. Where vapor barriers are indicated, apply vapor-barrier mastic on seams and joints and at ends adjacent to duct flanges and fittings.

- 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.

3.3 PIPE AND DUCTWORK PENETRATIONS

- A. Insulation Installation at Roof Penetrations: Install insulation continuously through roof penetrations.
 - 1. Seal penetrations with flashing sealant.
 - 2. Install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
 - 3. Extend jacket of outdoor insulation outside roof/wall flashing at least 2 inches below top of roof flashing.
 - 4. Seal jacket to roof/wall flashing with flashing sealant.

- B. Insulation Installation at Interior Wall and Partition Penetrations (That Are Not Fire Rated): Install insulation continuously through walls and partitions.

- C. Insulation Installation at Fire-Rated Penetrations:
 - 1. Fire Dampers: 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.
 - 2. Pipe or duct penetrations (no fire damper): Install insulation continuously through penetrations of fire-rated walls and partitions. Comply with requirements in Division 7 for firestopping and fire-resistive joint sealers.

3.4 INSTALLATION OF PIPING INSULATION

- A. Metal shields shall be installed between hangers or supports and the piping insulation. Provide in accordance with Section 230529.
- B. Insulation Installation on Fittings, Valves, Strainers, Flanges, and Unions:
1. Install insulation over fittings, valves, strainers, flanges, unions, and other specialties with continuous thermal and vapor-retarder integrity unless otherwise indicated.
 2. Insulate pipe elbows using preformed fitting insulation or mitered fittings made from same material and density as adjacent pipe insulation. Each piece shall be butted tightly against adjoining piece and bonded with adhesive. Fill joints, seams, voids, and irregular surfaces with insulating cement finished to a smooth, hard, and uniform contour that is uniform with adjoining pipe insulation.
 3. Insulate tee fittings with preformed fitting insulation or sectional pipe insulation of same material and thickness as used for adjacent pipe. Cut sectional pipe insulation to fit. Butt each section closely to the next and hold in place with tie wire. Bond pieces with adhesive.
 4. Insulate valves using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. For valves, insulate up to and including the bonnets, valve stuffing-box studs, bolts, and nuts. Fill joints, seams, and irregular surfaces with insulating cement.
 5. Insulate strainers using preformed fitting insulation or sectional pipe insulation of same material, density, and thickness as used for adjacent pipe. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker. Fill joints, seams, and irregular surfaces with insulating cement. Insulate strainers so strainer basket flange or plug can be easily removed and replaced without damaging the insulation and jacket. Provide a removable reusable insulation cover. For below-ambient services, provide a design that maintains vapor barrier.
 6. Insulate flanges and unions using a section of oversized preformed pipe insulation. Overlap adjoining pipe insulation by not less than two times the thickness of pipe insulation, or one pipe diameter, whichever is thicker.
 7. Cover segmented insulated surfaces with a layer of finishing cement and coat with a mastic. Install vapor-barrier mastic for below-ambient services and a breather mastic for above-ambient services. Reinforce the mastic with fabric-reinforcing mesh. Trowel the mastic to a smooth and well-shaped contour.
 8. For services not specified to receive a field-applied jacket except for flexible elastomeric, install fitted PVC cover over elbows, tees, strainers, valves, flanges, and unions. Terminate ends with PVC end caps. Tape PVC covers to adjoining insulation facing using PVC tape.
- C. Insulate instrument connections for specialties (examples: thermometers, sensors, etc.) on insulated pipes. Shape insulation at these connections by tapering it to and around the connection with insulating cement and finish with finishing cement, mastic, and flashing sealant.
- D. Install removable insulation covers at fittings and equipment that require servicing and locations with service requirements.

E. Glass Fiber Piping Insulation

1. Locate seams in the least visible location.
2. Insulation installed on piping operating below ambient temperatures must have a continuous vapor retarder. All joints, seams and fittings must be sealed. On systems operating above ambient, the butt joints should not be sealed.

F. Flexible Elastomeric Insulation

1. Seal longitudinal seams and end joints with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
2. Insulation Installation on Pipe Flanges: Install pipe insulation to outer diameter of pipe flange. Make width of insulation section same as overall width of flange and bolts, plus twice the thickness of pipe insulation. 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. Secure insulation to flanges and seal seams with manufacturers recommended adhesive to eliminate openings in insulation that allow passage of air to surface being insulated.
3. Insulation Installation on Pipe Fittings and Elbows: Install mitered sections of pipe insulation. 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.
4. Insulation Installation on Valves and Pipe Specialties: Install preformed valve covers manufactured of same material as pipe insulation when available. 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. Install insulation to flanges as specified for flange insulation application. 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.
5. After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating. Prior to applying the finish, the insulation shall be wiped clean with denatured alcohol. The finish shall not be tinted. To insure good adhesion, the temperature should be above 50 °F during application and drying. Outdoor exposed piping shall have the seams located on the lower half of the pipe.
6. Outdoor exposed piping shall be painted with two coats of Armaflex WB Finish. Prior to applying the Finish, the insulation shall be wiped clean with denatured alcohol. The Finish shall not be tinted. Outdoor exposed piping shall have the seams located on the lower half of the pipe.

3.5 INSTALLATION OF DUCTWORK INSULATION

A. Flexible Fiberglass Blanket Insulation Installation:

1. Secure with adhesive and insulation pins.
2. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
3. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
4. Firmly butt all joints.

5. Where vapor retarder performance is required, all penetrations and damage to the facing shall be repaired using pressure-sensitive tape matching the facing, or mastic prior to system startup. Pressure-sensitive tapes shall be a minimum 3 inches wide and shall be applied with moving pressure using a squeegee or other appropriate sealing tool. Closure shall have a 25/50 Flame Spread/Smoke Developed Rating per UL 723. The longitudinal seam of the vapor retarder must be overlapped a minimum of 2 inches.
 6. 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. Insulation shall be additionally secured to the bottom of rectangular ductwork over 24 inches wide using mechanical fasteners on 18-inch centers. Care should be exercised to avoid over-compression of the insulation during installation.
 - d. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
 - e. Do not over-compress insulation during installation. Install Duct Wrap using manufacturer's stretch-out tables to obtain specified R-value using a maximum compression of 25%.
 - f. Impale insulation over 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.
 7. 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.
 8. 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.
 9. Insulate duct stiffeners, hangers, and flanges that protrude beyond insulation surface with 6-inch-wide strips of same material used to insulate duct. Secure on alternating sides of stiffener, hanger, and flange with pins spaced 6 inches o.c.
- B. For ducts and plenums with surface temperatures below ambient, install a continuous unbroken vapor barrier. Create a facing lap for longitudinal seams and end joints with insulation by removing 2 inches from one edge and one end of insulation segment. Secure laps to adjacent insulation section with 1/2-inch outward-clinching staples, 1 inch o.c. Install vapor barrier consisting of factory- or field-applied jacket, adhesive, vapor-barrier mastic, and sealant at joints, seams, and protrusions.
1. Repair punctures, tears, and penetrations with tape or mastic to maintain vapor-barrier seal.
 2. Install vapor stops for ductwork and plenums operating below 50°F at 18-foot intervals. Vapor stops shall consist of vapor-barrier mastic applied in a Z-shaped pattern over insulation face, along butt end of insulation, and over the surface. Cover insulation face and surface to be insulated a width equal to two times the insulation thickness, but not less than 3 inches.

3.6 FIELD-APPLIED JACKET INSTALLATION

- A. Where PVC jackets are indicated, install with 1-inch overlap at longitudinal seams and end joints; for horizontal applications. Seal with manufacturers recommended adhesive. Apply two continuous beads of adhesive to seams and joints, one bead under lap and the finish bead along seam and joint edge.
- B. 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.

3.7 FINISHES

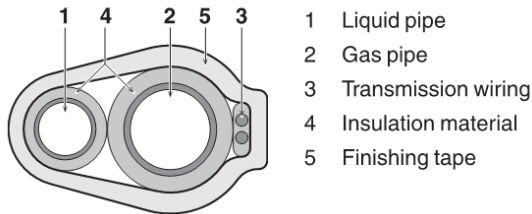
- A. Flexible Elastomeric Thermal Insulation: After adhesive has fully cured, apply two coats of insulation manufacturer's recommended protective coating.

3.8 PIPING INSULATION APPLICATION SCHEDULE

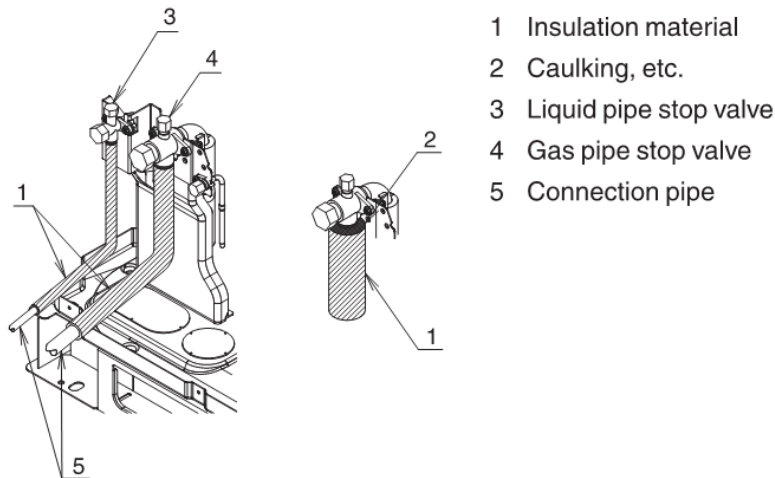
- A. Application schedules identify piping system and indicate pipe size ranges and material, thickness, and jacket requirements. For piping systems not indicated, insulate to with a similar thickness and type as those specified.
- B. All cold surfaces that may "sweat" must be insulated. Vapor barrier must be maintained, insulation shall be applied with a continuous, unbroken moisture and vapor seal. All hangers, supports, anchors, or other projections that are secured to cold surfaces shall be insulated and vapor sealed to prevent condensation.
- C. For above-ambient services, do not install insulation to the following: testing agency labels and stamps, nameplates, and cleanouts.
- D. Insulation thicknesses and installations shall meet or exceed the requirements of ASHRAE Standard 90.1-2010, IECC 2012, or thicknesses indicated, whichever is of superior insulating performance. If piping type is omitted from list below, provide insulation per ASHRAE or IECC or as per similar duty.
- E. Domestic hot water: R4 per inch of the nominal diameter of the pipe.
- F. Domestic cold water: Glass Fiber, ½" thickness.
- G. Horizontal Rainwater conductors: Glass Fiber, 1" thickness. Provide for all horizontal piping and any vertical piping within 10 feet of the roof drain.
- H. Roof Drain Bodies: Flexible Elastomeric, ½" thickness. Alternatively, roof drain bowls can be insulated with 2" of closed-cell spray-foam provided by Division 7. Coordinate with Division 7.
- I. AC pan drain or other cold drain piping; (35° to 60°F): Flexible Elastomeric, ½" thickness; Note: Insulation not required for PVC pan drains at rooftop units.

- J. Ductless split: ½” Armaflex for liquid and gas piping. Coordinate with Section 238130, insulated line kits may be furnished.
- K. Heating supply and return, indoors:
 - 1. Pipe size 1-1/4” and less: Glass Fiber; 1-1/2” thickness.
 - 2. Pipe size 1-1/2” and larger: Glass Fiber; 2” thickness.
 - 3. Piping through roof to ERV (within insulated dunnage): 3” thickness, no gaps, must be fully insulated.
 - 4. Insulation is not required strainers, control valves, unions, and balancing valves associated with piping 1” or less diameter. Insulate piping to within approximately 1-inch of un-insulated items.
- L. VRF: Insulate piping and fittings per VRF system manufacturer’s instructions.

Outside the units, the transmission wiring must be finished simultaneously with the local refrigerant piping, and wound with tape (field supply) as shown in the figure below.



- Reinforce the insulation on the refrigerant piping according to the installation environment. Condensation might form on the surface of the insulation. Refer to the below.
 - Ambient temperature : 86°F (30°C), humidity : 75% to 80% RH : minimum thickness : 9/16 in. (15 mm).
 - If the ambient temperature exceeds 86°F (30°C) and the humidity 80% RH, then the minimum thickness is 3/4 in. (20 mm).See the Engineering data book for detail.
- If there is a possibility that condensation on the stop valve might drip down into the indoor unit through gaps in the insulation and piping because the outdoor unit is located higher than the indoor unit, this must be prevented by caulking the connections. (Refer to the following figure.)



3.9 DUCT SYSTEM APPLICATIONS

- A. Insulation materials and thicknesses are specified in schedules at the end of this Section. For duct systems not indicated, insulate to with a similar thickness and type as those specified.
- B. Insulation thicknesses and installations shall meet or exceed the requirements of ASHRAE Standard 90.1-2013, or thicknesses indicated, whichever is of superior insulating performance.
- C. Items Not Insulated: Unless otherwise indicated, do not apply insulation to the following systems, materials, and equipment:
1. Metal ducts with duct liner.
 2. Factory-insulated flexible ducts.
 3. Factory-insulated plenums, casings, and access doors.
 4. Flexible connectors.

3.10 DUCT AND PLENUM APPLICATION SCHEDULE

- A. Heat Pump Supply Ducts: Flexible Fiber Glass Blanket; R-6 minimum, 1.5" thickness.
 - 1. Exposed to Conditioned Space: None
- B. Exterior ERV Supply & Return Ducts: R10 minimum with weather proof jacket.
- C. Interior ERV Supply & Return Ducts: None required.
- D. Return ducts within conditioned space: None required.

END OF SECTION 230700

SECTION 230900 – INSTRUMENTATION AND CONTROL FOR HVAC

PART 1 - GENERAL

1.1 SUMMARY

- A. Provide all labor, materials, equipment, and service necessary for an extension of the existing/addition to the existing building automation system.
- B. Provide a fully integrated building automation system, incorporating direct digital control (DDC) for energy management, equipment monitoring and control. Use of multiple manufacturers' products is not allowed.
- C. A peer-to-peer network of DDC controllers and a Web-based operator interface. Depict each mechanical system and building floor plan by a point-and-click graphic. A Web server with a network interface card shall gather data from the system and generate Web pages accessible through a conventional Web browser on each PC connected to the network. Operators shall be able to perform all normal operator functions through the Web browser interface.
- D. A network system touch screen display shall reside on site for local system interface to control and monitor all system equipment.
- E. Provide control system consisting of thermostats, control valves, dampers operators, indicating devices, interface equipment and other apparatus and accessories to operate mechanical systems and to perform functions specified.
- F. Provide installation and calibration, supervision, adjustments and fine tuning necessary for complete and fully operational system.
- G. Provide and perform factory start-up of all variable speed drives (VSD) as part of this contract. Drive installation shall be carried out by Division 26.
- H. Software Ownership: The Owner shall have full ownership and full access rights for all network management, operating system server, engineering and programming software required for the ongoing maintenance and operation of the BMS.

1.2 RELATED WORK SPECIFIED ELSEWHERE

- A. Cooperation with Other Trades: Coordinate the Work of this section with that of other sections to insure that the Work will be carried out in an orderly fashion. It shall be this Contractor's responsibility to check the Contract Documents for possible conflicts between his Work and that of other crafts in equipment location, pipe, duct and conduit runs, electrical outlets and fixtures, air diffusers, and structural and architectural features.

- B. Products Supplied But Not Installed Under This Section:
 - 1. Control valves.
 - 2. Flow switches.
 - 3. Wells, sockets and other inline hardware for water sensors (temperature, pressure, flow).
 - 4. Automatic control dampers, where not supplied with equipment.
 - 5. Terminal unit controllers and actuators, when installed by terminal unit manufacturer.
 - 6. Variable Frequency Drives.
- C. Products Installed But Not Supplied Under This Section:
 - 1. None.
- D. Products Not Furnished or Installed But Integrated with the Work of This Section:
 - 1. Variable Refrigerant Volume Systems.
 - 2. Smoke Detectors (through alarm relay contacts).
- E. Work Required Under Division 26 Related to This Section:
 - 1. Power wiring to line side of motor starters, disconnects or variable frequency drives.
 - 2. Provision and wiring of smoke detectors and other devices relating to fire alarm system.

1.3 ACTION SUBMITTALS

- A. Eight copies of shop drawings of the entire control system shall be submitted and shall consist of a complete list of equipment and materials, including manufacturers' catalog data sheets and installation instructions.
 - 1. Network riser diagrams showing programmable control unit locations and network data conductors.
 - 2. Connected data points, including connected control unit and input-output device.
 - 3. System graphics showing monitored systems, data (connected and calculated).
 - 4. System configuration with peripheral devices, batteries, power supplies, diagrams, modems and interconnections.
 - 5. Description and sequence of operation for operating user.
 - 6. Product data: Submit data for each system component and software module.
- B. Samples of written Controller Checkout Sheets and Performance Verification Procedures for applications similar in scope shall be included for approval.
- C. Shop drawings shall also contain complete wiring and schematic diagrams, sequences of operation, control system bus layout and any other details required to demonstrate that the system has been coordinated and will properly function as a system.
- D. Terminal identification for all control wiring shall be shown on the shop drawings.
- E. Upon completion of the work, provide eight complete sets of 'as-built' drawings and other project-specific documentation in 3-ring hard-backed binders and on compact disc.

1.4 CLOSEOUT SUBMITTALS

A. Project Record Documents:

1. Record actual locations of control panels and components, including control units, thermostats and sensors.
2. Revise shop drawings to reflect actual installation and operating sequences.

B. Operation and Maintenance data:

1. Submit interconnection wiring diagrams, complete field installed systems with identified and numbered, system components and devices.
2. Submit inspection period, cleaning methods, cleaning materials recommended and calibration tolerances.

1.5 QUALITY ASSURANCE

A. Manufacturer: Company specializing in manufacturing products specified in this section with a minimum of ten years global experience and with technology center within 120 miles of this project.

B. Installer: Company specializing in performing work of this section with a minimum five years documented HVAC experience, trained, certified and approved by manufacturer.

C. Provide a complete, neat and workmanlike installation.

D. All work, materials, and equipment shall comply with the rules and regulations of all codes and ordinances of the local, state, and federal authorities. Such codes, when more restrictive, shall take precedence over these plans and specifications.

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

F. Comply with NFPA 90A, "Installation of Air Conditioning and Ventilation Systems."

G. Comply with ASHRAE 135 for DDC system control components.

H. The contractor shall protect all work and material from damage by his/her work or employees. The contractor shall be responsible for his/her work and equipment until finally inspected, tested, and accepted. The contractor shall protect any material that is not immediately installed. The contractor shall close all open ends of work with temporary covers or plugs during storage and construction to prevent entry of foreign objects.

1.6 CONTRACTOR QUALIFICATIONS

A. Qualified Bidders: System shall be as manufactured, installed and serviced by:

1. AAA Energy - Trend Controls

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.
- B. Maintain integrity of shipping cartons for each piece of equipment and control device through shipping, storage, and handling as required to prevent equipment damage. Store equipment and materials inside and protected from weather.

1.8 WARRANTY

- A. Refer to Division 1 Requirements.
- B. At the end of the final start-up, testing, and commissioning phase, if equipment and systems are operating satisfactorily to the engineer, the engineer shall sign certificates certifying that the control system's operation has been tested and accepted in accordance with the terms of this specification. The date of acceptance shall be the start of warranty. All work shall have a single warranty date, even when the owner has received beneficial use due to an early system start-up.
- C. All components, system software, and parts supplied by the BAS contractor shall be guaranteed against defects in materials and workmanship for one year from acceptance date. The BAS contractor at no charge shall furnish Labor to repair, reprogram, or replace components during the warranty period. All corrective software modifications made during warranty periods shall be updated on all user documentation and on user and manufacturer archived software disks. The Contractor shall respond to the owner's request for warranty service within 24 hours during normal business hours.
- D. Provide remote service diagnostic monitoring from the nearest service location. At the request of the owner, a service diagnostic call will be made to troubleshoot and resolve (if possible) any reported system complaints. The owner will provide a dedicated telephone line for connection to the system.
- E. Operator workstation software, project-specific software, graphic software, database software, and firmware updates that resolve known software deficiencies as identified by the contractor shall be provided at no charge during the warranty period. Any upgrades or functional enhancements associated with the above-mentioned items also can be provided during the warranty period for an additional charge to the owner by purchasing an in-warranty service agreement from the contractor. Written authorization by the owner must, however, be granted prior to the installation of any of the above-mentioned items.

PART 2 - PRODUCTS

2.1 DIRECT DIGITAL CONTROLS

- A. Acceptable manufacturers: Trend.

2.2 COMMUNICATION

- A. Control products, communication media, hubs, and routers shall comprise a unified control network. Acceptable network mediums are Cat 5 Ethernet or twisted pair networks. Controller products and hardware or software gateways shall be from a single manufacturer.
- B. Use existing TCP/IP Ethernet backbone for network segments to all DDC Building Controller panels marked on project drawings. Project drawings indicate remote buildings or sites to be connected via intranet or Internet connections. In each remote location an intranet or Internet connection shall be provided for connection to the building automation system (BAS).
- C. Connection to BAS shall be by connecting to any Ethernet port in the facility for temporary connection to a laptop computer or other operator interface such as a Pocket PC or system display panel. In addition, any workstation in the facilities may be used for Web browser communication to BAS system. Connection shall support commissioning and troubleshooting operations.
- D. System shall automatically synchronize controller time clocks daily from an operator-designated controller via the network. If applicable, system shall automatically adjust for daylight saving and standard time.
- E. System shall communicate in a peer-to-peer way and discretely check for system errors and verify controller communications.

2.3 OPERATOR INTERFACE

- A. Integrate new controls into the existing owner interface.
- B. Operation. Graphical User Interface shall have full Client-Server capabilities. Server PC shall reside on the data network and be accessible from building intranet or Internet as specified by building owner by a standard Web browser.
- C. No other software or data files will be required on client PCs other than a standard Web browser with Java enabled.
- D. In the event of failure, the Server PC will not be required to run for normal operation of the DDC system.
- E. Communication. Server PC and Building Controller network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer using TCP/IP protocol. GUI software shall have the capability to connect to remote sites via intranet, Internet or over standard telephone lines without the need for supervisory software at remote sites.
- F. BACnet Communication. GUI software to provide access to BACnet devices. GUI shall map BACnet devices in the system, enabling consistent supervision tasks between devices. GUI shall allow values from the BACnet devices to be included in schematic pages, and also enable users to make adjustments to and receive alarms from those devices.
- G. Graphical Functionality. Operator interface shall be graphically based and shall include at least one graphic per piece of equipment or occupied zone, graphics for each chilled water and hot

water system, and graphics that summarize conditions on each floor of each building included in this contract. Graphics shall allow operator to monitor system status, to view a summary of the most important data for each controlled zone or piece of equipment, to use point-and-click navigation between zones or equipment, and to edit setpoints and other specified parameters.

2.4 BUILDING CONTROLLERS

- A. General: Provide Building Controllers (BC) as required to achieve sequence of operation. Provide one BC for each piece of mechanical equipment. Controller shall be capable of adequately covering all IO points listed in points list plus 25% expansion capability. Using more than one BC to carry out an equipment application is not acceptable.
- B. Stand-Alone Operation. Each BC on the BAS system shall be of true stand-alone operation. All schedules, data logs, time-clock, alarms graphics and program application shall reside in the controller. BCs that require global or master controllers or devices are not acceptable. Each BC shall be able to broadcast data from one to another or globally throughout the system in a true peer-to-peer way, any data value within the controller to any other controller, specified group of controllers, or globally around the system. Controllers shall build LAN and Internetwork communications across data networks and routers and report communications loss to Operator Interface.
- C. Hardware Design. BCs must be modular in design and be mounted on standard DIN Rail for ease of replacement and expansion. Every input or output shall have 2-part connectors provided to facilitate commissioning and replacement. BCs shall have a minimum of 16 IO points and be capable of expanding to a total of 128 input-output points through a series of plug in input-output modules. Input-output modules shall be connected to the BC by a CAN network bus and have the capability of being mounted up to 33 feet from controller. Each BC shall provide a serial service communication port for connection to a Portable Operator's Terminal or connection to a local controller display panel.
- D. Hardware. Controllers shall be powered by 24VAC or DC and shall be protected by a self-resetting solid state circuit breaker and bus communications shall be protected by a multifuse. Controllers shall be rated to operate at plus or minus 15%. Each BC shall have LED status indication of network, bus, power and controller failure.
- E. Environment. Controller hardware shall be suitable for anticipated ambient conditions and mounted in plenum or inside specified equipment. Controllers shall have the following specifications as a minimum:
 - 1. UL916 Listed: Enclosed Energy Management Equipment
 - 2. Temperature: rated at 32°F to 120°F
 - 3. Humidity: 0 to 90%RH non-condensing
- F. Memory. BC must have flash memory that is non-volatile to power cycles. Application program and controller parameters must be stored in flash in case of a power outage. Controllers using batteries to store program or parameters are not acceptable. A minimum of 16MB of SDRAM and 8MB of Flash memory shall be employed at each controller.
- G. Network communication. Each BC shall have a minimum of one 10BaseT Ethernet port as its primary network communications connection and communicate directly on the buildings

TCP/IP data network without the need for master control panels. Each BC shall have an on-board Web server that will allow local or remote system control, monitoring and configuration via a standard Web browser.

- H. BACnet Communication. Each BC shall be native BACnet and integrate seamlessly with a BACnet system, communicating on a BACnet IP LAN at up to 10Mbps.
- I. Real Time Clock. Each BC must have a Real Time Clock. In case of a power outage the time-clock must be maintained for 6 days by a capacitor. Any BC shall have the ability to act as the system time-master. System timemaster will automatically adjust to Daylight Savings Times.
- J. Sequencing. BC shall execute all program sequences independent of program size once per second. Controller shall execute all program and mathematical functions and PID Loops as described in Section 2.4.E.
- K. Scheduling. BC controllers shall provide the following schedule options as a minimum. All schedule, exception or holiday changes shall be configurable from the Web browser interface or the Operator Interfaces.
 - 1. Weekly. Provide separate schedules for each day of the week. Each schedule shall be able to include up to 50 occupied periods (50 start-stop pairs). Days shall have the ability of being copied and pasted from the Web browser.
 - 2. Exception. Operator shall be able to designate an exception schedule for each of the next 365 days in advance. After an exception schedule has executed, system shall discard and replace exception schedule with standard schedule for that day of the week. Exceptions shall have up to 16 priority levels. Should exceptions overlap, exception with highest priority level shall take precedence over others with lower priorities. Exceptions shall be added, edited or adjusted from the Web browser.
 - 3. Holiday. Web operator shall be able to define holiday exception schedules of varying length on a scheduling calendar that repeats each year.
 - 4. Controller shall support multiple shifted scheduling, enabling start-stop of equipment up to 6 hours before-after normal schedule start-stop. Shifted scheduling shall also support Optimized start-stop.
 - 5. Optimized start-stop. One optstart-stop function shall be assigned to any schedule within the controller. Optstart functions shall be self-learning and shall have operator adjustable start-stop limits.
- L. Data Logs. Each BC shall be able to log any data within a controller at one second, 1 minute, 5 minute, 10 minute, 15 minute, 20 minute, 30 minute, 1 hour, 6 hour or 24 hour intervals. 1000 points of data must be held in data log until last value is overwritten. Multiple data logs with differing intervals shall have the capability of being attached to any data point. Any data log shall be viewed from the browser or Operator Interfaces. Data logs shall be viewed in graphical or text format by the operator.
- M. Alarms. BCs shall generate alarms configured by the programming tool. Alarms shall be sent to the operator interface workstation. In event that operator workstation is off-line for any reason, alarms shall be sent to the system Display Panel, via email or cell phone text message directly from the controller across the data network to any internal or external email or cell phone email address. Alarms shall have the capability of being sent to different locations depending on schedule status or operator defined alarm group. An internal alarm log shall record the last 50

alarms generated by controller. Alarm log shall be viewed from the browser or Operator Interfaces.

- N. Graphics. Each BC shall be capable of containing graphics pages of the connected mechanical equipment as well as the application program. Dynamic data points shall be shown on graphical backdrops representing all hardware and software points within the controller. Graphics pages shall contain links to other graphics pages within the controller, other building controllers on the BAS system, any intranet or Internet Website and any valid email address. Controller shall have the ability to add any user defined text to any graphics page. Graphics pages shall be accessible from any standard Web browser on the intranet or Internet.
- O. Security. Each BC shall have username and password security with the ability to have a unique username and password for up to 500 users. In addition, each user shall have a level of access from 0 to 100 to the controller ranging from read only access through to full configuration rights to the controller. Access to the controller shall be read only until a valid username and password is entered via any standard Web browser. All users and levels of access shall be configurable by the operator. Each user shall have a default graphics page assigned and loaded when valid username and password is entered.
- P. Controller Input-Outputs. All controller inputs and outputs may be overridden on-off or by any analog value of the operator's choice via a standard Web browser. In addition an override timer may be initiated to switch all inputs-outputs to automatic operation after user has logged out.
1. Controller inputs shall all be Universal Inputs and be selectable by moving a jumper for the required input type. Controller shall support thermistor, 0-10vdc voltage and 0-20 or 4-20mA current inputs with 12-bit resolution. All digital inputs shall be volt free contacts capable of pulse counting up to 30 pulses per second. When input is selected for digital, LED shall indicate when contact is closed. All sensor scaling and curves shall be software configurable.
 2. Controller shall have analog or Form C relay outputs. Analog outputs shall be modulating 0-10Vdc and current limited to 20mA as required to properly control output devices. All analog outputs shall have modulating LED's to indicate output voltage. Analog outputs shall have 11-bit resolution as a minimum. Form-C relay outputs shall have common, normally-open and normally-closed contacts. All relay outputs shall have LED's to indicate relay status.
 3. Protection. All input and outputs shall have over-voltage protection built-in to protect main board from failure.
- Q. PID Loops. Loops shall have the capability to be sequenced once per second and switched between occupied and unoccupied setpoints. In addition, a manual override and level may be initiated and implemented in logic. PID Loops shall support drift-limit alarm and controlled input alarms. Should controlled input fail or alarm, one of the following actions shall be initiated:
1. Maintain output at level when sensor failed and return to normal operation on alarm clear.
 2. Automatically go to pre-defined controlled input value and return to normal operation on alarm clear.
 3. Automatically go to pre-defined loop output level and return to normal operation on alarm clear.

4. Automatically go to pre-defined loop output level and stay there until a alarm clears and a manual override is initiated by operator.
- R. Runtime Totalization. Controller shall provide an algorithm that can totalize runtime for each digital input or output and calculate the number of starts. Operator shall be able to enable runtime alarm based on exceeded adjustable runtime limit via the Web browser interface.
- S. Staggered Start. Controller shall stagger controlled equipment restart after power outage. Operator shall be able to adjust equipment restart order and time delay between equipment restarts via the Web browser interface.
- T. Web Browser. In addition, the Web browser interface shall support the following functions on the building controller other than outlined above:
 1. Configuration and editing of any function or programming module stored within the controller.
 2. Operator override of any function module or software point within the controller in addition to the physical input-outputs.
 3. Support of navigation through logic flow diagram to support commissioning via the browser.
 4. Display lists of each type of function or programming module within the controller in numerical order and highlight any current alarm points in flashing red format.
 5. Operation will be mouse driven point and click between views, graphics and modules. Values shall be changed by drop-down menus or by clicking and typing in open fields.

2.5 BACnet UNITARY CONTROLLERS

- A. Provide fully programmable BACnet VAV controllers with or without an on-board actuator. Both shall include a built-in airflow sensor and a pressure transducer. BACnet VAV controllers shall have a pre-loaded strategy and also shall be fully programmable.
- B. Provide fully programmable BACnet unitary controllers with universal I/O for terminal equipment control of RTU's, HP, FCU, UV, and others.
- C. Network Communication. As a BACnet controller, the unitary controllers shall integrate seamlessly with the building control system, communicating at up to 76.8Kbps on a BACnet MS/TP LAN.
- D. Hardware Design. BACnet VAV controller actuator shall be left or right mountable with ability to set actuator to clockwise or counter-clockwise rotation. BACnet unitary controllers shall be DIN-rail mounted and have software-configurable inputs and outputs allowing for compatibility with a wide range of HVAC and other control and monitoring applications.

2.6 APPLICATION SPECIFIC CONTROLLERS

- A. Provide one Application Specific Controller (ASC) for each piece of mechanical equipment such as VAV, unit ventilator or fan coil application. Controller must be capable of adequately covering all IO points listed in points list. Using more than one controller to carry out an application is not acceptable. Each ASC must be specifically designed for its intended use.

Using ASCs for any controlled point other than designed application is not permitted and point should be controlled at the Building Controller level.

- B. Stand-Alone Operation. Each ASC on the BAS system shall have stand-alone operation. Controller shall be factory programmed and will be operational at power-up without the need for network communications. Each controller shall have its own time-clock, built-in alarms and program application. Controllers shall obtain schedule status from Building Controllers. Controller parameters shall reside in controller and will not require a master or global controller to receive parameter changes. Controllers that use this method are unacceptable. Each ASC shall be able to broadcast data from one to another or globally throughout the system in a true peer-to-peer way, any data value within the controller to any other controller, specified group of controllers, or globally around the system. Controllers shall build LAN and inter-network communications across networks and routers and report communications loss to Operator Interface.
- C. Hardware Design. ASCs must be designed for the application specified and must be damper or DIN Rail mounted for ease of installation or replacement. Two-part connectors shall be provided on the controller for commissioning and to facilitate easy replacement.
- D. Hardware. Controllers shall be powered by 24VAC and shall be protected by a self-resetting solid state fuse. Controllers shall be rated to operate at plus or minus 15% of supply voltage.
- E. Environment. Controller hardware shall be suitable for anticipated ambient conditions and mounted in plenum or inside specified equipment. Controllers shall have the following specifications as a minimum.
 - 1. UL916 Listed: Open Energy Management Equipment
 - 2. UL873 Recognized: Temperature Indicating and Regulating Equipment
 - 3. EMC Emissions Compliance: FCC Part 15
 - 4. Temperature: rated at 32°F to 120°F
 - 5. Humidity: 0 to 90%RH non-condensing
- F. Memory. ASCs must have flash memory that is non-volatile to power cycles. Application program and controller parameters must be stored in flash in case of a power outage. Controllers using batteries to store program or parameters are not acceptable.
- G. Network communication. Each ASC shall use LonWorks free topology networks and use FTT-10A transceivers at 78Kbaud for network communications. Lonbus installation must follow the network guidelines as stated in the LonWorks Interoperable guidelines. ASCs shall comply to the following network rules:
 - 1. There shall be no more than 40 ASCs per Lon segment to allow for future expansion.
 - 2. Use of Repeaters shall not be allowed.
 - 3. Each Lon segment shall be separated from the backbone segment by a self-learning router.
 - 4. Each segment shall have at least one network terminator device installed.
- H. Interoperability. Each ASC shall be LonMark certified and have a published list of SNVTs (Standard Network Variable Types) defined by the manufacturer. ASCs shall conform to the following guidelines:

1. LonMark certified at version 3.3 or greater.
 2. ASCs shall conform to LonMark profile 8500.
 3. ASCs shall have XIF and DRF files available from LonMark.
 4. ASCs shall self-install on Lon without the need for a network management tool. Should LonWorks integration be required, ASCs shall be fully capable of being integrated on a Network Management Tool.
 5. ASCs shall have the capability to be bound to 3rd party LonWorks sensors and actuators by a Lon network management tool without the need for hardware or software gateways.
- I. Software Clock. Each ASC must have a Software Clock for time and date stamping alarms and data logs. In case of a power outage the time-clock shall be updated by a building controller.
- J. Alarms. ASCs shall generate network and input alarms pre-defined at manufacture. Should a controller go off-line, an alarm shall be generated indicating network controller off-line. Alarms shall be sent to the operator interface workstation.
- K. Controller Input-Outputs
1. Controller inputs shall all be 10K Type II thermistor and digital to meet specific application. All digital inputs shall be volt free contacts suitable for plant status. All sensor scaling and curves shall be pre-defined at manufacture.
 2. Controllers shall have analog, triac or Form C relay outputs. Analog outputs shall be modulating 0-10Vdc and current limited to 20mA as required to properly control output devices. Analog outputs shall have 11-bit resolution as a minimum. Form-C relay outputs shall have common, normally-open and normally-closed contacts.
 3. Tri-State Outputs. Control three-point floating electronic actuators without feedback with tri-state outputs (two coordinated relay outputs). Tri-State outputs may be used to provide analog output control in zone control and terminal unit control applications such as duct-mounted heating coils, and zone dampers.
 4. Protection. All input and outputs shall have over-voltage protection built-in to protect main board from failure.

2.7 AUXILIARY CONTROL DEVICES

- A. Low-Voltage Space Thermostats and Aquastats. Low-voltage space thermostats shall be 24 V, bimetal-operated, snap-action switch type, with adjustable anticipation heater, concealed setpoint adjustment, 40°F-90°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
- B. Line-Voltage Space Thermostats and Aquastats. Line-voltage space thermostats shall be bimetal-actuated, open-contact type or bellows-actuated, enclosed, snap-switch type or equivalent solid-state type, with heat anticipator, UL listing for electrical rating, concealed setpoint adjustment, 55°F-85°F setpoint range, 2°F maximum differential, and vented ABS plastic cover.
- C. Low-Limit Freezestats. Low-limit airstream thermostats shall be of vapor pressure type. Element shall be at least 20 ft long. Element shall sense temperature in each 1 ft section and shall respond to lowest sensed temperature. Low-limit freezestat shall be manual reset.

- D. Temperature Sensors. Temperature sensors shall be thermistor or 4–20mA dependent on application.
1. Duct Supply Air Sensors. Terminal unit supply duct sensors shall be 6” long thermistor. AHU supply duct sensors shall be 16” long thermistors of type 10KII.
 2. Mixed air sensors shall be averaging sensors shall be a minimum of 5 feet in length per 10 ft ² of duct cross-section. Sensors shall generate a 4-20mA signal.
 3. Immersion Sensors. Provide immersion sensors with a separable stainless steel or brass well. Well pressure rating shall be consistent with system pressure it will be immersed in. Well shall withstand pipe design flow velocities. Immersion sensors shall be thermistor of type 10KII.
 4. Outside Air Sensors shall be mounted on north facing wall and be a 10K type II thermistor. Sensor shall be mounted in a water-proof enclosure.
 5. Space Sensors. Space sensors shall be wall mounted thermistors and shall have setpoint adjustment and override button options. See plans for required types and locations. Space sensors shall be 10KII type thermistors and shall have guards fitted on locations shown on plans.
 6. Digital Readout Space Sensors. Space sensors shall be wall mounted thermistors and shall have a digital readout of temperature, setpoint and occupancy status. Adjustments shall include setpoint and occupancy. See plans for required types and locations. Space sensors shall be 10KII type thermistors and shall have guards fitted on locations shown on plans.
- E. Humidity Sensors
1. Duct and room sensors shall have a sensing range of 20%-80%.
 2. Duct sensors shall have a sampling chamber.
 3. Outdoor air humidity sensors shall have a sensing range of 20%-95% RH and shall be suitable for ambient conditions of 40°F-170°F.
 4. Humidity sensors shall not drift more than 1% of full scale annually.
 5. Humidity sensors shall have a 2% rated accuracy.
- F. Flow Switches. Flow-proving switches shall be paddle (water service only) or differential pressure type (air or water service) as shown. Switches shall be UL listed, SPDT snap-acting, and pilot duty rated (125 VA minimum).
1. Paddle switches shall have adjustable sensitivity and NEMA 1 enclosure unless otherwise specified.
 2. Differential pressure switches shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.
- G. Relays
1. Control Relays. Control relays shall be plug-in type, UL listed, and shall have dust cover and LED “energized” indicator. Contact rating, configuration, and coil voltage shall be suitable for application.
 2. Time Delay Relays. Time delay relays shall be solid-state plug-in type, UL listed, and shall have adjustable time delay. Delay shall be adjustable $\pm 100\%$ from setpoint shown. Contact rating, configuration, and coil voltage shall be suitable for application. Provide NEMA 1 enclosure for relays not installed in local control panel.

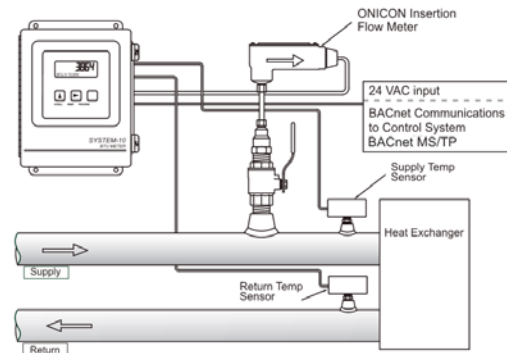
3. Relay-in-box. Shall be UL listed and have a compact NEMA 1 housing with ½ or ¾ inch NPT nipples. Relays shall have LED “energized” indication. Wires shall be color-coded. Contact rating, configuration, and coil voltage shall be suitable for application.

H. BTU Meter

1. The entire Energy Measurement System shall be built and calibrated by a single manufacturer, ONICON Incorporated, or approved equal; and shall consist of a flow meter, two temperature sensors, a Btu meter, temperature thermowells, and all required mechanical installation hardware. A certificate of NIST traceable calibration shall be provided with each system. All equipment shall be covered by the manufacturer’s two year warranty.

**TYPICAL SYSTEM-10-BAC-MS/TP
INSTALLATION**

Insertion turbine flow meter shown. Any ONICON flow meter may be used with the System-10 BTU Meter. Consult with ONICON for additional flow meter types.



2. Btu Meter: Provide an ONICON System-10 BTU Meter. The Btu meter shall provide the following information via both an integral LCD, and via serial network communications (protocol conforming to BACnet MS/TP): Energy Total, Energy Rate, Flow Total, Flow Rate, Supply Temperature and Return Temperature. Each Btu meter shall be factory programmed for its specific application, and shall be re-programmable using the front panel keypad (no special interface device or computer required).
3. Flow Meter: Provide an ONICON Turbine Flow Meter. Insertion type flow meters shall be provided complete with all installation hardware necessary to enable insertion and removal of the meter without system shutdown, and be hand-insertable up to 400 psi. Inline meters shall be installed with isolation valves to allow installation or removal of the flow meter without a system shutdown. Turbine rotation shall be detected by electronic impedance-based sensing (non-magnetic). Each flow meter shall be individually wet-calibrated against a primary volumetric standard that is accurate to within 0.1% and traceable to NIST. A certificate of calibration shall be provided with each flow meter. Accuracy shall be within ± 0.5% of rate at the calibrated velocity, within ± 1% of rate over a 10:1 turndown (3.0 to 30 ft/s) and within ± 2% of rate over a 50:1 turndown (from 0.4 to 20 ft/s). The flow meter shall include an integral 0-15V square wave output as an input to the ONICON Btu Meter.
 - a. Provide 5 feet of straight pipe upstream and downstream of the flow meter.
4. Temperature sensors: Temperature sensors shall be loop-powered current based (mA) sensors and shall be bath-calibrated and matched (NIST traceable) for the specific temperature range for each application. The calculated differential temperature used in the energy calculation shall be accurate to within ±0.15°F (including the error from individual temperature sensors, sensor matching, input offsets, and calculations).

I. Current Transmitters

1. AC current transmitters shall be self-powered, combination split-core current transformer type with built-in rectifier and high-gain servo amplifier with 4-20 mA two-wire output.

Full-scale unit ranges shall be 10 A, 20 A, 50 A, 100 A, 150 A, and 200 A, with internal zero and span adjustment. Unit accuracy shall be $\pm 1\%$ full-scale at 500 ohm maximum burden.

2. Transmitter shall meet or exceed ANSI/ISA S50.1 requirements and shall be UL/CSA recognized.
3. Unit shall be split-core type for clamp-on installation on existing wiring.

J. Current Transformers

1. AC current transformers shall be UL recognized and shall be completely encased (except for terminals) in approved plastic material.
2. Transformers shall be available in various current ratios and shall be selected for $\pm 1\%$ accuracy at 5 A full-scale output.
3. Use fixed-core transformers for new wiring installation and split-core transformers for existing wiring installation.

K. Voltage Transformers

1. AC voltage transformers shall be UL recognized, 600 Vac rated, and shall have built-in overload trip protection.
2. Transformers shall be suitable for ambient temperatures of 40°F-130°F and shall provide $\pm 0.5\%$ accuracy at 24 Vac and 5 VA load.
3. Windings (except for terminals) shall be completely enclosed with metal or plastic.

L. Current Switches: Current-operated switches shall be self-powered, solid-state with adjustable trip current. Select switches to match application current and DDC system output requirements. Any current switches used on VSDs shall be specialized for VSD application. Current switches shall be Veris Hawkeye or equivalent.

M. Pressure Transducers

1. Transducers shall have linear output signal and field-adjustable zero and span.
2. Continuous operating conditions of positive or negative pressure 50% greater than calibrated span shall not damage transducer sensing elements.
3. Water pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 150 psi. Transducer shall have 4-20 mA output, suitable mounting provisions, and block and bleed valves.
4. Water differential pressure transducer diaphragm shall be stainless steel with minimum proof pressure of 150 psi. Over-range limit (differential pressure) and maximum static pressure shall be 300 psi. Transducer shall have 4-20 mA output, suitable mounting provisions, and 5-valve manifold.

N. Differential Pressure Switches. Differential pressure switches (air or water service) shall be UL listed, SPDT snap-acting, pilot duty rated (125 VA minimum) and shall have scale range and differential suitable for intended application and NEMA 1 enclosure unless otherwise specified.

O. Local Control Panels

1. Indoor control panels shall be fully enclosed NEMA 1 construction with hinged door key-lock latch and removable sub-panels. A common key shall open each control panel and sub-panel.

2. Prewire internal and face-mounted device connections with color-coded stranded conductors tie-wrapped or neatly installed in plastic troughs. Field connection terminals shall be UL listed for 600 V service, individually identified per control and interlock drawings, with adequate clearance for field wiring.
3. Each Building Control panel shall have one 110Vac power outlet for connecting laptops or Portable Operators Terminal.

2.8 ELECTRONIC ACTUATORS AND VALVES

A. Quality Assurance for Actuators and Valves

1. UL Listed Standard 873 and C.S.A. Class 4813 02 certified.
2. NEMA 2 rated enclosures for inside mounting, provide with weather shield for outside mounting.
3. Five-year manufacturer's warranty. Two-year unconditional and three-year product defect from date of installation.

B. Execution Details for Actuators and Valves

1. Provide a Freeze-stat and install "Hard Wire" interlock to disconnect the mechanical spring return actuator power circuit for fail-safe operation. Use of the control signal to drive the actuators closed is not acceptable.
2. Each DDC analog output point shall have an actuator feedback signal, independent of control signal, wired and terminated in the control panel for true position information and troubleshooting. Or the actuator feedback signal may be wired to the DDC as an analog input for true actuator position status.
3. VAV box damper actuation shall be analog (2–10VDC, 4–20mA).
4. Booster-heat valve actuation shall be analog (2-10vdc, 4-20ma).
5. Primary valve control shall be analog (2–10VDC, 4–20mA).

C. Actuators for damper and control valves 0.5–6 inches shall be electric unless otherwise specified, provide actuators as follows:

1. UL Listed Standard 873 and Canadian Standards association Class 481302 shall certify actuators.
2. NEMA 2 rated actuator enclosures for inside mounting. Use additional weather shield to protect actuator when mounted outside.
3. Five-year manufacturer's warranty. Two-year unconditional and Three year product defect from date of installation.
4. Mechanical spring shall be provided when specified. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
5. Position indicator device shall be installed and made visible to the exposed side of the actuator. For damper short shaft mounting, a separate indicator shall be provided to the exposed side of the actuator.
6. Overload Protection: Actuators shall provide protection against actuator burnout by using an internal current limiting circuit or digital motor rotation sensing circuit. Circuit shall insure that actuators cannot burn out due to stalled damper or mechanical and electrical paralleling. End switches to deactivate the actuator at the end of rotation are acceptable only for butterfly valve actuators.
7. A Pushbutton gearbox release shall be provided for all non-spring actuators.

8. Modulating actuators shall be 24VAC and consume 10VA power or less.
9. Conduit connectors are required when specified and when code requires it.

D. Damper Actuators

1. Outside air and exhaust air damper actuators shall be mechanical spring return. capacitors or other non-mechanical forms of fail-safe are not acceptable. The actuator mounting arrangement and spring return feature shall permit normally open or normally closed positions of the damper as required.
2. Economizer actuators shall utilize analog control 2–10VDC, floating control is not acceptable.
3. Electric damper actuators (including VAV box actuators) shall be direct shaft-mounted and use a V-bolt and toothed V-clamp causing a cold weld effect for positive gripping. Single bolt or set-screw type fasteners are not acceptable.
4. One electronic actuator shall be direct shaft-mounted per damper section. No connecting rods or jackshafts shall be needed. Small outside air and return air economizer dampers may be mechanically linked together if one actuator has sufficient torque to drive both and damper drive shafts are both horizontal installed.
5. Multi-section dampers with electric actuators shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft-mounted per damper section. (See below execution section for more installation details.)

E. Valve Actuators

1. Mechanical spring shall be provided on all actuators for pre-heat coil and actuators for AHU heating or cooling coil when units are mounted outside. See plans for fail-safe flow function: Normal Open or Normal Closed. Capacitors or other non-mechanical forms of fail-safe are not acceptable.
2. All zone service actuators shall be non-spring return unless otherwise specified.
3. The valve actuator shall be capable of providing the minimum torque required for proper valve close-off for the required application.
4. All control valves actuators shall have an attached 3-foot cable for easy installation to a junction box.
5. Override handle and gearbox release shall be provided for all non-spring return valve actuators.

F. Control Dampers

1. The BAS contractor shall furnish and size all automatic control dampers unless provided with packaged equipment. The sheet metal contractor shall install all dampers unless provided with packaged equipment.
2. All dampers used for modulating service shall be opposed blade type and arranged for normally open or normally closed operation as required. The damper is to be sized so that, when wide open, the pressure drop is a sufficient amount of its close-off pressure drop for effective throttling.
3. All dampers used for two-position or open-close control shall be parallel blade type arranged for normally open or closed operation as required.
4. Damper linkage hardware shall be constructed of aluminum or corrosion-resistant zinc and nickel-plated steel and furnished as follows:
5. Bearing support bracket and drive blade pin extension shall be provided for each damper section. Sheet metal contractor shall install bearing support bracket and drive blade pin

extension. Sheet metal contractor shall provide permanent indication of blade position by scratching or marking the visible end of the drive blade pin extension.

6. Drive pin may be round only if V-bolt and toothed V-clamp is used to cause a cold weld effect for positive gripping. For single bolt or set-screw type actuator fasteners, round damper pin shafts must be milled with at least one side flat to avoid slippage.
7. Damper manufacturer shall supply alignment plates for all multi-section dampers.

G. Control Valves 0.5–6” inches

1. The BAS contractor shall furnish all specified motorized control valves and actuators. BAS contractor shall furnish all control wiring to actuators. The plumbing contractor shall install all valves. Equal percentage control characteristic shall be provided for all water coil control valves. Linear valve characteristic is acceptable for 3-way valves that are 2.5 inches and above.
2. Characterized control valves shall be used for hydronic heating or cooling applications and small to medium AHU water-coil applications to 100GPM. Actuators are non-spring return for terminal unit coil control unless otherwise noted. If the coil is exposed to the outside air stream, see plans for spring return requirement.
 - a. Leakage is zero percent, close-off is 200psi, maximum differential is 30psi; rangeability is 500:1.
 - b. Valves 0.5–2 inches shall be nickel-plated forged brass body, NPT screw type connections.
 - c. Valves 0.5–1.25 inches shall be rated for ANSI Class 600 working pressure. Valves 1.5 and 2 inches shall be rated for ANSI Class 400 working pressure.
 - d. The operating temperature range shall be 0–250 degrees F.
 - e. Stainless steel ball and stem shall be furnished on all modulating valves.
 - f. Seats shall be fiberglass reinforced Teflon.
 - g. Two-way and three-way valves shall have an equal percentage control port. Full stem rotation is required for maximum flow to insure stable BTU control of the coil.
 - h. Three-way valve shall be applicable for both mixing and diverting.
 - i. The characterizing disc is made of TEFZEL and shall be keyed and held secure by a retaining ring.
 - j. The valves shall have a blow-out proof stem design.
 - k. The stem packing shall consist of 2 lubricated O-rings designed for on-off or modulating service and require no maintenance.
 - l. The valves shall have an ISO type, 4-bolt flange for mounting actuator in any orientation parallel or perpendicular to the pipe.
 - m. A non-metallic thermal isolation adapter shall separate valve flange from actuator.
 - n. One fastening screw shall secure the direct coupling of the thermal isolation adapter between the actuator and the valve. This will prevent all lateral or rotational forces from affecting the stem and its packing O-rings.

H. Performance Verification Test

1. Control loops shall cause productive actuation with each movement of the actuator and actuators shall modulate at a rate that is stable and responsive. Actuator movement shall not occur before the effects of previous movement have affected the sensor.

2. Actuator shall have capability of signaling a trouble alarm when the actuator Stop-Go Ratio exceeds 30%.
- I. Actuator mounting for damper and valve arrangements shall comply to the following:
1. Damper actuators: Shall not be installed in the air stream
 2. A weather shield shall be used if actuators are located outside. For damper actuators, use clear plastic enclosure.
 3. Damper or valve actuator ambient temperature shall not exceed 122°F through any combination of medium temperature or surrounding air. Appropriate air gaps, thermal isolation washers or spacers, standoff legs, or insulation shall be provided as necessary.
 4. Actuator cords or conduit shall incorporate a drip leg if condensation is possible. Water shall not be allowed to contact actuator or internal parts. Location of conduits in temperatures dropping below dew point shall be avoided to prevent water from condensing in conduit and running into actuator.
 5. Damper mounting arrangements shall comply to the following:
 - a. The ventilation subcontractor shall furnish and install damper channel supports and sheet metal collars.
 - b. No jack shafting of damper sections shall be allowed.
 - c. Multi-section dampers shall be arranged so that each damper section operates individually. One electronic actuator shall be direct shaft mounted per section.
 6. Size damper sections based on actuator manufacturer's specific recommendations for face velocity, differential pressure and damper type.
 7. Multiple section dampers of two or more shall be arranged to allow actuators to be direct shaft mounted on the outside of the duct.
 8. Multiple section dampers of three or more sections wide shall be arranged with a 3-sided vertical channel (8 inches wide by 6 inches deep) within the duct or fan housing and between adjacent damper sections. Vertical channel shall be anchored at the top and bottom to the fan housing or building structure for support. The sides of each damper frame shall be connected to the channels. Holes in the channel shall allow damper drive blade shafts to pass through channel for direct shaft-mounting of actuators. Open side of channel shall be faced downstream of the airflow, except for exhaust air dampers.
 9. Multiple section dampers to be mounted flush within a wall or housing opening shall receive either vertical channel supports as described above or sheet metal stand out collars. Sheet metal collars (12-inch minimum) shall bring each damper section out of the wall to allow direct shaft-mounting of the actuator on the side of the collar.
- J. Valve Sizing for Water Coil
1. On/Off control valves shall be line size.
 2. Modulating control valve body size may be reduced, at most, two pipe sizes from the line size or not less than half the pipe size. The BAS contractor shall size all water coil control valves for the application as follows:
 - a. Booster-heat valves shall be sized not to exceed 4–9psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.

- b. Primary valves shall be sized not to exceed 5–15psi differential pressure. Size valve for 50% valve authority. Valve design pressure drop is equal to the sum of coil drop plus the balance valve drop.
- 3. Valve mounting arrangements shall comply to the following:
 - a. Unions shall be provided on all ports of two-way and three-way valves.
 - b. Install three-way equal percentage characterized control valves in a mixing configuration with the “A” port piped to the coil.
 - c. Install 2.5 inches and above, three-way globe valves, as manufactured for mixing or diverting service to the coil.

2.9 WIRING RACEWAYS AND POWER SUPPLIES

- A. General. Provide copper wiring, plenum cable, and raceways as specified in applicable sections of Division 26.
- B. Insulated wire shall use copper conductors and shall be UL listed for 200°F minimum service and be plenum rated.
- C. Power Supplies. Control transformers shall be UL listed. Furnish Class 2 current-limiting type or furnish over-current protection in primary and secondary circuits for Class 2 service in accordance with NEC requirements. Limit connected loads to 80% of rated capacity.
- D. DC power supply output shall match output current and voltage requirements. Unit shall be full-wave rectifier type with output ripple of 5.0 mV maximum peak-to-peak. Regulation shall be 1.0% line and load combined, with 100-microsecond response time for 50% load changes. Unit shall have built-in over-voltage and over-current protection and shall be able to withstand 150% current overload for at least three seconds without trip-out or failure.

PART 3 - EXECUTION

3.1 GENERAL

- A. Install system and materials in accordance with manufacturer’s instructions, and as detailed on the project drawing set.
- B. Line and low voltage electrical connections to control equipment shown specified or shown on the control diagrams shall be furnished and installed by the Control System Contractor in accordance with these specifications.
- C. Equipment furnished by the Mechanical Contractor that is normally wired before installation shall be furnished completely wired. Control wiring normally performed in the field will be furnished and installed by the Control System Contractor.
- D. All control devices mounted on the face of control panels shall be clearly identified as to function and system served with permanently engraved phenolic labels.

3.2 WIRING

- A. All electrical control wiring to the control panels shall be the responsibility of the Control System Contractor.
- B. All wiring shall be in accordance with the Project Electrical Specifications (Division 26), the National Electrical Code and any applicable local codes. All control wiring shall be installed in raceways.

3.3 ACCEPTANCE TESTING

- A. Upon completion of the installation, the Control System Contractor shall load all system software and start-up the system. The Control System Contractor shall perform all necessary calibration, testing and de-bugging and perform all required operational checks to insure that the system is functioning in full accordance with these specifications.
- B. The Control System Contractor shall perform tests to verify proper performance of components, routines, and points. Repeat tests until proper performance results. This testing shall include a point-by-point log to validate 100% of the input and output points of the DDC system operation.
- C. System Acceptance: Satisfactory completion is when the Control System Contractor has performed successfully all the required testing to show performance compliance with the requirements of the Contract Documents to the satisfaction of the Owner's Representative. System acceptance shall be contingent upon completion and review of all corrected deficiencies.

3.4 OPERATOR TRAINING

- A. During system commissioning and at such time acceptable performance of the Control System hardware and software has been established, the Control System Contractor shall provide on-site operator instruction to the owner's operating personnel. Operator instruction shall be done during normal working hours and shall be performed by a competent representative familiar with the system hardware, software and accessories.
- B. The Control System Contractor shall provide 40 hours of comprehensive training in two separate sessions (80 hours total) for system orientation, product maintenance and troubleshooting, programming and engineering, if not provided under a previous contract at the site using the same brand and type of controllers within the previous 3 years.
- C. The Control System Contractor shall provide 16 hours (total) of instruction to the owner's designated personnel on the operation of the BMS and describe its intended use with respect to the programmed functions specified. Operator orientation of the BMS shall include, but not be limited to; the overall operation program, equipment functions (both individually and as part of the total integrated system), commands, systems generation, advisories, and appropriate operator intervention required in responding to the System's operation

3.5 WARRANTY PERIOD SERVICES

- A. Equipment, materials and workmanship incorporated into the work shall be warranted for a period of one year from the time of system acceptance.
- B. Within this period, upon notice by the Owner, any defects in the BMS due to faulty materials, methods of installation or workmanship shall be promptly repaired or replaced by the Control System Contractor at no expense to the Owner
- C. Maintenance of Computer Software Programs: The Control System Contractor shall maintain all software during the warranty period. In addition, all factory or sub-vendor upgrades to software shall be added to the systems, when they become available, at no additional cost. New products are not considered upgrades in this context.
- D. Maintenance of Control Hardware: The Control System Contractor shall inspect, repair, replace, adjust, and calibrate, as required, the controllers, control devices and associated peripheral units during the warranty period. The Control System Contractor shall then furnish a report describing the status of the equipment, problem areas (if any) noticed during service work, and description of the corrective actions taken. The report shall clearly certify that all software is functioning correctly.
- E. Service Period: Calls for service by the Owner shall be honored within 24 hours and are not to be considered as part of routine maintenance.
- F. Service Documentation: A copy of the service report associated with each owner-initiated service call shall be provided to the owner.

3.6 WARRANTY ACCESS

- A. The Owner shall grant to the Control System Contractor reasonable access to the BMS during the warranty period. Remote access to the BMS (for the purpose of diagnostics and troubleshooting, via the Internet, during the warranty period) will be allowed.

3.7 OPERATION & MAINTENANCE MANUALS

- A. See Division 1 for requirements. O&M manuals shall include the following elements, as a minimum:
 - 1. As-built control drawings for all equipment.
 - 2. As-built Network Communications Diagram.
 - 3. General description and specifications for all components.
 - 4. Completed Performance Verification sheets.
 - 5. Completed Controller Checkout/Calibration Sheets.

3.8 INSTALLATION

- A. Provide all components in accordance with the manufacturer's recommendations. Perform the installation under the supervision of competent technicians regularly employed in the installation of DDC systems.
- B. Provide equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.
- C. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.
- D. All equipment, installation, and wiring shall comply with acceptable industry specifications and standards for performance, reliability, and compatibility and be executed in strict adherence to local codes and standard practices. Contractor shall continually monitor the field installation for code compliance and quality of workmanship. Contractor shall have work inspected by local and/or state authorities having jurisdiction over the work.
- E. Temperature Sensors: Provide temperature sensors in locations that are accessible and provide a good representation of sensed media. Installations in dead spaces are not acceptable. Calibrate sensors according to manufacturer's instructions. Do not use sensors designed for one application in a different application.
- F. Room Temperature Sensors: Verify location of thermostats and other exposed control sensors with plans and room details before installation. Mount the sensors on interior walls to sense the average room temperature at the locations indicated. Avoid locations near heat sources such as copy machines or locations by supply air outlet drafts. Mount the center of the sensor 48 inches above the floor to meet ADA requirements.
- G. Provide guards on room temperature sensors as shown on the plans.
- H. Duct Temperature Sensors
 - 1. Probe Type: Provide a gasket between the sensor housing and the duct wall. Seal the duct penetration air tight. Seal the duct insulation penetration vapor tight.
 - 2. Averaging Type (and coil freeze protection thermostats): Weave the capillary tube sensing element in a serpentine fashion perpendicular to the flow, across the duct or air handler cross-section, using durable non-metal supports. Prevent contact between the capillary and the duct or air handler internals. Provide a duct access door at the sensor location. The access door shall be hinged on the side, factory insulated, have cam type locks, and be as large as the duct will permit; maximum 18 x 18 inches. For sensors inside air handlers, the sensors shall be fully accessible through the air handler's access doors without removing any of the air handler's internals.
- I. Outside Air Temperature Sensors: Provide outside air temperature sensors in weatherproof enclosures on the north side of the building, away from exhaust hoods and other areas that may affect the reading. Provide a shield to shade the sensor from direct sunlight.
- J. Provide automatic dampers according to Section 233113 "Ductwork."
- K. Provide damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

- L. Provide labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."
- M. Provide hydronic instrument wells, valves, and other accessories according to Section 232116 "Hydronic Piping Specialties." Provide thermowells for sensors measuring piping, tank, or pressure vessel temperatures. Locate wells to sense continuous flow conditions. Do not install wells using extension couplings. Where piping diameters are smaller than the length of the wells, provide wells in piping at elbows to sense flow across entire area of well. Wells shall not restrict flow area to less than 70 percent of pipe area. Increase piping size as required to avoid restriction. Provide thermal conductivity material within the well to fully coat the inserted sensor.

3.9 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain HVAC instrumentation and controls. Refer to Section 017900 "Demonstration and Training."
- B. Provide a qualified instructor (or instructors) with five years minimum field experience with the installation and programming of similar BACnet DDC systems. Orient training to the specific systems installed. Coordinate training times with the Owner. Training shall take place at the job site.
- C. This training shall last 8 hours and shall be conducted at the DDC system workstation, at a notebook computer connected to the DDC system in the field, and at other site locations as necessary. Upon completion of the Training, each trainee should fully understand the project's DDC system operation. The training session shall include the following:
 - D. Provide basic control system fundamentals training.
 - 1. This project's list of control system components
 - 2. This project's list of points and objects
 - 3. This project's device and network communication architecture
 - 4. This project's sequences of control, and:
 - 5. Alarm capabilities
 - 6. Trending capabilities
 - 7. Troubleshooting communication errors
 - 8. Troubleshooting hardware errors
- E. Provide additional project-specific training:
 - 1. A walk-through tour of the mechanical system and the installed DDC components (controllers, valves, dampers, surge protection, switches, thermostats, sensors, etc.)
 - 2. A discussion of the components and functions at each DDC panel
 - 3. Logging-in and navigating at each operator interface type
 - 4. Using each operator interface to find, read, and write to specific controllers and objects
 - 5. Modifying and downloading control program changes
 - 6. Modifying setpoints
 - 7. Creating, editing, and viewing trends
 - 8. Creating, editing, and viewing alarms

9. Creating, editing, and viewing operating schedules and schedule objects
10. Backing-up and restoring programming and data bases
11. Modifying graphic text, backgrounds, dynamic data displays, and links to other graphics
12. Creating new graphics and adding new dynamic data displays and links
13. Alarm and Event management
14. Adding and removing network devices

END OF SECTION 23900

SECTION 230901 - VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes solid-state, PWM, VFDs for speed control of three-phase, squirrel-cage induction motors.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for Mechanical"
 - 2. Division 26

1.3 SUBMITTALS

- A. Shop Drawings shall include: Wiring diagrams, electrical schematics, front and side views of enclosures, overall dimensions, conduit entrance locations and requirements, nameplate legends, physical layout and enclosure details.
- B. Product Data: Provide data sheets showing; voltage, ratings of customer use switching and over-current protective devices, short circuit ratings, and weights.
- C. Manufacturer's Installation Instructions and Technical Manuals: Indicate application conditions and limitations of use stipulated by product testing agency specified under regulatory requirements. Include instructions for storage, handling, protection, examination, preparation, installation, and starting of adjustable speed drive. Document the sequence of operation, cautions and warnings, trouble shooting procedures, spare parts lists and programming guidance

1.4 QUALITY ASSURANCE

- A. Manufacturer Qualifications: A qualified manufacturer. Maintain, within 100 miles of Project site, a service center capable of providing training, parts, and emergency maintenance and repairs.
- B. Source Limitations: Obtain VFDs of a single type through one source from a single manufacturer.
- C. Electrical Components, Devices, and Accessories: Comply with NFPA 70. 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. Store VFDs indoors in clean, dry space with uniform temperature to prevent condensation. Protect VFDs from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.5 COORDINATION

- A. Coordinate power wiring to VFD with Division 26.
- B. Coordinate layout and installation of VFDs with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.
- C. Coordinate features of VFDs, installed units, and accessory devices with pilot devices and control circuits to which they connect.
- D. Coordinate features, accessories, and functions of each VFD and each installed unit with ratings and characteristics of supply circuit, motor, required control sequence, and duty cycle of motor and load.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Honeywell SmartVFD
 - 2. Eaton H-Max Series
 - 3. ABB ACH550
 - 4. Cerus Industrial P Series
 - 5. Danfoss VLT HVAC Drive
 - 6. GE AF-600 FP
 - 7. Allen-Bradley PowerFlex 700
 - 8. Toshiba VF-FS1
 - 9. Yaskawa E7 Series
 - 10. Siemens Micromaster

2.2 VARIABLE FREQUENCY DRIVES

- A. The VFDs shall be rated for voltage as scheduled. The VFD shall provide microprocessor based control for three-phase induction motors. The controller's full load output current rating shall be based on Variable Torque application at 40° C ambient and 1-16 kHz switching frequency below 50 HP and 1-10 kHz 50 HP and above to reduce motor noise and avoid increased motor losses.
- B. The VFD shall be of the Pulse Width Modulated (PWM) design converting the utility input voltage and frequency to a variable voltage and frequency output via a two-step operation. Adjustable Current Source VFD are not accepted. Insulated Gate Bipolar Transistors (IGBT's)

shall be used in the inverter section. Bipolar Junction Transistors, GTO's or SCR's are not accepted. The VFD shall run at the above listed switching frequencies.

- C. The VFD shall have an efficiency at full load and speed that exceeds 95% for VFD below 15 HP and 97% for drives 15 HP and above. The efficiency shall exceed 90% at 50% speed and load.
- D. The VFD shall maintain a minimum line side displacement power factor of 0.96, regardless of speed and load. The VFD shall have a one (1) minute overload current rating of 110% for variable torque applications.
- E. The VFD shall be capable of operating any NEMA design B squirrel cage induction motor, regardless of manufacturer, with a horsepower and current rating within the capacity of the VFD.
- F. The VFD shall have an integral EMI/RFI filter as standard.
- G. The VFD shall limit harmonic distortion reflected onto the utility system to voltage and current levels as defined by IEEE 519-1992 for general systems applications, by utilizing the standard 3% nominal impedance integral AC three-phase line reactor. DC link chokes are not accepted.
- H. Any harmonic calculations shall be done based on the kVA capacity, X/R ratio and the impedance of the utility transformer feeding the installation, as noted on the drawings, and the total system load. The calculations shall be made with the point of common coupling (PCC) being the point where the utility feeds multiple customers.
- I. Total harmonic distortion shall be calculated under worst case conditions in accordance with the procedure outlined in IEEE 519-1992. Copies of these calculations are to be made available upon request. The contractor shall provide any needed information to the VFD supplier three (3) weeks prior to requiring harmonic calculations.
- J. The system containing the VFD shall comply with the 5% level of total harmonic distortion of line voltage and the line current limits as defined in IEEE 519-1992. If the system cannot meet the harmonic levels with the VFD provided with the standard input line reactor or optional input isolation transformer, the VFD manufacturer shall supply an eighteen pulse, multiple bridge rectifier, AC to DC conversion section with phase shifting transformer for all drives above 75 HP. This eighteen pulse rectifier converter shall result in a multiple pulse current waveform that will more nearly approximate a true sine wave to reduce voltage harmonic content on the utility line. The phase shifting transformer shall be of a single winding type to optimize its KVA rating and harmonic cancellation capability. Harmonic filters are not accepted above 75 HP.
- K. The VFD shall be able to start into a spinning motor. The VFD shall be able to determine the motor speed in any direction and resume operation without tripping. If the motor is spinning in the reverse direction, the VFD shall start into the motor in the reverse direction, bring the motor to a controlled stop, and then accelerate the motor to the preset speed.
- L. Standard operating conditions shall be:
 - 1. Incoming Power: Three-phase, VAC as scheduled (+10% to -15%) and 50/60 Hz (+/-5 Hz) power to a fixed potential DC bus level.

2. Frequency stability of +/-0.05% for 24 hours with voltage regulation of +/-1% of maximum rated output voltage.
3. Speed regulation of +/- 0.5% of base speed.
4. Load inertia dependant carryover (ride-through) during utility loss.
5. Insensitive to input line rotation.
6. Humidity: 0 to 95% (non-condensing and non-corrosive).
7. Altitude: 0 to 3,300 feet (1000 meters) above sea level.
8. Ambient Temperature: -10 to 40 °C (VT).
9. Storage Temperature: -40 to 70 °C.

M. Control Functions

1. Frequently accessed VFD programmable parameters shall be adjustable from a digital operator keypad located on the front of the VFD. The VFD shall have a 3 line alphanumeric programmable display with status indicators. Keypads must use plain English words for parameters, status, and diagnostic messages. Keypads that are difficult to read or understand are not accepted, and particularly those that use alphanumeric code and tables. Keypads shall be adjustable for contrast with large characters easily visible in normal ambient light.
2. The keypad shall include a Hand-Off-Auto membrane selection and an Inverter/Bypass membrane selection. When in "Hand" the VFD will be started and the speed will be controlled from the up/down arrows. When in "Off", the VFD will be stopped. In "Auto", the VFD will start via an external contact closure or a communication network and the VFD speed will be controlled via an external speed reference.
3. The keypad shall have copy / paste capability.
4. Upon initial power up of the VFD, the keypad shall display a start up guide that will sequence all the necessary parameter adjustments for general start up.
5. Standard advanced programming and trouble-shooting functions shall be available by using a personal computer's RS-232 port and Windows™ based software. In addition the software shall permit control and monitoring via the VFD' RS232 port. The manufacturer shall supply a diskette with the required software. An easily understood instruction manual and software help screens shall also be provided. The computer software shall be used for modifying the drive setup and reviewing diagnostic and trend information as outlined in this section through Section 18.
6. The operator shall be able to scroll through the keypad menu to choose between the following:
 - a. Parameter Menu
 - b. Keypad Control
 - c. System Menu
 - d. Expander Boards
 - e. Monitoring Menu
 - f. Operate Menu
7. The following setups and adjustments, at a minimum, are to be available:
 - a. Start command from keypad, remote or communications port
 - b. Speed command from keypad, remote or communications port
 - c. Motor direction selection
 - d. Maximum and minimum speed limits
 - e. Acceleration and deceleration times, two settable ranges

- f. Critical (skip) frequency avoidance
- g. Torque limit
- h. Multiple attempt restart function
- i. Multiple preset speeds adjustment
- j. Catch a spinning motor start or normal start selection
- k. Programmable analog output

N. The VFD shall have the following system interfaces:

1. Inputs – A minimum of six (6) programmable digital inputs, two (2) analog inputs and serial communications interface shall be provided with the following available as a minimum:
 - a. Remote manual/auto
 - b. Remote start/stop
 - c. Remote forward/reverse
 - d. Remote preset speeds
 - e. Remote external trip
 - f. Remote fault reset
 - g. Process control speed reference interface, 4-20mA DC
 - h. Potentiometer or process control speed reference interface, 0 -10VDC
 - i. RS-232 programming and operation interface port
2. Outputs – A minimum of two (2) discrete programmable digital outputs, one (1) programmable open collector output, and one (1) programmable analog output shall be provided, with the following available at minimum.
 - a. Programmable relay outputs with one (1) set of Form C contacts for each, selectable with the following available at minimum:
 - 1) Fault
 - 2) Run
 - 3) Ready
 - 4) Reversing
 - 5) Jogging
 - 6) At speed
 - 7) In torque limit
 - 8) Motor rotation direction opposite of commanded
 - 9) Over-temperature
 - b. Programmable open collector output with available 24 Vdc power supply and selectable with the following available at minimum:
 - 1) Fault
 - 2) Run
 - 3) Ready
 - 4) Reversing
 - 5) Jogging
 - 6) At speed
 - 7) In torque limit

- 8) Motor rotation direction opposite of commanded
 - 9) Overtemperature
 - c. Programmable analog output signal, selectable with the following available at minimum:
 - 1) Output frequency
 - 2) Frequency reference
 - 3) Motor speed
 - 4) Output current
 - 5) Motor torque
 - 6) Motor power
 - 7) Motor voltage
 - 8) DC link voltage
 - 9) PID controller reference value
 - 10) PID controller actual value 1
 - 11) PID controller actual value 2
 - 12) PID controller error value
 - 13) PID controller output
 3. Capability of two additional expandable I/O interface cards. Upon installation, software shall automatically identify the interface card and activate the appropriate parameters. This should be done without adding any new software.
- O. Monitoring and Displays
1. The VFD display shall be a LCD type capable of displaying three (3) lines of text and the following thirteen (13) status indicators:
 - a. Run
 - b. Forward
 - c. Reverse
 - d. Stop
 - e. Ready
 - f. Alarm
 - g. Fault
 - h. Input/Output (I/O) Terminal
 - i. Keypad
 - j. Bus/communication
 - k. Hand
 - l. Auto
 - m. Off
 2. The VFD keypad shall be capable of displaying the following monitoring functions at a minimum:
 - a. Motor Speed (RPM and %)
 - b. Frequency reference
 - c. Output frequency
 - d. Motor current
 - e. Motor torque

- f. Motor power
- g. Motor voltage
- h. DC-link voltage
- i. Heat sink temperature
- j. Motor run time (resettable)
- k. Total operating days counter
- l. Operating hours (resettable)
- m. Total megawatt hours
- n. Megawatt hours (resettable)
- o. Voltage level of analog input
- p. Current level of analog input
- q. Digital inputs status
- r. Digital and relay outputs status
- s. Motor temperature rise
- t. PID references

P. Protective Functions

1. The VFD shall include the following protective features at minimum:
 - a. Over-current
 - b. Over-voltage
 - c. System fault
 - d. Under-voltage
 - e. Input line supervision
 - f. Output phase supervision
 - g. Under-temperature
 - h. Over-temperature
 - i. Motor stalled
 - j. Motor over temperature
 - k. Motor under-load
 - l. Logic voltage failure
 - m. Microprocessor failure
 - n. Brake chopper supervision
 - o. DC Injection braking
2. The VFD shall provide ground fault protection during power-up, starting, and running. VFD with no ground fault protection during running are not accepted.

Q. Diagnostic Features

1. Active Faults
2. The last 10 faults shall be recorded and stored in sequential order
3. Fault code and description of fault shall be displayed on the keypad.
4. Fault or alarm LED shall blink
5. Display drive data at time of fault
6. In the event several faults occur simultaneously, the sequence of active faults shall be viewable.

7. During a fault, the drive must be able to identify the following:
 - a. Drive Speed
 - b. Running hours
 - c. Running Days
 - d. Amps during fault
 - e. Motor Power
 - f. Motor Torque
 - g. DC bus Voltage
 - h. Drive Temperature
 8. Fault History
 - a. The last 30 faults shall be recorded and stored in sequential order.
 - b. Display drive data at time of fault
- R. Additional features included in the VFD:
1. The following indicating lights shall be provided on the keypad.
 - a. Drive Ready
 - b. Drive Run
 - c. Drive Fault
 2. The current withstand rating of the drive shall be 100,000 AIC. The rating of the complete drive assembly shall be UL tested and listed at 65kAIC.
 3. Communication card for interface with BACnet control system.
 4. The VFD shall have a cooling fan that is field replaceable using non-screw accessibility.
- S. Enclosure
1. The VFD shall be designed in a NEMA Type [1- general purpose] [12-drip tight] [3R-rain proof] enclosure. Packaging of the drive shall be designed and manufactured by the manufacturer of the drive for quality assurance.
 2. The VFD shall have complete front accessibility with easily removable assemblies.
 3. Cable entry shall be bottom entry.
- T. Disconnect Switch: allows a convenient means of disconnecting the drive from the line; operating mechanism can be padlocked in the OFF position; factory-mounted in the enclosure.
- U. T230he VFD manufacturer shall maintain, as part of a national network, engineering service facilities within 250 miles of project to provide start-up service, emergency service calls, repair work, service contracts, maintenance and training of customer personnel.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas, surfaces, and substrates to receive VFDs for compliance with requirements, installation tolerances, and other conditions affecting performance. Examine roughing-in for conduit systems to verify actual locations of conduit connections before VFD installation.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Select features of each VFD 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.

3.3 INSTALLATION

- A. Anchor each VFD assembly to steel-channel sills or unitstrut arranged and sized according to manufacturer's written instructions. Attach by bolting. Level and grout sills flush with mounting surface.
- B. Comply with mounting and anchoring requirements specified in Division 26.
- C. Controller Fuses: Install fuses in each fusible switch. Comply with requirements in Division 26.

3.4 IDENTIFICATION

- A. Identify VFDs, components, and control wiring according with labeling that indicates the controlled device.

3.5 CONTROL WIRING INSTALLATION

- A. Install wiring between VFDs and remote devices according to Division 26.
- B. Bundle, train, and support wiring in enclosures.
- C. Connect hand-off-automatic switch and other automatic-control devices where applicable.
 - 1. Connect selector switches to bypass only manual- 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.

3.6 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."

3.7 FIELD QUALITY CONTROL

- A. Provide the services of a qualified manufacturer's employed Field Service Engineer or authorized service representative to assist the Contractor in installation and start-up of the equipment specified under this section. Field Service personnel shall be factory trained with periodic updates and have experience with the same model of VFD's on the job site. Sales representatives will not be accepted to perform this work. The manufacturer's service representative shall provide technical direction and assistance to the Contractor in general assembly of the equipment, installation as specified in manufacturer's installation instructions, wiring, application dependant adjustments, and verification of proper VFD operation.
- B. The following minimum work shall be performed by the Contractor under the technical direction of the manufacturer's service representative.
 - 1. Inspection and final adjustments.
 - 2. Operational and functional checks of VFDs and spare parts.
 - 3. The contractor shall certify that he has read the drive manufacturer's installation instructions and has installed the VFD in accordance with those instructions.
- C. The Contractor shall provide three (3) copies of the manufacturer's field start-up report before final payment is made. 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.

3.8 ADJUSTING

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

3.9 DEMONSTRATION

- A. The Contractor shall provide a training session for one normal workday with a maximum of one trip. Training and instruction time shall be in addition to that required for start-up service. The

training shall be conducted by the manufacturer's qualified representative. The training program shall consist of the following:

1. Instructions on the proper operation of the equipment.
2. Instructions on the proper maintenance of the equipment.

END OF SECTION 230901

SECTION 230993 - SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for Mechanical"
 - 2. Section 230900 – Instrumentation and Control for HVAC for control equipment and devices and submittal requirements.
 - 3. Division 23 Sections – Equipment with built in DDC controllers
 - 4. Division 23 Section "Testing, Adjusting, and Balancing"
 - 5. Division 26

1.2 SUMMARY

- A. This Section includes control sequences for HVAC systems, subsystems, and equipment. Provide control devices, control software and control wiring as required for automatic operation of each sequence specified.
 - 1. Provide automatic control for system operation as described herein, although word "automatic" or "automatically", is not used.
 - 2. Manual operation is limited only where specifically described; however, provide manual override for each automatic operation.
 - 3. Where manual start-up is called for, also provide scheduled automatic start-stop capabilities.
- B. The system is BAS controlled using electric actuation. Provide proportional-integral-derivative (PID) algorithms for all control programs.
- C. Functions called for in sequence of operations are minimum requirements and not to limit additional BAS system capabilities. Determine, through operation of the system, proportional bands, interval time, integral periods, adjustment rates, and any other input information required to provide stable operation of the control programs.
- D. For each item of equipment, provide following functions which are not specifically mentioned in each Sequence of Operation:
 - 1. Start-Stop, manual, and scheduled
 - 2. On-Off status of each piece of equipment
 - 3. Run-time
 - 4. Alarm

- E. All setpoints shall be monitored and adjustable. Setpoints listed herein are approximate. It is the responsibility of the BAS contractor to calibrate the system and all setpoints to actual working conditions once the system is on line.

PART 2 - SEQUENCES

2.1 GENERAL

- A. Deadband – Must maintain 5°F between heating and cooling space temp setpoints
- B. Automatic Shutdown – Shutdown the system when occupants are not present.
- C. Control systems shall automatically return to program defaults no more than 2 hours after a program override by building occupants.
- D. Night Setback – Relaxed thermostat setpoints during unoccupied periods. Increase 5°F in cooling. Reduce 10°F in heating
- E. Optimum Start – Reduce the amount of time it takes to bring spaces to occupied temperature setpoint.

2.2 WHOLE BUILDING METERING

- A. Provide the building with measurement equipment including measurement devices capable of measuring whole-building electric and heating hot water usage in one-hour intervals.
 - 1. Electrical: Wire to electrical meter (meter provided by Division 26)
 - 2. Hot water: BTU Meter (see 230900)
- B. Building Automation System (BAS) shall display energy usage for current day, previous day, and same day of previous year; monthly data and cumulative energy usage for previous 12 months.
- C. Storage in the BAS of no less than 36 months of data for all energy types connected to all measurement devices and accessible from the user interface (remote data storage solutions are acceptable alternatives to on-site data storage provided the data is continuously available to an on-site display system).
- D. Peak Demand Limiting (PDL): The BAS system shall monitor the building electrical demand KW. During a restart or morning warmup, the KW demand must be limited to not exceed the peak KW demand for the previous 12 months.
 - 1. Provide a PDL program to limit the consumption of electricity to prevent electrical peak demand charges.
 - 2. PDL shall continuously track the amount of electricity being consumed, by monitoring a kilowatt-hour/demand input.
 - 3. PDL shall sample the kilowatt-hour/demand data to continuously forecast the demand likely to be used during successive time intervals.

4. If the PDL forecasted demand indicates that electricity usage is likely to exceed a user preset maximum allowable level, then PDL shall automatically shed electrical loads.
5. Once the demand peak has passed, loads that have been shed shall be restored and returned to normal control.

2.3 ENERGY RECOVERY VENTILATOR – LOWER SCHOOL

A. Rooftop Energy Recovery with heating coil.

1. Occupied Mode: User defined occupancy schedule.
2. Unit shall start and run with VAV boxes at their minimum positions. The ERV has a minimum airflow run requirement of 50% airflow (confirm minimum with ERV manufacturer). See supply & exhaust air terminal schedule for minimum airflow to each zone.
3. Heating mode:
 - a. ERV 2-way control valve modulates and coil circulating pump runs to maintain discharge air setpoint. Monitor OA temperature to automatically reset the supply air temperature in response to representative building loads. Provide a reset schedule, with 72°F supply air when OA is 0°F, to 55°F supply air when OA temperature is 55°F or higher.
 - b. Energize pump upon a call for heating or whenever the outside air temperature is below 40°F, provide 100% water flow thru the coil.
4. Variable Air Volume Control – provide VFD's for the supply fan & exhaust fan.
 - a. Supply & exhaust air static pressure control shall be provided by a proportional integral derivative (PID) algorithm that modulates the VFD to maintain a duct static pressure set point.
 - b. Fan-pressure optimization: Static pressure setpoint shall be reset using trim and respond logic within the range 0.2 inches to 1.5 inches for VAV AHUs. When fan is off, lock setpoint at the minimum value (0.2 inches). While fan is proven on, every 2 minutes, decrease the setpoint by 0.04 inches if there are no pressure requests. If there are more than two (adjustable) pressure requests, increase the setpoint by 0.04. Where VAV zone damper position is known, a pressure request is generated when any VAV damper served by the system is wide open. Where VAV zone damper position is unknown, a pressure request is made when the ratio of the zone's actual supply airflow to supply airflow setpoint is less than 90%. All values adjustable from fan graphic. The control logic shall be slow-acting to avoid hunting.
 - c. Automatically detect those zones that may be excessively driving the reset logic and generate an alarm to the system operator. Readily allow operator removal of zone(s) from the reset algorithm.
 - d. If the controller does not receive a valid duct static-pressure value, it shall generate a diagnostic and shut down the unit.
 - e. Static-pressure controller located in fan discharge stops fan and signals alarm when static pressure rises above excessive-static-pressure set point.
 - f. Set variable-speed drive to minimum speed when fan is stopped. The algorithm shall provide soft start of the fan by ensuring the VFDs are at minimum speed before energizing the fan.

5. Unoccupied Mode:
 - a. User defined schedule.
 - b. Damper and Fan Shutoff Controls – Motorized OA and EA dampers shall close and SF & EF will be OFF.
6. Safety:
 - a. Duct smoke detectors (furnished by Division 26).
 - b. Freezestat
 - c. Low discharge air temperature
7. BAS: Display the following data:
 - a. Monitoring DA temperature.
 - b. Freezestat (Generate an alarm).
 - c. Monitor supply fan and exhaust fan status.
 - d. Monitor system operating mode: heating, economizing.
 - e. Supply air temperature.

2.4 AIR TERMINAL UNITS – FRESH AIR TO ZONES

A. Occupied Mode

1. The BAS shall schedule the VAV to occupied mode. ERV-1 shall be running before the VAV will operate in the occupied mode.
 - a. Input Device: VAV box controller
 - b. Output Device: VAV box actuator
 - c. Action: The pressure independent VAV box shall provide scheduled minimum OA flow to the space. Refer to the VAV Box schedule for OA flows.
2. CO2 Demand Control Ventilation:
 - a. Input Device: Zone CO2 sensor – provide for each supply air terminal unit.
 - b. Output Device: VAV box actuator
 - c. Action: When the zone CO2 sensor is below 900 ppm (adj.), the system will have the terminal damper at minimum position. If the CO2 level at the zone 1,000 ppm the system will begin to modulate the damper open from minimum to maximum using a PID control loop. When the CO2 level set point is reached the box will stop modulation and begin back toward minimum position.

B. Operator Station Display: Indicate the following on operator workstation display terminal:

- a. Room/area served.
- b. VAV box CFM
- c. VAV box damper % open
- d. CO2 Setpoint
- e. CO2 ppm

2.5 UNIT HEATERS

- A. Unit Heater: On call for heat space thermostat starts fan and opens 2-way control valve on call for heat after pipe mounted aquastat setpoint (135°F) is satisfied. When space reaches setpoint the reverse happens.
 - 1. Occupied Mode: The unit shall maintain a heating setpoint of 65°F (adj.).
 - 2. Unoccupied Mode (night setback): The unit shall maintain a heating setpoint of 60°F
- B. Operator Workstation: Display the following data:
 - 1. Room/area served.
 - 2. Room temperature indication
 - 3. Room temperature set point, occupied.
 - 4. Room temperature set point, unoccupied.
 - 5. Control-valve position.

2.6 KILN EXHAUST FAN

- A. Interlock: Wire to kiln control circuit to start the fan.

2.7 VRV SYSTEM

- A. VRV System shall be furnished with factory controls as specified in Section 23 81 26. Provide supplementary wiring and components as required.
- B. Control contractor shall provide the communication wiring between indoor and outdoor units. All work shall be in accordance with VRV system manufacturer's recommendations.
- C. Control contractor shall wire to the BACnet interface provided by Section 23 81 26. VRV system setpoints shall be controlled and monitored via BACnet.
 - 1. Control functions:
 - a. Operation / Stop
 - b. Peak Demand Limiting
 - c. Space temperature settings
 - d. Cooling/heating change-over
 - 2. Monitoring functions:
 - a. Operation
 - b. Trouble
 - c. Room Temperature
 - 3. Management functions.
 - a. Energy and power saving control
 - b. Adjust setpoints

- c. Read temperatures
- d. Total system control

D. Sequence:

- 1. Input Devices: wall temperature sensor.
- 2. Output Device: VRV indoor units
- 3. Action: VRV indoor units provide heating or cooling as needed.

2.8 DUCTLESS SPLIT AIR CONDITIONING UNITS

- A. AC unit shall operate by manufacturer-supplied controls and wall thermostat to maintain setpoint during occupied and unoccupied modes.
- B. Provide a wall sensor to monitor room conditions.
- C. Alarm high condensate level at BAS.
- D. Display the following thru BAS for the above:
 - 1. Unit status ON/OFF.

END OF SECTION 230993

SECTION 231123 – FACILITY FUEL GAS PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 2 Sections.
 - 2. Division 7 Section for fire stopping.
 - 3. Division 23 Section "Common Work Results for HVAC"
 - 4. Division 23 Section "Hangers and Supports"

1.2 SUMMARY

- A. This Section includes fuel gas piping, specialties, and accessories.

1.3 PROJECT CONDITIONS

- A. Natural Gas System Pressure: Coordinate with gas supplier. **The gas pressure is very low at the project site.**

1.4 SUBMITTALS

- A. Product Data: For the following:
 - 1. Corrugated, stainless-steel tubing systems. Include associated components.
 - 2. Specialty valves
 - 3. Pressure regulators.
 - 4. Meters
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- C. Maintenance Data: For natural gas specialties and accessories to include in maintenance manuals specified in Division 1.
- D. Seismic Delegated-Design Submittal:
 - 1. For piping and equipment indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

- a. Determine seismic restraint sizes and locations.
 - b. Provide seismic restraints as scheduled or specified.
 - c. Provide calculations and materials if required for restraint of un-isolated equipment.
 - d. Provide installation instructions, drawings and trained field supervision to insure proper installation and performance.
2. Seismic restraints shall be designed in accordance with seismic force levels as detailed herein.
- a. Applicable Code: IBC
 - b. Seismic Design Category: See structural plans.
 - c. Design Spectral Response at Short Periods (SDS): See structural plans.
 - d. Short Period Spectral Response Acceleration (SS): See structural plans.
 - e. Building Use Group or Occupancy Category: See structural plans.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data

1.6 QUALITY ASSURANCE

- A. All work shall be performed by fuel gas licensed technicians.
- B. Installations of fuel gas must also comply with all other applicable statutes or rules of the State and all applicable ordinances, orders, rules, and regulations of local municipalities.
- C. Electrical Components and Devices: Listed and labeled as defined in NFPA 70, Article 100, by testing agency acceptable to authorities having jurisdiction, and marked for intended use.
- D. All work shall be per the following codes. Year edition of code shall be as recognized by the authority with jurisdiction
1. NFPA 54 "National Fuel Gas Code".
 2. Maine Fuel Board Rules
 3. NFPA 30, Flammable and Combustible Liquids Code
- E. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. Handling Flammable Liquids: Remove and legally dispose of liquids from drips in existing gas piping. Handle cautiously to avoid spillage and ignition. Notify fuel gas supplier. Handle flammable liquids used by Installer with proper precautions and do not leave on premises from end of one day to beginning of next day.

1.8 COORDINATION

- A. Natural Gas: Make arrangements with local utility for gas service to the Owner's distribution system. Provide service to the building as required by the Utility Company. Coordinate all activities between the Owner and Utility Company. The installation of the gas service shall comply with the published Utility Company standards. Pay all utility company charges; include charges in the base bid.
- B. Existing Utilities: Do not interrupt utilities serving facilities occupied by Owner or others unless permitted under the following conditions and then only after arranging to provide temporary utility services according to requirements indicated:
 - 1. Notify Architect not less than two days in advance of proposed utility interruptions.
 - 2. Do not proceed with utility interruptions without Architect's written permission.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Corrugated, Stainless-Steel Tubing Systems:
 - a. Omega Flex, Inc.
 - b. Titeflex Corp.
 - c. Tru-Flex Metal Hose Corp.
 - d. Ward Manufacturing, Inc.
 - 2. Valves:
 - a. American Valve.
 - b. Conbraco Industries, Inc.; Apollo Div.
 - c. Crane Valves.
 - d. Grinnell Corp.
 - e. Honeywell, Inc.
 - f. McDonald: A. Y. McDonald Mfg. Co.
 - g. Milwaukee Valve Co., Inc.
 - h. Nibco, Inc.
 - i. Mueller Co.; Mueller Gas Products Div.
 - j. Watts Industries, Inc.
 - 3. Pressure Regulators:
 - a. American Meter Co.
 - b. Equimeter, Inc.
 - c. Fisher Controls International, Inc.
 - d. Maxitrol Co.
 - e. National Meter.

- f. Richards Industries, Inc.; Jordan Valve Div.
- g. Schlumberger Industries; Gas Div.

2.2 PIPING MATERIALS

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

2.3 PIPES, TUBES, FITTINGS, AND JOINING MATERIALS

- A. Steel Pipe: ASTM A 106, Grade B; Schedule 40; black.
 - 1. Malleable-Iron Threaded Fittings: ASME B16.1, Class 150, standard pattern, with threaded ends according to ASME B1.20.1.
 - 2. Unions: ASME B16.39, Class 150, malleable iron with brass-to-iron seat, ground joint, and threaded ends according to ASME B1.20.1.
 - 3. Steel Welding Fittings: ASME B16.9, wrought steel or ASME B16.11, forged steel.
 - 4. Steel Threaded Fittings: ASME B16.11, forged steel with threaded ends according to ASME B1.20.1.
 - 5. Joint Compound and Tape: Suitable for natural gas.
 - 6. Steel Flanges and Flanged Fittings: ASME B16.5.
 - 7. Gasket Material: Thickness, material, and type suitable for natural gas.
- B. Corrugated Stainless Steel Tubing Systems: Gastite or approved equal; a corrugated stainless steel tubing complying with NFPA 54 and ANSI LC 1/CSA 6.26. Manufacturing materials shall be: ASTM A240 type 300 corrugated stainless steel tubing with a minimum wall thickness of .010", jacketing of UV resistant polyethylene meeting the requirements of ASTM E84 for flame spread and smoke density. All mechanical tube fittings shall be SAE CA360 brass incorporating double wall flare sealing and Jacket Lock[®] jacket capturing for steel tubing protection.
 - 1. Striker Plates: Steel, designed to protect tubing from penetrations.
 - 2. Manifolds: Malleable iron or steel with protective coating. Include threaded connections according to ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
- C. Transition Fittings: Type, material, and end connections to match piping being joined.
- D. Common Joining Materials: Refer to Division 23 Section "Common Work Results for HVAC" for joining materials not in this Section.

2.4 SPECIALTY VALVES

- A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.
- B. Appliance Connector Valves: ANSI Z21.15 and IAS listed.
- C. Gas Stops: Bronze body with AGA stamp, plug type with bronze plug and flat or square head, ball type with chrome-plated brass ball and lever handle, or butterfly valve with stainless-steel disc and fluorocarbon elastomer seal and lever handle; 2-psig minimum pressure rating.

- D. Gas Valves: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating.

2.5 NATURAL GAS SERVICE METER AND PRESSURE REGULATOR

- A. Natural Gas Service Meter: Provided by gas supplier. Coordinate requirements and pay all fees.

2.6 PRESSURE REGULATORS

- A. Regulators may include vent limiting device, instead of vent connection to outside, if approved by authorities having jurisdiction. Provide venting as required by code.
- B. Line Pressure Regulators: ANSI Z21.80 with 10-psig inlet pressure rating, unless otherwise indicated.
- C. Appliance Pressure Regulators: ANSI Z21.18.
- D. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.
- E. Pressure gages shall conform to ASME B40.100, Type I, Class 1. Pressure-gage size shall be 3-1/2-inch nominal diameter. Case shall be corrosion-resistant steel conforming to any of the AISI 300 series of ASTM A 666, with a No. 4 standard commercial polish or better. All gages shall be equipped with adjustable red marking pointer and damper screw adjustment in inlet connection.

2.7 SEISMIC RESTRAINTS

- A. Seismic-restraint devices shall have horizontal and vertical load testing and analysis performed according to OSHPD and shall bear anchorage preapproval "R" number, from OSHPD or another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If pre-approved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer. Testing and calculations must include both shear and tensile loads and 1 test or analysis at 45 degrees to the weakest mode.
- B. Seismic Cable Restraints shall consist of galvanized steel aircraft cables sized to resist seismic loads with a minimum safety factor of two and arranged to provide all-directional restraint.
- C. Seismic solid braces shall consist of steel angles or channels to resist seismic loads with a minimum safety factor of 2 and arranged to provide all directional restraint.
- D. Steel angles, sized to prevent buckling, shall be clamped to pipe or equipment rods utilizing a minimum of three ductile iron clamps at each restraint location when required.

- E. Pipe clevis cross bolt braces are required in all restraint locations. They shall be special purpose preformed channels deep enough to be held in place by bolts passing over the cross bolt.

2.8 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

3.1 EXAMINATION

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

3.2 EARTHWORK

- A. Comply with requirements in Division 31 for excavating, trenching, and backfilling.

3.3 PREPARATION

- A. Close equipment shutoff valves before turning off fuel gas to premises or section of piping. Perform leakage test as specified in "Field Quality Control" Article to determine that all equipment is turned off in affected piping section.
- B. Inspect natural-gas piping according to NFPA 54 to determine that natural-gas utilization devices are turned off in piping section affected.
- C. Comply with NFPA 54 requirements for prevention of accidental ignition.

3.4 NATURAL GAS SERVICE ENTRANCE PIPING

- A. Extend fuel gas piping and connect to fuel gas distribution for service entrance to building.
- B. Exterior fuel gas distribution system piping, service pressure regulator, and service meter will be provided by gas utility.
- C. Provide dielectric fitting downstream from and adjacent to each service meter unless meter is supported from service-meter bar with integral dielectric fitting. Provide shutoff valve downstream from and adjacent to dielectric fitting.

- D. Provide metal bollards to protect meter assemblies.

3.5 PIPING APPLICATIONS

- A. Flanges, unions, transition, and special fittings with pressure ratings same as or higher than system pressure rating may be used in applications below, unless otherwise indicated.
- B. Fuel Gas Piping: Use the following:
 - 1. NPS 1 and Smaller: steel pipe, malleable-iron threaded fittings, and threaded joints. Option: Corrugated, stainless-steel tubing may be used for runouts at individual appliances.
 - 2. NPS 1-1/4 to NPS 2: Steel pipe, malleable-iron threaded fittings, and threaded joints.
 - 3. NPS 2-1/2 and Larger: Steel pipe, steel welding fittings, and welded joints.
- C. In-slab (within building) Fuel Gas Piping: Not permitted.
- D. Underground Fuel Gas Piping: Provide underground, PE, natural-gas piping according to ASTM D 2774. Install underground piping buried at least 36 inches below finished grade.
- E. Containment Conduits: Steel pipe, steel welding fittings, and welded joints.
- F. Gas Service Piping at Meters and Regulators: Steel pipe, steel welding fittings, and welded joints.

3.6 VALVE APPLICATIONS

- A. Appliance Shutoff Valves for Pressure 0.5 psig or Less: Appliance connector valve or gas stop.
- B. Appliance Shutoff Valves for Pressure 0.5 to 2 psig: Gas stop or gas valve.
- C. Piping Line Valves, NPS 2 and Smaller: Gas valve.
- D. Piping Line Valves, NPS 2-1/2 and Larger: Plug valve or general-duty valve.
- E. Valves at Service Meter, NPS 2 and Smaller: Gas valve.
- F. Valves at Service Meter, NPS 2-1/2 and Larger: Plug valve.

3.7 PIPING INSTALLATION

- A. Refer to Division 22 Section "Common Work Results for HVAC" for basic piping installation requirements.
- B. All work must be conducted, installed, and completed in a neat and professional manner reflecting a minimum level of competent workmanship.
- C. Drips and Sediment Traps: Provide drips at points where condensate may collect. Locate where readily accessible for cleaning and emptying. Do not install where condensate would be

subject to freezing. Construct drips and sediment traps using tee fitting with bottom outlet plugged or capped. Use minimum-length nipple of 3 pipe diameters, but not less than 3 inches long, and same size as connected pipe. Provide with space between bottom of drip and floor for removal of plug or cap.

- D. Provide fuel gas piping at uniform grade of ¼" per 15 feet.
- E. Use eccentric reducer fittings to make reductions in pipe sizes. Provide fittings with level side down.
- F. Connect branch piping from top or side of horizontal piping.
- G. Provide unions in pipes NPS 2 and smaller, adjacent to each valve, at final connection to each piece of equipment, and elsewhere as indicated. Unions are not required on flanged devices.
- H. Provide flanges on valves, specialties, and equipment having NPS 2-1/2 and larger connections.
- I. Provide corrugated, stainless-steel tubing system according to manufacturer's written instructions. Include striker plates to protect tubing from puncture where tubing is restrained and cannot move.
- J. Provide strainer on inlet of each line pressure regulator.
- K. Extend relief vent connections for service regulators, line regulators, and overpressure protection devices to outdoors and terminate with weatherproof vent cap.
- L. Refer to Division 23 Section "Common Work Results for HVAC" for basic piping joint construction.
- M. Concealed Locations: Except as specified below, install concealed gas piping in airtight conduit constructed of Schedule 40, seamless, black steel pipe with welded joints. Vent conduit to outside and terminate with screened vent cap.
 - 1. Above-Ceiling Locations: Gas piping may be installed in accessible spaces, subject to approval of authorities having jurisdiction, whether or not such spaces are used as plenums. Do not locate valves above ceilings.
 - 2. In Floors: Not permitted.
 - 3. In Partitions: Do not install concealed piping in solid partitions. Tubing may be installed if protected with striker barriers per NFPA 54.
 - 4. In Walls: Gas piping with welded joints and protective wrapping specified in "Protective Coating" Article in Part 2 may be installed in masonry walls, subject to approval of authorities having jurisdiction.
 - 5. Prohibited Locations: Do not install gas piping where not allowed by NFPA.

3.8 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.

3.9 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports."
- B. Provide seismic restraints on piping.
- C. Provide hangers for horizontal steel piping with the following maximum spacing and minimum rod sizes:
1. NPS 1 and Smaller: Maximum span, 6 feet; minimum rod size, 3/8 inch.
 2. NPS 3/4 or NPS 1: Maximum span, 8 feet; minimum rod size, 3/8 inch.
 3. NPS 1-1/4 to 2": Maximum span, 10 feet; minimum rod size, 3/8 inch.
 4. NPS 2-1/2 to NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.
 5. NPS 4 and Larger: Maximum span, 10 feet; minimum rod size, 5/8 inch.
- D. Corrugated stainless steel piping shall be supported per manufacturer's recommendations.
- E. Support horizontal corrugated, stainless-steel tubing from structure according to manufacturer's written instructions.

3.10 SEISMIC RESTRAINT OF PIPING

- A. Seismic restraint systems must be installed in strict accordance with the manufacturers written instructions and all certified submittal data.
- B. Installation of seismic restraints must not cause any change of position of equipment or piping resulting in stresses or misalignment.
- C. Coordinate work with other trades to avoid rigid contact with the building.

- D. Overstressing of the building structure must not occur because of overhead support of equipment. Generally bracing may occur from:
1. Flanges of structural beams.
 2. Upper truss cords in bar joist construction.
 3. Cast in place inserts or wedge type drill-in concrete anchors.
- E. Cable restraints shall be installed slightly slack to avoid short-circuiting the isolated suspended equipment, piping or conduit. Cable assemblies shall be installed taut on non-isolated systems. Seismic solid braces may be used in place of cables on rigidly attached systems only.
1. The support rods must be braced when necessary to accept compressive loads with steel angles and rod clamp assemblies.
 2. At all locations where restraints are attached to pipe clevis's, the clevis cross bolt must be reinforced with pipe clevis cross bolt braces.
 3. Seismically restrain the following piping: Fuel gas piping that is 1" I.D. or larger.
 4. Piping exclusions:
 - a. Gas piping less than 1" inside diameter.
 - b. All piping suspended by individual hangers 12" or less as measured from the top of the pipe to the bottom of the support where the hanger is attached. However, if the 12" limit is exceeded by any hanger in the run, seismic bracing is required for the run.
 - c. The 12" exemption applies for trapeze-supported systems if the top of each item supported by the trapeze qualifies.
 5. Transverse piping restraints shall be at 20' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 6. Longitudinal restraints shall be at 80' maximum spacing for all pipe sizes, except where lesser spacing is required to limit anchorage loads.
 7. Transverse restraint for one pipe section may also act as a longitudinal restraint for a pipe section of the same size connected perpendicular to it if the restraint is installed within 24" of the elbow or tee or combined stresses are within allowable limits at longer distances.
 8. Hold down clamps must be used to attach pipe to all trapeze members before applying restraints in a manner similar to clevis supports.
 9. Branch lines may not be used to restrain main lines.
- F. Adjust seismic restraints to permit free movement of equipment within normal mode of operation.

3.11 CONNECTIONS

- A. Drawings indicate general arrangement of fuel gas piping, fittings, and specialties.
- B. Provide piping adjacent to appliances to allow service and maintenance.
- C. Connect piping to generator using gas with shutoff valves and unions. Provide flexible gas connectors. Provide pressure reducing valve per generator manufacturers recommendations.

- D. Sediment Traps: Provide tee fitting with capped nipple in bottom to form drip, as close as practical to inlet of each appliance using gas.

3.12 LABELING AND IDENTIFYING

- A. Equipment Nameplates and Signs: Provide engraved plastic-laminate equipment nameplate or sign on or near each service meter, pressure regulator, and specialty valve.
 - 1. Text: In addition to name of identified unit, distinguish between multiple units, inform operator of operational requirements, indicate safety and emergency precautions, and warn of hazards and improper operations.
 - 2. Refer to Division 23 Section "Identification for HVAC" for nameplates and signs.

3.13 PAINTING

- A. Comply with requirements in Division 9 for painting interior and exterior LPG piping.
- B. Paint outdoor exposed, exterior metal piping, valves, regulators, service meters and meter bars, and piping specialties, except components with factory-applied paint or protective coating.
 - 1. Alkyd System: MPI EXT 5.1D.
 - a. Prime Coat: Alkyd anticorrosive metal primer.
 - b. Intermediate Coat: Exterior alkyd enamel matching topcoat.
 - c. Topcoat: Exterior alkyd enamel
 - d. Color: As selected by Architect
- C. Damage and Touchup: Repair marred and damaged factory-applied finishes with materials and by procedures to match original factory finish.

3.14 FIELD QUALITY CONTROL

- A. Inspect, test, and purge piping according to NFPA 54 chapter: "Inspection, Testing, and Purging," and requirements of authorities having jurisdiction.
- B. Repair leaks and defects with new materials and retest system until satisfactory results are obtained.
- C. Report test results promptly and in writing to Architect and authorities having jurisdiction.
- D. Verify capacities and pressure ratings of service meters, pressure regulators, valves, and specialties.
- E. Verify correct pressure settings for pressure regulators.
- F. Verify that specified piping tests are complete.
- G. Verify that the gas piping has been grounded by Division 16 in accordance with NFPA requirements.

3.15 ADJUSTING

- A. Adjust controls and safety devices. Replace damaged and malfunctioning controls and safety devices.

END OF SECTION 231123

SECTION 232113 – HYDRONIC HVAC PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 7 Section for materials and methods for sealing pipe penetrations through fire and smoke barriers.
 - 2. Division 23 Section "Common Work Results for Mechanical"
 - 3. Division 23 Section "Hangers and Supports" for pipe supports, product descriptions, and installation requirements.
 - 4. Division 23 Section "Thermometers and Pressure Gages"
 - 5. Division 23 Section "Mechanical Identification" for labeling and identifying hydronic piping.
 - 6. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories for hydronic piping.
 - 7. Division 23 controls section for temperature-control valves and sensors.

1.2 SUMMARY

- A. This Section includes piping, special-duty valves, and specialties for hydronic HVAC piping.

1.3 SUBMITTALS

- A. Product Data: Provide manufacturer's standard submittal cut sheets. For each type of special-duty valve indicated. Include flow and pressure drop curves based on manufacturer's testing for diverting fittings, calibrated balancing valves, and automatic flow-control valves.
- B. Maintenance Data: For hydronic specialties and special-duty valves to include in maintenance manuals specified in Division 1.

1.4 QUALITY ASSURANCE

- A. Welding: Qualify processes and operators according to the ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
- B. Qualify soldering processes, procedures, and solderers for copper and copper alloy pipe and tube in accordance with ASTM B 828.
- C. Qualify brazing processes for copper and copper alloy pipe and tube according to ANSI/AWS C3.4.

- 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 the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1.

1.5 COORDINATION

- A. Drawings show the general layout of piping and accessories but do not show all required fittings and offsets that may be necessary to connect piping to equipment and to coordinate with other trades. Fabricate piping based on field measurements. Provide all necessary fittings and offsets.
- B. Coordinate layout and installation of hydronic piping and suspension system components with other construction, including light fixtures, HVAC equipment, fire-suppression-system components, and partition assemblies.
- C. Coordinate pipe sleeve installations for foundation wall penetrations.
- D. Coordinate piping installation with roof curbs, equipment supports, and roof penetrations. Roof specialties are specified in Division 7 Sections.
- E. Coordinate pipe fitting pressure classes with products specified in related Sections.
- F. Coordinate installation of pipe sleeves for penetrations through exterior walls and floor assemblies. Refer to Division 23 Section "Common Work Results for Mechanical".

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Grooved Mechanical-Joint Fittings and Couplings:
 - a. Victaulic Company of America.
 - b. Anvil
 - c. Grinnell Corporation.
 - 2. Balancing Valves:
 - a. Griswold Controls.
 - b. ITT Bell & Gossett
 - c. Taco, Inc.
 - d. Tour & Anderson
 - e. Flow Design, Inc.
 - f. Griswold Controls
 - g. Watts Industries Inc.
 - h. Nexus

3. Hydronic Specialties:
 - a. Amtrol, Inc.
 - b. Woods
 - c. ITT Bell & Gossett
 - d. Taco, Inc.
 - e. Aurora
 - f. Watts Industries Inc.
 - g. Wessels
 - h. Patterson
 - i. Thrush

4. Air Vents and Vacuum Breakers:
 - a. Armstrong International, Inc.
 - b. Barnes & Jones, Inc.
 - c. ITT Hoffman
 - d. Johnson Corp. (The).
 - e. Spirax Sarco, Inc.

2.2 PIPING MATERIALS

- A. General: Refer to Part 3 "Piping Applications" Article for applications of pipe and fitting materials.

2.3 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. Wrought-Copper Unions: ASME B16.22.
- F. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.
- G. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.4 HYDRONIC VALVES

- A. Ball Valves
 1. Threaded Ends 4" and Smaller: 150 psi WP and 600psi non-shock CWP, forged brass full-port or cast bronze two piece body, hard chrome plated forged brass ball, true adjustable packing nut ("O"-ring only type stem seal not acceptable), blow-out proof

- stem: Watts FBV-3C series/B6080 series, Hammond 8501, Nibco T-585-70, Milwaukee BA100, Apollo 70-Series, or approved equal.
2. Soldered Ends 3" and Smaller: 150 psi WP and 600psi non-shock CWP, full-port cast bronze or forged brass two piece body, hard chrome plated forged brass ball, true adjustable packing nut ("O"-ring only type stem seal not acceptable), blow-out proof stem: Watts FBVS-3C series/B6081 series, Hammond 8511, Nibco S-585-70, Milwaukee BA150, Apollo 70-Series, approved or equal.
 3. Comply with MSS SP-110.

B. Swing check valves:

1. Construct pressure containing parts of Valves as follows: Bronze Valves: 125 or 150 psi: ANSI/ASTM B 62; Iron Body Valves: ANSI/ASTM A-126, Grade B
2. Comply with the following standards for design, workmanship, material and testing: Bronze Valves: MSS SP – 80; Cast Iron Valves: MSS SP – 71.
3. Construct valves of pressure casting free of any impregnating materials. Construct disc and hanger as one piece. Support hanger pins by removable side plug.
4. Threaded Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc: Hammond IB904, Nibco T-413Y, Stockham B320T, Milwaukee 509 or approved equal.
5. Soldered Ends 2" and Smaller: Class 125, bronze body, screwed cap, Teflon disc: Hammond IB912, Nibco S-413-Y, Stockham B310T, Milwaukee 511 or approved equal.

2.5 HOOKUPS AND BALANCING

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

1. Nexus (Basis of Design)
2. Flow Design
3. Hays
4. Griswold
5. Victaulic
6. Taco
7. Bell & Gossett

B. Minimum Requirements Per Coil Installation:

1. Manual Flow Control Valve (MFCV) as indicated.
2. Y-strainer.
3. Temperature Control Valve (TCV) – see 230900.
4. Union connections at coil and TCV.
5. Air vent on return side.
6. Blowdown/drain valve on supply side.
7. Pressure/temperature test plugs across coil and TCV.
8. Full port, union end ball valves or butterfly valve for shutoff.

C. Materials Of Construction (2½" and smaller, except as noted)

1. Brass or stainless steel metals.
2. Teflon, EPDM or FKM seals.

D. Installation

1. Installation shall conform to basic piping methods specifications.
2. All components shall be isolated by shutoff valves.
3. Flexible hoses shall be installed at coil connections as shown in the plans or at the option of the mechanical contractor.
4. Union tailpieces may be used to reduce pipe sizes to match coil and TCV valve sizes.
5. Pressure/Temperature test plugs shall be installed across coil.
6. A Y-strainer or combination strainer and valve shall be installed on the supply side.
7. Unions shall be used to isolate the coil, AFCV and TCV.

E. Shutoff Valves (2½" and smaller) shall be forged brass ball valves, Nexus Model UX:

1. A one-piece body rated at 600 psi WP, 325° F.
2. Interchangeable union ends with FKM O-ring seal (ground joint is not acceptable).
3. Multiple ¼" tapped ports for test plugs, vent, and/or drain.
4. Blowout-proof stem with dual KFM O-ring seals.
5. Hard chrome plated stainless steel ball with Teflon seats.

F. Manual Flow Control Valves (2½" and smaller) shall be a combination of metering/balance type of forged brass construction, Nexus Model XB:

1. A modified venturi equipped with (2) pressure/temperature ports and an ID tag.
2. A combination shutoff and memory stop device-indicating degree of opening.
3. A rating of 600 WOG, 325°F.
4. An interchangeable union ends with FKM O-ring type seal.
5. Blowout proof stem with dual FKM O-ring seals.
6. Hard chrome plated stainless steel ball with Teflon seats.

G. Temperature Control Valves, ref. Section 230900 & 230993.

H. Combination Strainer/Ball Valves (2½" and smaller) used for supply side shutoff and strainer requirements shall be forged brass construction, Nexus Model UY:

1. A minimum rating of 600 WOG, 325° F.
2. Interchangeable union end with FKM O-ring seal.
3. Multiple ¼" tapped ports for test plugs, vent, or other accessories.
4. Blowout proof stem with dual FKM O-ring seals.
5. Hard chrome plated stainless steel ball with Teflon seats.
6. A 20 mesh 304 stainless steel filter screen, accessible without affecting the valve piping.
7. A port in the filter cap for a blowdown/drain valve.

I. Y-Strainers (2½" and smaller) shall be forged brass body, Nexus Model UYX:

1. ¼" tapped accessory ports.
2. A rating of 600 WOG, 325° F.
3. A 20 mesh 304 stainless steel filter screen, removable without affecting the strainer piping.
4. A port in the filter cap for a blowdown/drain valve.

J. Blowdown/Drain Valves shall be forged brass ball valve construction, Nexus Model BD:

1. A minimum rating of 600 WOG, 325° F.
2. Blowout proof stem with dual FKM O-ring seals.
3. Hard chrome plated brass ball with Teflon seats.
4. A ¾" hose end and nylon / brass cap with retainer to protect threads.

K. Unions (2" and smaller) shall be forged brass, Nexus Model UU:

1. A minimum of 600 psi WP, 325° F.
2. Multiple ¼" tapped ports for test plugs, vent and/or drain valves.
3. FKM O-ring seal.

L. Accessories to coil piping components shall conform to the following:

1. Nexus PT Pressure/Temperature test plugs shall be rated for 1000 psi, 325° F, with brass body, Nordel check plugs, and sealed cap.
2. Flexible hoses shall be designed for water, and fire retarding conform to ASTM codes E84-00, with stainless steel outer braid.
3. Hoses (½" thru 1"), Nexus UFHF.
 - a. Shall have a Kevlar reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 400 psi, 248°F.
 - b. Provide dual union or swivel end fittings.
4. Hoses (1¼" thru 2"), Nexus UFHM:
 - a. Shall have Rayon reinforced EPDM tube core, brass end fittings, and designed for a working pressure of 300 psi, 248° F.
 - b. Provide least one union or swivel end fitting
5. Nexus MV Manual air vents shall be of brass construction and rated at 400 psi, 325° F.
6. Shaft extensions (2" and smaller) for insulated pipe shall be at least 2¼" tall and constructed of brass

2.6 HYDRONIC SPECIALTIES

- A. Manual Air Vent: Bronze body and nonferrous internal parts; 150-psig working pressure; 225 deg F operating temperature; manually operated with screwdriver or thumbscrew; with NPS 1/8 discharge connection and NPS 1/2 inlet connection.
- B. Automatic Air Vent: designed to vent automatically with float principle; bronze body and nonferrous internal parts; 150-psig working pressure; 240 deg F operating temperature; with NPS 1/4 discharge connection and NPS 1/2 inlet connection. Seton, Brady, or approved equal.

PART 3 - EXECUTION

3.1 HYDRONIC PIPING APPLICATIONS – ABOVE GROUND

- A. Hot Water: Type L drawn-temper copper tubing with soldered joints.
- B. Drain Lines: PVC or DWV Copper Tubing: ASTM B 306, Type DWV.

3.2 VALVE INSTALLATION

- A. Install valves with unions or flanges at each piece of equipment arranged to allow service, maintenance, and equipment removal without system shutdown.
- B. Locate valves for easy access and provide separate support where necessary.
- C. Install valves in horizontal piping with stem at or above center of pipe.
- D. Install valves in position to allow full stem movement.
- E. Install check valves for proper direction of flow.

3.3 VALVE APPLICATIONS

- A. Hydronic Valve Applications: Unless otherwise indicated, use the following valve types:
 - 1. Shutoff Duty: Ball valves.
 - 2. Throttling Duty: Globe valves.
- B. Install shutoff duty valves at each branch connection to supply mains, at supply connection to each piece of equipment, unless only one piece of equipment is connected in the branch line. Install throttling duty valves at each branch connection to return mains, at return connections to each piece of equipment, and elsewhere as indicated.
- C. Install check valves at each pump discharge and elsewhere as required to control flow direction.

3.4 HYDRONIC PIPING INSTALLATIONS

- A. Refer to Division 23 Section "Common Work Results for Mechanical" for basic piping installation requirements.
- B. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.
- C. Refer to Division 23 Section "Common Work Results for Mechanical" for joint construction requirements.

- D. Hydronic piping systems shall be provided to permit the system to be drained. Install drains, consisting of a tee fitting, NPS 3/4 ball valve, and hose-end fitting with cap, at low points in piping system mains and elsewhere as required for system drainage.
- E. Install piping at a uniform grade of 0.2 percent upward in direction of flow.
- F. Pipe size at connections to equipment shall be distribution main size, not connection size.
- G. Reduce pipe sizes using eccentric reducer fitting installed with level side up.
- H. Provide dielectric fittings as specified in Section 230500.
- I. Unless otherwise indicated, install branch connections to mains using tee fittings in main pipe, with the takeoff coming out the bottom of the main pipe. For up-feed risers, install the takeoff coming out the top of the main pipe.
- J. Install unions in piping, NPS 2 and smaller, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

3.5 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor devices are specified in Division 23 Section "Hangers and Supports."

3.6 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. For automatic air vents in ceiling spaces or other concealed locations, provide vent tubing to nearest drain.

3.7 CONTROL VALVE INSTALLATION

- A. Perform the following as directed by the BAS contractor:
 - 1. Install modulating control valves with minimum of 10 pipe diameters straight pipe at inlet and 5 pipe diameters straight pipe at outlet.
 - 2. Installation of immersion wells and pressure tapplings, along with associated shut-off cocks.
 - 3. Installation of flow switches.
 - 4. Setting of automatic control valves or other control devices.
- B. Valve submittals shall be coordinated for type, quantity, size, and piping configuration to ensure compatibility with pipe design.
- C. Slip-stem control valves shall be installed so that the stem position is not more than 60 degrees from the vertical up position. Ball type control valves shall be installed with the stem in the horizontal position.
- D. Valves shall be installed in accordance with the manufacturer's recommendations.

- E. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be serviced and removed without interference from structure or other pipes and/or equipment.
- F. Isolation valves shall be installed so that the control valve body may be serviced without draining the supply/return side piping system. Unions shall be installed at all connections to screw-type control valves.

3.8 TERMINAL EQUIPMENT CONNECTIONS

- A. Size for supply and return piping connections shall be same as for equipment connections.
- B. Install control valves in accessible locations close to connected equipment.
- C. Arrange piping with offsets to allow for expansion, as well as terminal unit removal.

3.9 CLEANING AND FLUSHING

- A. Initial flushing: Remove loose dirt, mill scale, metal chips, weld beads, rust, and like deleterious substances without damage to any system component. Provide temporary piping or hose to bypass coils, control valves, exchangers and other factory cleaned equipment unless acceptable means of protection are provided and subsequent inspection of hide-out areas takes place. Isolate or protect clean system components, including pumps and pressure vessels, and remove any component which may be damaged. Open all valves, drains, vents and strainers at all system levels. Remove plugs, caps, spool pieces, and components to facilitate early debris discharge from system. Sectionalize system to obtain debris carrying velocity of 6 feet/second if possible. Connect dead-end supply and return headers as necessary. Flush bottoms of risers. Install temporary strainers where necessary to protect down-stream equipment. Supply and remove flushing water and drainage by various type hose, temporary and permanent piping and Contractor's booster pumps. Flush until clean.

3.10 FIELD QUALITY CONTROL

- A. Prepare piping according to ASME B31.9 and as follows:
 - 1. Leave joints, including welds, un-insulated and exposed for examination during test.
 - 2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
 - 3. Flush system with clean water. Clean strainers.
 - 4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
 - 5. Install safety valve, set at a pressure no more than one-third higher than test pressure, to protect against damage by expanding liquid or other source of overpressure during test.

B. Perform the following tests on 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 trapped air. Use drains installed at low points for complete draining of liquid.
3. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the design pressure but not less than 100 psi. 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 either 90 percent of specified minimum yield strength or 1.7 times "SE" value in Appendix-A of ASME B31.9, "Building Services Piping."
4. After hydrostatic test pressure has been applied for at least 15 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components and repeat hydrostatic test until there are no leaks.
5. Prepare written report of testing.

3.11 ADJUSTING

A. Perform these adjustments before operating the system:

1. Open valves to fully open position.
2. Check air vents at high points of system and determine if all are installed and operating and bleed air completely.
3. Set temperature controls so all coils are calling for full flow.

3.12 CLEANING

- A. Flush piping systems with clean water.
- B. Remove and clean or replace strainer screens.
- C. After cleaning and flushing hydronic-piping systems, but before balancing, remove disposable fine-mesh strainers in pump suction diffusers, and replace with the permanent stainless steel screens.

END OF SECTION 232113

SECTION 232123 - HYDRONIC PUMPS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for HVAC"

1.2 SUMMARY

- A. This Section includes
- B. Hydronic pumps and accessories.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of pump. Include certified performance curves and rated capacities, operating characteristics, furnished specialties, final impeller dimensions, and accessories for each type of product indicated. Indicate pump's operating point on curves.
- B. Wiring Diagrams: Detail wiring for power, signal, and control systems and differentiate between manufacturer-installed and field-installed wiring.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For pumps to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. UL Compliance: Fabricate and label pumps to comply with UL 778, "Motor-Operated Water Pumps," for construction 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.

1.6 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.

1.7 COORDINATION

- A. Coordinate electrical power with Division 26.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
- B. Hydronic Pumps
 - 1. Taco
 - 2. Armstrong
 - 3. Bell & Gossett ITT
 - 4. PACO
 - 5. Grundfos
 - 6. Patterson

2.2 IN-LINE WET ROTOR PUMPS.

- A. Taco 00e Series VR3452 pumps shall be self-adjusting, high-efficiency wet rotor circulators.
- B. Pump casing shall be constructed of EN-GJL-250 or ASTM-A 48 Class 35 cast iron. The pump casing / volute shall be rated for 175psi working pressure for all jobs. The pump flanges shall be matched to suit the working pressure of the piping components on the job, with ANSI Class 125 flanges.
- C. All casings shall be flanged connections.
- D. The impeller and shaft shall be Class 304 stainless steel.

- E. The pump and motor form an integral unit without a mechanical seal. The bearings are lubricated by the pumped liquid. No petroleum lubricated bearings will be accepted.
- F. Provide automatic mode – the pump shall automatically set the operating pressure, depending on the hydraulic system. By doing so, the pump shall find the optimal operating position.
- G. The wiring / electronics enclosure shall be class 2, IP44. Pumps should meet UL 778, 1004-1, 508C. The pumps shall be electronically protected, be rated for continuous duty and have a built-in startup circuit. The pump electronics shall provide overcurrent, line surge and current limit protection, thermal monitoring, heat sink status and over temperature protection.
- H. The pump must be driven by an electrically commutated electrical motor (ECM) with permanent magnet rotor. The rotor magnets shall be time stable, non-toxic ceramic magnets (Sr-Fe). The electrically commutated electrical motor shall be driven by a frequency converter with an integrated PFC filter.

2.3 AUTOMATIC CONDENSATE PUMP UNITS

- A. Sauermann Omega Pack or approved equal by Aspen or Little Giant; packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls.
 - 1. Provide ¼” tubing; self-sealing fitting to connect discharge tube to drain pipe.
 - 2. Si-20 piston pump with clear PVC tube fitted with a pre-mounted drain safe device
 - 3. 5’ power cable: 2 power wires, 2 safety contact wires
 - 4. Anti-vibration rubber damper
 - 5. Case, 2 pieces: backplate & cover
 - 6. 3 screw & plugs for affixing backplate
 - 7. Detection unit – Si2958, 2’ cable
 - 8. Detection unit installation kit:
 - a. Rubber elbow
 - b. Vent tube
 - c. Split connector
 - d. 3 double wire clamps
 - e. 3 tie wrap

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine equipment foundations for compliance with requirements for installation. Examine roughing-in for piping systems to verify actual locations of piping connections before pump installation. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 PUMP INSTALLATION

- A. Install pumps and equipment according to manufacturer's written instructions.
- B. Install pumps to provide access for periodic maintenance, including removing motors, impellers, couplings, and accessories.
- C. Pipe connections to pumps shall be made in such a manner so as not to exert any stress on pump housings. If necessary to meet this requirement, provide additional pipe supports and flex connectors.
- D. Pumps shall **NOT** be run dry to check rotation.

3.3 AUTOMATIC CONDENSATE PUMP UNITS

- A. Install units for collecting condensate and extend to open drain, floor drain, mop sink, or other approved location.
- B. Install check valve on each condensate pump unit discharge.
- C. Connect tubing provided with pump unit. Do not extend tubing through smoke or fire-rated walls.

3.4 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 the same size as piping connected to pumps.
- D. Install suction and discharge pipe sizes equal to or greater than diameter of pump nozzles. Install fittings and specialties as detailed on the plans.
- E. Install electrical connections for power, controls, and devices. Electrical power and control wiring and connections are specified in Electrical Specification Sections. Ground equipment. 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.

3.5 COMMISSIONING

- A. Verify that pumps are installed and connected according to the Contract Documents.
- B. Verify that electrical wiring installation complies with manufacturer's written instructions and the Contract Documents.

- C. Perform the following preventive maintenance operations and checks before starting:
 - 1. Lubricate bearings.
 - 2. Disconnect coupling and check motor for proper rotation that matches direction marked on pump casing.
 - 3. Verify that pumps are free to rotate by hand. Do not operate pumps if they are bound or drag, until cause of trouble is determined and corrected.
 - 4. Check suction piping connections for tightness to avoid drawing air into pumps.
 - 5. Clean strainers.
 - 6. Verify that pump controls are correct for required application.

- D. Starting procedure for pumps with shutoff power not exceeding safe motor power is as follows:
 - 1. Prime pumps by opening suction valves and closing drains, and prepare pumps for operation.
 - 2. Start motors with suction valves open and discharge valve closed. Open discharge valves slowly.
 - 3. Check general mechanical operation of pumps and motors.
 - 4. Follow manufacturers recommended procedures.

- E. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for detailed requirements for testing, adjusting, and balancing hydronic systems.

3.6 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain hydronic pumps as specified below:
 - 1. Train Owner's maintenance personnel on procedures and schedules for starting and stopping, troubleshooting, servicing, and maintaining pumps.
 - 2. Review data in maintenance manuals.

END OF SECTION 232123

SECTION 232300 - REFRIGERANT PIPING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes refrigerant piping used for systems specified in Section 238126.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of valve and refrigerant piping specialty indicated.
- B. 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.
- C. Refrigerant piping indicated on Drawings is schematic only. Size piping and design actual piping layout, including oil traps, 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. VRV system manufacturer shall design and approve the proposed pipe sizing, fittings, layout, and configuration.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For refrigerant valves and piping specialties to include in maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Comply with ASHRAE 15, "Safety Code for Refrigeration Systems."
- B. Comply with ASME B31.5, "Refrigeration Piping and Heat Transfer Components."

1.6 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.

1.7 COORDINATION

- A. Coordinate size and location of exterior condensing unit support pads.

PART 2 - PRODUCTS

2.1 COPPER TUBE AND FITTINGS

- A. Copper Tube: Joint-less phosphor-deoxidized copper pipe, as recommended by VRV system manufacturers.
- B. Wrought-Copper Fittings: ASME B16.22.
- C. Wrought-Copper Unions: ASME B16.22.
- D. Brazing Filler Metals: Do not use flux when brazing the refrigerant piping. Use the phosphor copper brazing filler metal (B-Cu93P-710/795: ISO 3677) which does not require flux. (Flux has extremely negative effect on refrigerant piping systems. For instance, if the chlorine based flux is used, it will cause pipe corrosion or, in particular, if the flux contains fluorine, it will damage the refrigerant oil.)

2.2 VALVES AND SPECIALTIES

- A. Provide as recommended by VRV and ductless split system manufacturers.

2.3 REFRIGERANTS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Atofina Chemicals, Inc.
 - 2. DuPont Company; Fluorochemicals Div.
 - 3. Honeywell, Inc.; Genetron Refrigerants.
 - 4. INEOS Fluor Americas LLC.
- B. ASHRAE 34, R-410A: Pentafluoroethane/Difluoromethane.

PART 3 - EXECUTION

3.1 VALVE AND SPECIALTY APPLICATIONS

- A. Provide REFNET joints, fittings, and accessories as recommended by the heat pump manufacturer.

3.2 PIPING INSTALLATION

- A. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Provide in accordance with field conditions and manufacturer's recommendations.
- B. Piping and installations must be in accordance with the VRV system manufacturers instructions.
- C. Install refrigerant piping according to ASHRAE 15.
- 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. Install piping adjacent to machines to allow service and maintenance.
- H. Install piping free of sags and bends.
- I. Install fittings for changes in direction and branch connections.
- J. Select system components with pressure rating equal to or greater than system operating pressure.
- 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.
- M. Install refrigerant piping in protective conduit where installed belowground.
- N. Slope refrigerant piping as per heat pump manufacturer's instructions.
- O. Install piping with adequate clearance between pipe and adjacent walls and hangers or between pipes for insulation installation.
- P. Identify refrigerant piping and valves according to Section 230553 "Identification for HVAC Piping and Equipment."

- Q. Install sleeves and for piping penetrations of walls, ceilings, and floors. Not required for core-drilled holes.

3.3 PIPE 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. Fill pipe and fittings with an inert gas (nitrogen or carbon dioxide), during brazing or welding, to prevent scale formation.
- D. Brazed Joints: Construct joints according to AWS's "Brazing Handbook," Chapter "Pipe and Tube."
 - 1. Be sure to perform nitrogen permutation or nitrogen blow when brazing. Brazing without performing nitrogen permutation or nitrogen blow into the piping will create large quantities of oxidized film on the inside of the pipes, adversely affecting valves and compressors in the refrigerating system and preventing normal operation.
 - 2. The pressure regulator for the nitrogen released when doing the brazing should be set to about 2.9 psi (Enough to feel a slight breeze on your cheek).
 - 3. Do not use anti-oxidants when brazing the pipe joints. Residue can clog pipes and break equipment.

3.4 HANGERS AND SUPPORTS

- A. Hanger, support, and anchor products are specified in Section 230529 "Hangers and Supports for HVAC Piping and Equipment."
- B. Install the following pipe attachments:
 - 1. Adjustable steel clevis hangers for individual horizontal runs less than 20 feet long.
 - 2. Copper-clad hangers and supports for hangers and supports in direct contact with copper pipe.
- C. Install hangers for copper tubing with the following maximum spacing and minimum rod sizes:
 - 1. NPS 5/8 or smaller: Maximum span, 60 inches; minimum rod size, 1/4 inch.
 - 2. NPS 1: Maximum span, 72 inches; minimum rod size, 1/4 inch.
 - 3. NPS 1-1/8: Maximum span, 72 inches; minimum rod size, 3/8 inch.
- D. Support multi-floor vertical runs at least at each floor.

3.5 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 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. Air tight test: Pressurize the liquid pipe, gas pipe, and equalizer pipe from the service ports of each shutoff valve to 550 psi (do not pressurize more than 550 psi). If the pressure does not drop within 24 hours, the system passes the test. If there is a pressure drop, check for leaks, make repairs and perform the air tight test again.
 - c. Vacuum drying: Evacuate the system from the liquid pipe and gas pipe shutoff valve service ports by using a vacuum pump for more than 2 hours and bring the system to -14.6 psi or less. After keeping the system under that condition for more than 1 hour, check if the vacuum gauge rises or not. If it rises, the system may either contain moisture inside or have leaks.
 - d. System shall maintain test pressure at the manifold gage throughout duration of test.
 - e. Test joints and fittings with electronic leak detector or by brushing a small amount of soap and glycerin solution over joints.
 - f. Remake leaking joints using new materials and retest until satisfactory results are achieved.
 - a. Absolutely do not open the shutoff valve until the main power circuit insulation measurement has been completed.

3.6 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.

END OF SECTION 232300

SECTION 233113 - DUCTWORK

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 8 for Access Doors
 - 2. Division 23 Section "Common Work Results for Mechanical"
 - 3. Division 23 Section "Mechanical Insulation"
 - 4. Division 23 Section "Air Terminals"
 - 5. Division 23 Section "Diffusers, Registers, and Grilles."
 - 6. Division 23 Control Section
 - 7. Division 23 Section "Testing, Adjusting, and Balancing".

1.2 SUMMARY

- A. This Section includes metal ducts and accessories for heating, ventilating, and air-conditioning systems.

1.3 SYSTEM DESCRIPTION

- A. Drawings show the general layout of ductwork and accessories but do not show all required fittings and offsets that may be necessary to connect ducts to equipment, diffusers, grilles, etc., and to coordinate with other trades. Fabricate ductwork based on field measurements. Provide all necessary fittings and offsets. Coordinate with other trades for space available and relative location of HVAC equipment and accessories on ceiling grid. Duct sizes on the drawings are inside dimensions, which may be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.
- B. The contractor must comply with the enclosed specification in its entirety. If on inspections, the engineer finds changes have been made without prior written approval, the contractor will make the applicable changes to comply with this specification, at the contractor's expense.
- C. At the discretion of the engineer, sheet metal gauges, and reinforcing may be randomly checked to verify all duct construction is in compliance.

1.4 PERFORMANCE REQUIREMENTS

- A. Delegated Duct Design: Duct construction, including sheet metal thicknesses, seam and joint construction, reinforcements, and hangers and supports, shall comply with SMACNA's "HVAC

Duct Construction Standards - Metal and Flexible" and performance requirements and design criteria indicated in "Duct Schedule" Article.

- B. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1.

1.5 ACTION SUBMITTALS

- A. Product Data: For each type of the following products:

1. Liners and adhesives.
2. Sealants and gaskets.
3. Seismic-restraint devices.

- B. 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, seismic restraints, and vibration isolation.

- C. Delegated-Design Submittal:

1. Sheet metal thicknesses.
2. Joint and seam construction and sealing.
3. Reinforcement details and spacing.
4. Materials, fabrication, assembly, and spacing of hangers and supports.

- D. Ductwork Specialties Product Data; provide for the following:

1. Sealant
2. Duct Liner
3. Duct-mounted access doors and panels.
4. Flexible ducts.
5. Manual-volume dampers: Damper manufacturer's printed application and performance data including pressure, velocity and temperature limitations shall be submitted for approval.
6. Fire dampers: Provide complete submittal information (including installation instructions) and the manufacturer's certification of compliance with these specifications

for approval prior to bidding. Contractor shall include damper manufacturer's Installation Instructions as part of the submittal. These instructions shall describe the applicable requirements for damper sleeve thickness, retaining angles, and methods of attachment, duct-to-sleeve connections, preparation of wall or floor openings, and all other requirements to provide an installation equivalent to that tested by the damper manufacturer during the UL Standard 555 qualification procedures. Contractor shall detail any proposed installations that deviate from these manufacturer's instructions and explain the needed deviations.

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Plans, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:
 - 1. Duct installation in congested spaces, indicating coordination with general construction, building components, and other building services. Indicate proposed changes to duct layout.
 - 2. Suspended ceiling components.
 - 3. Structural members to which duct will be attached.
 - 4. Size and location of initial access modules for acoustical tile.
 - 5. Penetrations of smoke barriers and fire-rated construction.
 - 6. Items penetrating finished ceiling – examples: lighting fixtures, sprinklers, etc.
 - 7. Areas of building where coordination drawings are required:
 - a. Congested areas including all duct mains.
- B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.
- C. Record Drawings: Indicate actual routing, fitting details, reinforcement, support, and installed accessories and devices.

1.7 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air duct accessories to include in operation and maintenance manuals.

1.8 APPLICABLE PUBLICATIONS

- A. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
- B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- C. National Fire Protection Association (NFPA):
 - 1. 90A: Standard for the Installation of Air Conditioning and Ventilating Systems

- D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):
 - 1. 3rd Edition: 2005 HVAC Duct Construction Standards, Metal and Flexible
 - 2. 1st Edition: 1985 HVAC Air Duct Leakage Test Manual

1.9 DELIVERY, STORAGE, AND HANDLING

- A. Deliver sealant and fire stopping materials to site in original unopened containers or bundles with labels indicating manufacturer, product name and designation, color, expiration period for use, pot life, curing time, and mixing instructions for multi-component materials.
- B. Deliver, store and handle materials according to manufacturer's written recommendations.
- C. All ductwork, equipment, and fittings delivered and stored on the job site must be capped to prevent the entry of moisture, construction dust or other debris.

PART 2 - PRODUCTS

2.1 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: G60 or G90 as indicated.
 - 2. Finishes for Surfaces Exposed to View: Mill phosphatized.
- C. 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.
- D. 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.
- E. 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.

2.2 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 2-1, "Rectangular Duct/Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- C. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-2, "Rectangular Duct/Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."
- D. Cross Breaking or Cross Beading: Cross break or cross bead duct sides 19 inches and larger and 0.0359 inch thick or less, with more than 10 sq. ft. of un-braced panel area, unless ducts are lined. All large ducts must be braced as required to prevent drumming.
- E. 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 4, "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."
 - 1. Fig. 2-3 Rectangular Elbows: Type RE2 square throat with vanes, Type RE1 radius (1.5W minimum), or Type RE5 dual radius. Square throat is not allowed.
 - 2. Vane support in elbows: Fig 2-4. Turning vanes shall be Harper double wall turning vanes fabricated from the same material as the duct. Mounting rails shall have friction insert tabs that align the vanes automatically. Tab spacing shall be as specified in Figure 2-3 of the 1995 SMACNA Manual, "HVAC Duct Construction Standards, Metal & Flexible" Second Edition standard. Rail systems with non-standard tab spacing shall not be accepted. Due to tensile loading, vanes shall be capable of supporting 250 pounds when secured according to the manufacturer's instructions.
 - 3. Fig. 2-5 Rectangular Divided Flow Branches: Type 1, Type 2, Type 4A, or 4B.
 - 4. Fig. 2-6 Branch Connections: 45-degree entry, 45-degree lead-in, bell-mouth or spin-in (single diffuser supply only).
 - 5. Fig. 2-7 Offsets and Transitions. Use gradual offsets as shown, 90-degree offsets shall be avoided.
 - 6. Fig 2-9 Duct Coils: Hot water heating coils with transitions and access door as shown.

2.3 ROUND DUCT FABRICATION

- A. Fabricate supply ducts of galvanized steel according to SMACNA's "HVAC Duct Construction Standards--Metal and Flexible" latest edition.
- B. Longitudinal Seams: Select seam types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-2, "Round Duct Longitudinal Seams," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

1. Exposed Round Ducts: Shall be Spiral Seam (RL-1 seam) at 2-inch wg construction.
 2. Concealed Round Ducts: Shall be longitudinal Grooved Seam Flat lock (RL-5 seam) at 2-inch wg construction.
 3. Snap lock seams shall not be used for this project.
- C. Transverse Joints: Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-1, "Round Duct Transverse Joints," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.4 HANGERS AND SUPPORTS

- A. Hanger Rods for Noncorrosive Environments: Cadmium-plated steel rods and nuts.
- B. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."
- C. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A 603.
- D. 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.
- E. Duct Attachments: Sheet metal screws, blind rivets, or self-tapping metal screws; compatible with duct materials.
- F. Trapeze and Riser Supports:
1. Supports for Galvanized-Steel Ducts: Galvanized-steel shapes and plates.
 2. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.
- G. Supports For Roof Mounted Ductwork:
1. Bases shall be high density polypropylene with UV inhibitors and anti-oxidants.
 2. Steel frame: Steel, 12ga 1-5/8" or 1-7/8" strut galvanized per ASTM A123 or 14ga 13/16" strut galvanized per ASTM A653 for PP10 and SS8.
 3. PHP Duct Support (Enclosed) - designed to support any size of square or round duct at any required height above the roof surface.
 - a. Support Spacing subject to local codes and authorities but will not exceed 10 feet
 - b. Bracing required when using base with swivel, when duct exceeds 24 inches above roof.



2.5 SEALANT MATERIALS

- A. Joint Sealant/Mastic: Shall be flexible, water-based, adhesive sealant designed for use in all pressure duct systems. After curing, it shall be resistant to ultraviolet light and shall prevent the entry of water, air and moisture into the duct system. Sealer shall be UL 723 and UL 181 listed and meet NFPA 90A requirements.
1. Maximum 5 flame spread and 0 smoke-developed (ASTM E-84 Tunnel Test).
 2. Generally provide liquid sealant for low clearance slip joints and heavy, permanently elastic, mastic type where clearances are larger.
 3. Resistance to mold, mildew and water: Excellent
 4. Color: Gray
 5. Duct sealant/mastic shall meet requirement for "LEED IEQ Credit 4.1: Low Emitting Materials: Adhesive and Sealant". ITW TACC Miracle Kingco water-based sealants, or approved equal.
- B. Flange Gaskets: Butyl rubber, neoprene, or EPDM polymer with polyisobutylene plasticizer.
- C. 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. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.6 FITTINGS

- A. Tees, Laterals, and Conical Tees: Use 45 degree; fabricate to comply with SMACNA's "HVAC Duct Construction Standards--Metal and Flexible," with metal thicknesses specified for longitudinal seam straight duct.
- B. Diverging-Flow Fittings: Fabricate with a reduced entrance to branch taps with no excess material projecting from body onto branch tap entrance.

- C. Elbows: Diameters 3 through 8 inches shall be two-section die stamped; all others shall be gored construction, maximum 18 degree angle, with all seams continuously welded or standing seam. Coat galvanized areas of fittings damaged by welding with corrosion resistant aluminum paint or galvanized repair compound.

2.7 DUCT LINER

- A. All products shall be certified by Greenguard Environmental Institute; independent testing of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Greenguard provides independent, third-party certification of IAQ performance. Certification is based upon criteria used by EPA, OSHA and WHO.
- B. Liner Thickness: 1 inch (R4.2)
- C. Flexible Elastomeric
 - 1. Basis-of-Design Product: Subject to compliance with requirements, provide Armacell LLC; AP Armaflex, or a comparable product by one of the following:
 - a. Aeroflex USA Inc.; Aerocel.
 - b. RBX Corporation; Insul-Sheet 1800
 - 2. Armaflex: All ducts, where shown on the drawings, shall be lined with thick AP/Armaflex SA duct liner, or approved equal. The liner shall meet the requirements of NFPA 90A and UL 181.
 - a. Temperature Range: -40F to 180F.
 - b. Thermal conductivity: 0.27 @ 75°F (24°C) mean temp (ASTM C 518).
 - c. Water vapor transmission: less than 0.08 (1.16×10^{-13}) (ASTM E 96, Procedure A)
 - d. Water vapor transmission: less than 0.2% by volume (ASTM C 209)
 - e. Microbial growth: none (ASTM C 1071), ASTM G21- fungal), ASTM G22 – bacterial).
 - f. Erosion Resistance: Does not break away, flake off or show evidence of delamination at velocities of 6,000ft./min. (ASTM C 1071)
 - g. 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.
 - h. Liner Adhesive: As recommended by insulation manufacturer and complying with NFPA 90A. Duct liner adhesive sealants shall meet requirement for "LEED IEQ Credit 4.1: Low Emitting Materials: Adhesive and Sealant".
 - i. Comply with ASTM C 534, Type II, Grade 1, for sheet materials.
 - j. Provide product recognized under Underwriters Laboratories "UL 94 - Plastic Component Classification" and listed in Factory Mutual "FM Approval Guide."
- D. Shop Application of Duct Liner: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 7-11, "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. Apply adhesive coating on longitudinal seams in ducts with air velocity of 2500 fpm.
7. 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.
8. 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.

2.8 MANUAL-VOLUME DAMPERS

- A. Manual balancing dampers meeting the following specifications shall be furnished and installed on all branch ducts and where shown on plans. Testing and ratings to be in accordance with AMCA Standard 500-D.
- B. Single-Blade Rectangular Dampers shall consist of: an 18 ga. galvanized steel frame with 3-1/2 in. depth; blades fabricated from 20 ga. galvanized steel; integral 1/2 in. dia axles. Damper suitable for pressures to 1.0 in. wg, velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBD-10.
- C. Multi-Blade Rectangular Dampers shall consist of: a 16 ga. galvanized steel hat channel frame with 5 in. depth; triple V type blades fabricated from 16 ga. galvanized steel; 1/2 in. dia. plated steel axles; external (out of the airstream) blade-to-blade linkage. Damper suitable for pressures to 4.0 in. w.g. (996 Pa), velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBD15.
- D. Round dampers shall consist of: a 20 ga. galvanized steel frame with 6 in. depth; blades fabricated from 20 ga. galvanized steel; 3/8 in. square plated steel axles turning in acetal bearings. Damper suitable for pressures to 1.0 in. wg, velocities to 2000 fpm and temperatures to 180°F. Basis of design is Greenheck model MBDR50.

2.9 FIRE DAMPERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Air Balance Inc.
 - 2. Cesco Products
 - 3. Greenheck Fan Corporation.
 - 4. METALAIRE, Inc.
 - 5. Nailor Industries Inc.
 - 6. Prefco
 - 7. Ruskin Company.
- B. Type: Static; rated and labeled according to UL 555S by an NRTL.
- C. Fire Rating: 1-1/2 hours.
- D. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch- thick galvanized steel; with mitered and interlocking corners.
- E. Mounting Sleeve: Factory- or field-installed, galvanized sheet steel.
 - 1. Minimum Thickness: 0.052 or 0.138 inch thick, as indicated, and of length to suit application.
 - 2. Exception: Omit sleeve where damper-frame width permits direct attachment of perimeter mounting angles on each side of wall or floor; thickness of damper frame must comply with sleeve requirements.
- F. Mounting Orientation: Vertical or horizontal as indicated.
- G. Blades: Roll-formed, interlocking, 0.034-inch- thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch- thick, galvanized-steel blade connectors.
- H. Horizontal Dampers: Include blade lock and stainless-steel closure spring.
- I. Heat-Responsive Device: Replaceable, 165°F rated, fusible links.

2.10 DUCT-MOUNTED ACCESS DOORS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Ductmate Industries, Inc.
 - 2. Greenheck Fan Corporation.
 - 3. McGill Air Flow LLC.
 - 4. Nailor Industries Inc.
 - 5. Cesco
 - 6. Buckley

- B. 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; rated for up to 4.5" static pressure.
 - b. Door panel filled with 1" fiberglass insulation; ¾ lb. density.
 - c. Hinges and Latches: 1-by-1-inch continuous piano hinge and cam latches.
 - d. Fabricate doors airtight and suitable for duct pressure class.
 2. Frame: Galvanized sheet steel, with bend-over tabs.
 3. Provide 1/8" thick neoprene gaskets.
 4. Number of Hinges and Locks:
 - a. Access Doors Less Than 12 Inches Square: No hinges and two cam locks.
 - b. Access Doors up to 24 Inches Square: One hinge and cam locks.

2.11 FLEXIBLE CONNECTORS

- A. Provide for all air moving equipment. General: Flame-retarded or noncombustible fabrics, coatings, and adhesives complying with UL 181, Class 0 or 1. Factory fabricated with a strip of fabric 3-1/2 inches wide attached to two strips of 2-3/4-inch- wide, 0.028-inch- thick, galvanized, sheet steel or 0.032-inch aluminum sheets. Select metal compatible with connected ducts. Duro-Dyne, Hardcast, or approved equal.
- B. Indoor Flexible Connector Fabric: Glass fabric double coated with polychloroprene or neoprene. Minimum Weight: 26 oz. /sq. yd. Tensile Strength: 480 lbf/inch in the warp, and 360 lbf/inch in the filling.
- C. Outdoor Flexible Connector Fabric: Glass fabric double coated with a synthetic-rubber or hypalon, white color; weatherproof coating resistant to the sun's ultraviolet rays and ozone environment. Minimum Weight: 24 oz. /sq. yd. Tensile Strength: 530 lbf/inch in the warp, and 440 lbf/inch in the filling.

2.12 FLEXIBLE DUCTS

- A. General: Comply with UL 181, Class 0 Or 1. Flame Spread: Less than 25; Smoke Developed: Less than 50.
- B. All products shall be certified by Greenguard Environmental Institute; independent testing of products for emissions of respirable particles and Volatile Organic Compounds (VOC's), including formaldehyde and other specific product-related pollutants. Greenguard provides independent, third-party certification of IAQ performance. Certification is based upon criteria used by EPA, OSHA and WHO.
- C. Rated Positive Pressure: 10" w.g. per UL-181. Maximum negative pressure: ¾".

- D. Flexible Ducts, Insulated: Factory-fabricated, insulated, round duct, with an outer jacket enclosing glass-fiber insulation around a continuous inner liner.
 - 1. R6 insulation, Basis of Design: Atco #86
 - 2. Reinforcement: Steel-wire helix encapsulated in inner liner.
 - 3. Outer Jacket: Polyethylene film.
 - 4. Inner Liner: Polyethylene film.
- E. Flexible Ducts, Un-insulated: A triple lamination of metallized polyester, aluminum foil, and polyester shall encapsulate a steel wire helix. Basis of Design: Atco #50
- F. Flexible Duct Clamps: Stainless-steel band with cadmium-plated hex screw to tighten band with a worm-gear action, in sizes 3 to 18 inches to suit duct size.
- G. Hangers shall be band type, 1" wide minimum.

2.13 DOWNDRAFT VENTILATION SYSTEM

- A. Downdraft Ventilation System: Skutt "EnviroVent 2" negative pressure downdraft ventilation system; capable of removing hazardous fumes only, not heat. System to consist of the following components:
 - 1. Blower motor with six (6) ft. power cord and in-line switch.
 - 2. 8 x 12 inch mounting plate.
 - 3. Eight (8) ft. x three (3) inch flexible aluminum duct.
 - 4. Spring-loaded plenum cup assembly.
 - 5. Blower inlet tube.
 - 6. Blower discharge tube.
 - 7. Plenum spring.
 - 8. Three (3) to four (4) inch connector.
 - 9. Floor mounting plate.
 - 10. Mounting hardware.

THE ENVIROVENT 2



The EnviroVent 2 is a negative pressure venting system that is U.L. Listed and meets building code standards for venting fumes from electric kilns. When used in conjunction with the **EnviroLink** the vent can be turned off automatically when the kiln is done firing.

The EnviroVent Kit includes the motor, plenum cup, 8 ft. of 3" aluminum duct and all the necessary hardware. Two kilns under 12 Cu/Ft a piece may be vented with one vent motor if used with **Dual Vent Kit**.

115V 1.4 Amps 140 CFM

- B. System fits a single top-loading, multi-sided, electric kiln with a chamber size less than 12 cu. ft.

- C. Electrical Switching Device: Skutt "EnviroLink" electrical switching device utilizing a programmable power output in the controller to turn the downdraft ventilation system on and off.
- D. Furniture Kit: Kit includes shelves and one (1) or more posts. Kits are designed to fire to Cone 10 temperatures.
- E. Provide system components on kiln in accordance with manufacturer's written instructions.
- F. Provide the blower and motor assembly on the wall in a location that is close enough for the flexible aluminum duct to reach the kiln without overstretching the duct.

PART 3 - EXECUTION

3.1 DUCT INSTALLATION, GENERAL

- 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 and accessories according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.
- C. Construct and install each duct system for the specific duct pressure classification indicated.
- D. Properly seam, brace, stiffen, support and render ducts mechanically airtight. Adjust ducts to suit job conditions. Dimensions may be changed as approved, if cross sectional area is maintained.
- E. Install ducts in lengths not less than 12 feet, unless interrupted by fittings. Install ducts with fewest possible joints.
- F. Install fabricated fittings for changes in directions, changes in size and shape, and connections.
- G. Install couplings tight to duct wall surface with a minimum of projections into duct.
- H. Install ductwork to allow maximum headroom. Install ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Install ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.
- I. Install ducts with a clearance of 1 inch, plus allowance for insulation thickness.
- J. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.
- K. Coordinate layout with suspended ceiling, lighting layouts, and similar finished work.

- L. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.
- M. Install duct accessories of materials suited to duct materials; use galvanized-steel accessories in galvanized-steel ducts, stainless-steel accessories in stainless-steel ducts, and aluminum accessories in aluminum ducts.

3.2 INSTALLATION OF EXPOSED DUCTWORK

- A. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.
- B. Hangers Exposed to View: Threaded rod and angle or channel supports.
- C. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system.
- D. Grind welds to provide smooth surface free of burrs, sharp edges, and weld splatter. When welding stainless steel with a No. 3 or 4 finish, grind the welds flush, polish the exposed welds, and treat the welds to remove discoloration caused by welding.
- E. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.
- F. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.3 MATERIALS

- A. Hangers, accessories, and dampers shall be same material as parent duct.
- B. Refer to Specification Section 230700 for sheet metal covering of rigid insulation for protection from maintenance personnel crossing insulated ductwork in mechanical spaces.
- C. All ducts shall be G60 galvanized steel except as follows:
 - 1. Exterior ductwork: Hangers and attachments shall be electro-galvanized, all-thread rod or galvanized rods with threads painted after installation. Refer to SMACNA Fig. 5-3. All ductwork shall be pitched or sloped to prevent "ponding" of water.
 - 2. Exposed Ductwork: Galvaneal (ready for paint)
 - 3. Radon exhaust ductwork installed in or beneath slabs: Schedule 40 PVC pipe that conforms to ASTM D 1785.

3.4 DUCT CLASSIFICATIONS AND SEALING

- A. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:
 - 1. Supply & Exhaust Ducts between ERV and VAV terminal units: 3 in. w.g.
 - 2. Supply & Exhaust Ducts between VAV terminal units and air outlets: 2-inch wg.
 - 3. Heat Pump Supply Ducts: 2 in. w.g.

4. Return Ducts: 2-inch wg, negative pressure.
5. Exhaust Ducts: 2-inch wg, negative pressure.

B. Seam And Joint Sealing

1. General: Seal duct seams and joints according to the duct pressure class indicated and as described in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible."
2. Seal to SMACNA Class A; all joints, longitudinal and transverse seams, and connections in ductwork shall be securely fastened and sealed with welds, gaskets, or duct sealant. Exceptions:
 - a. Continuously welded and locking-type longitudinal joints and seams on ducts operating at less than 2 in. wg pressure classification.
 - b. Exposed exhaust or return ducts operating at less than 2 in. wg pressure classification.
 - c. Exposed supply ducts in the space that the duct serves.
3. Seal externally insulated ducts before insulation installation.

3.5 DUCT PENETRATIONS

- A. Fire or Smoke Rated Penetrations not requiring a fire and/or smoke damper: Where ducts pass through walls, floors, or partitions that are required to have a fire resistance rating and fire dampers are not required, the opening in the construction around the duct shall be as follows:
 1. Not exceeding a 1" average clearance on all sides.
 2. Filled solid with firestopping material as specified in Section 230500.
- B. Fire-Rated Penetrations – Fire Damper: Provide fire damper as specified under Duct Accessories paragraph.
- C. Non-Fire-Rated Exposed Penetrations: Where ducts pass through interior partitions and exterior walls, and are exposed to view, conceal space between construction opening and duct or duct insulation with sheet metal flanges of same metal thickness as duct. Overlap opening on four sides by at least 1-1/2 inches.
- D. Non-Fire-Rated Concealed Penetrations: Provide insulation infill and acoustical sealant around gaps. Tightly seal to prevent sound transmission. Neatly finish.
- E. Roof penetrations by ducts shall use counter-flashed curbs.
- F. Flexible air ducts or connectors shall not pass through any wall, floor, or ceiling.

3.6 HANGER AND SUPPORT INSTALLATION

- A. Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 5, "Hangers and Supports."

- B. Building Attachments: Concrete inserts, powder-actuated fasteners, or structural-steel fasteners appropriate for construction materials to which hangers are being attached.
 - 1. Where practical, install concrete inserts before placing concrete.
 - 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.
 - 5. Do not use powder-actuated concrete fasteners for seismic restraints.
- C. Hanger Spacing: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct," for maximum hanger spacing; install hangers and supports within 24 inches of each elbow and within 48 inches of each branch intersection.
- D. 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.
- E. Install upper attachments to structures. Select and size upper attachments with pull-out, tension,

3.7 FLEXIBLE DUCT

- A. Provide in accordance with manufacturer's and Air Diffusion Council recommendations.
- B. Flexible ducts shall be supported at manufacturer's recommended intervals, but at no greater distance than 5 feet. Maximum permissible sag is 1/2" per foot of spacing between supports.
- C. Install duct fully extended; do not install in the compressed state or use excess lengths.
- D. Avoid bending ducts across sharp corners or incidental contact with metal fixtures, pipes, conduits, or hot equipment. Radius at centerline shall not be less than one duct diameter.
- E. Hanger or saddle material in contact with the duct shall be at least 1-1/2" wide.
- F. Provide at least 2 duct diameters of straight duct at the entrance to register, grilles, and diffusers.

3.8 SPECIALTY DUCTWORK

- A. Clothes Dryer Exhaust: Not needed – non-ducted electric condensing dryers will be used.

3.9 DUCT ACCESSORIES INSTALLATION

- A. Install duct accessories according to applicable details shown in SMACNA's "HVAC Duct Construction Standards--Metal and Flexible".

- B. Provide duct transitions, offsets and connections to dampers, coils, and other equipment in accordance with SMACNA Standards
- C. Each register, grille, or diffuser shall have a means of air flow adjustment. Provide volume damper in branch duct if not furnished with the RGD.
- D. Adjust operable devices for proper action.
- E. Perform the following as directed by the controls contractor:
 - 1. Installation of:
 - a. Automatic control dampers.
 - b. Smoke detectors.
 - c. Necessary blank off plates.
 - 2. Access doors where indicated and as required.
- F. Install duct access panels for access components that require servicing.
 - 1. Install duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining per equipment manufacturers' requirements.
 - 2. Install access panels on side of duct where adequate clearance is available.
 - 3. Locate panel upstream and/or downstream as recommended by manufacturer.
 - 4. Locations:
 - a. 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.
 - b. At each change in direction and at maximum 50-foot (15-m) spacing.
 - c. Upstream from turning vanes.
 - d. Control devices requiring inspection.
 - e. Elsewhere as indicated or required by duct accessory manufacturer
 - 5. Inspect locations of access doors and verify that purpose of access door can be performed.
- G. Control Damper Installation
 - 1. Damper submittals shall be coordinated for type, quantity, and size to ensure compatibility with sheet metal design.
 - 2. Duct openings shall be free of any obstruction or irregularities that might interfere with blade or linkage rotation or actuator mounting. Duct openings shall measure ¼ in. larger than damper dimensions and shall be square, straight, and level.
 - 3. Individual damper sections, as well as entire multiple section assemblies, must be completely square and free from racking, twisting, or bending. Measure diagonally from upper corners to opposite lower corners of each damper section. Both dimensions must be within 1/8 in. of each other.

4. Follow the manufacturer's instructions for field installation of control dampers. Unless specifically designed for vertical blade application, dampers must be mounted with blade axis horizontal.
5. Damper blades, axles, and linkage must operate without binding. Before system operation, cycle damper after installation to ensure proper operation. On multiple section assemblies, all sections must open and close simultaneously.
6. Provide a visible and accessible indication of damper position on the drive shaft end.
7. Support ductwork in area of damper when required to prevent sagging due to damper weight.
8. After installation of low-leakage dampers with seals, caulk between frame and duct opening to prevent leakage around perimeter of damper.

H. Fire Damper Installation

1. Examine areas to receive dampers. Notify the Engineer of conditions that would adversely affect installation or subsequent utilization of dampers. Do not proceed with installation until unsatisfactory conditions are corrected
2. Install dampers in accordance with manufacturer's UL Installation Instructions, labeling, and NFPA 90A at locations indicated on the drawings. Any damper installation that is not in accordance with the manufacturer's UL Installation Instructions must be approved prior to installation.
3. Dampers must be accessible to allow inspection, adjustment, and replacement of components. The sheet metal contractor shall furnish any access doors in ductwork or plenums required to provide this access. The general contractor shall furnish any access doors required in walls, ceilings, or other general building construction.
4. Install dampers square and free from racking.
5. The installing contractor shall provide and install bracing for multiple section assemblies to support assembly weight and to hold against system pressure.
6. Do not compress or stretch the damper frame into the duct or opening.
7. Attach multiple damper section assemblies together in accordance with manufacturer's instructions. Install support mullions as reinforcement between assemblies as required.
8. Handle dampers using the frame or sleeve. Do not lift or move dampers using blades, actuator or jackshaft.
9. Provide access door, properly located for serving.
10. Tests and Inspections: Operate dampers to verify full range of movement and verify that proper heat-response device is installed.

3.10 DUCT LINER INSTALLATIONS

- A. All portions of duct designated to receive duct liner shall be completely covered with duct liner. All joints shall be neatly butted and there shall be no interruptions or gaps. Duct liner shall be installed with the printed air stream surface treatment exposed to the air stream.
- B. Duct liner shall be adhered to the sheet metal with 90% (minimum) coverage of adhesive complying with the requirements of ASTM C 916.
- C. All transverse edges that are not to receive sheet metal nosing shall be coated. Longitudinal joints shall occur at the corners of ducts. If duct size and standard duct liner product dimensions make exposed longitudinal joints necessary, such joints shall be coated with adhesive designated for duct liner application and which meets the requirements of ASTM C 916. Such

joints shall be additionally secured with mechanical fasteners in accordance with NAIMA FGDLS, or SMACNA HVAC DCS as if they were transverse joints.

- D. Duct liner shall be additionally secured with mechanical fasteners complying with the requirements NAIMA FGDLS or SMACNA HVAC DCS and of the correct type for the duct liner being installed. Fasteners may be either weld-secured or impact-driven, and shall be installed perpendicular to the duct surface. Mechanical fasteners shall not compress the insulation more than 1/8" based on nominal insulation thickness. Fastener spacing with respect to interior duct dimensions shall be in accordance with NAIMA FGDLS or SMACNA HVAC DCS. Fastener heads or washers shall have a minimum area of 0.75 in², with beveled or cupped edges to prevent their cutting into the duct liner.
- E. Metal nosing shall be securely installed over transverse liner edges facing the airstream at fan discharge and at any point where lined duct is preceded by unlined duct.
- F. Duct liner in roll form shall be folded and compressed in the corners of rectangular duct sections, or shall be cut and fit to assure a lapped, compressed corner joint.
- G. Duct liner in sheet form shall be cut and fit to assure tight, over-lapped corner joints. Top pieces of liner shall be supported at the edges by the side pieces.
- H. Any damage to the air stream surface must be repaired by coating the damaged area with adhesive or coating designed for duct liner application. Adhesive or coating shall meet requirements of ASTM C916.

3.11 FIELD QUALITY CONTROL

- A. Protect duct interiors from moisture, construction debris and dust, and other foreign materials. Comply with SMACNA's "IAQ Guidelines for Occupied Buildings Under Construction," Appendix G, "Duct Cleanliness for New Construction Guidelines."
- B. HVAC systems shall not be operated during construction.
- C. Upon completion of installation duct systems and before HVAC system start-up, visually inspect the ductwork proper installation
- D. Cover supply openings with filter media prior to system start-up to catch any loose material that may remain inside the ductwork. Turn the HVAC system on and allow it to run until steady state operation is reached. Remove the temporary filter media from supply openings and, along with it, any loose material blown downstream and caught by the filter media.
- E. All ductwork shall be provided with temporary enclosures to keep the HVAC system free of dust and construction debris. The HVAC system includes any interior surface of the facility's air distribution system for conditioned spaces and/or occupied zones. This includes the entire duct from the points where the air enters the system to the points where the air is discharged from the system.
- F. Check all filters in accordance with their manufacturer's instructions. Use specified grade of filters at all times that system is operating.

G. Leakage Tests:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test.
2. Ducts shall meet a rate of air leakage (CL) less than or equal to 4.0 as determined by the following equation: $CL = F/P^{0.65}$
 - a. F = the measured leakage rate in CFM per 100 square feet of duct surface.
 - b. P = the static pressure of the test.
3. Test Ducts with a Pressure Class Higher Than 2-Inch wg: Test representative duct sections totaling no less than 25 percent of total installed duct area for each designated pressure class.
4. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
5. Test for leaks before applying external insulation.
6. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
7. Give seven days' advance notice for testing.

END OF SECTION 233113

SECTION 233600 - AIR TERMINAL UNITS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for HVAC"
 - 2. Division 23 Controls Section for control devices installed on air terminals.

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Single-duct air terminals.

1.3 ACTION SUBMITTALS

- A. Product Data: For each type of air terminal unit.
 - 1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for air terminal units.
 - 2. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

1.4 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For air terminal units to include in emergency, operation, and maintenance manuals.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate requirements of air terminals and are based on specific systems indicated. Other manufacturers' systems with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. Listing and Labeling: Provide electrically operated air terminals specified in this Section that are listed and labeled.
 - 1. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100.

2. Listing and Labeling Agency Qualifications: A "Nationally Recognized Testing Laboratory" as defined in OSHA Regulation 1910.7.
- C. Testing Requirements: Test and rate air terminals according to ARI 880, "Industry Standard for Air Terminals."
- D. Identification: Label each air terminal with plan number, nominal airflow, maximum and minimum factory-set airflows, and ARI certification seal.
- E. NFPA Compliance: Install air terminals according to NFPA 90A, "Standard for the Installation of Air Conditioning and Ventilating Systems."
- F. Comply with NFPA 70 for electrical components and installation.
- G. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and System Start-up."
- H. ASHRAE Compliance: Applicable requirements in ASHRAE/IES 90.1, "Section 6 - Heating, Ventilating, and Air Conditioning."

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide air terminals by one of the following:
 1. Trane
 2. Titus
 3. Environmental Technologies.
 4. Price
 5. Metal Aire
 6. Krueger
- B. All terminal units shall be ARI 880 - 98 certified and UL Listed.

2.2 SINGLE-DUCT AIR TERMINALS

- A. The unit casing shall be comprised of 22 gauge galvanized steel. Outlet connection shall be slip and drive.
- B. Casings: 22 gauge galvanized steel. Maximum casing leakage: 7 cfm at 1-inch wg inlet static pressure.
- C. 3/8" Closed-cell Insulation—Interior surface of the unit casing is acoustically and thermally lined with 3/8-inch, 4.4 lb/ft³ closed-cell insulation. Insulation is UL listed and meets NFPA-90A and UL 181 standards. Insulation has an R-Value of 1.4. There are no exposed edges of insulation (complete metal encapsulation).

- D. The air inlet connection shall be an 18 gauge galvanized steel cylinder sized to fit standard round duct. A multiple point, averaging flow sensing ring shall be provided with balancing taps for measuring within +/- 5% of unit cataloged airflow. Airflow versus pressure differential calibration chart shall be provided. The damper blade shall be constructed of a closed cell foam seal mechanically locked between two 22 gauge galvanized steel disks. The damper blade assembly shall be connected to a cast zinc shaft supported by self lubricating bearings. The shaft shall be cast with a damper position indicator. The valve assembly shall include a mechanical stop to prevent over stroking. At 4.0" wg air valve leakage does not exceed 1% of cataloged airflow.
- E. Disconnect Switch: A toggle disconnect shall disengage primary power to terminal.
- F. Controls
 - 1. The terminals will have pressure independent direct digital controls supplied and mounted by the control contractor.
 - 2. Terminals shall be furnished with a pneumatic inlet velocity sensor. The sensor shall be multi-point center averaging type, with a minimum of four measuring ports parallel to the take-off point from the sensor. Sensors with measuring ports in series are not acceptable. The sensor must provide a minimum differential pressure signal of 0.03" wg. at an inlet velocity of 500 fpm.
 - 3. Flow measuring taps and flow curves shall be supplied with each terminal for field balancing airflow.
 - 4. All pneumatic tubing shall be UL listed fire retardant (FR) type.
 - 5. Each terminal shall be equipped with labeling showing unit location, size, and scheduled cfm.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Install air terminals level and plumb, according to manufacturer's written instructions, rough-in drawings, original design, and referenced standards.
- B. Allow adequate clearance to meet NEC on control box side of unit to meet NEC.
- C. Support in accordance with SMACNA and manufacturer recommendations.
- D. Connect ductwork to air terminals according to Division 23 ductwork Sections. Slip each inlet duct over the inlet collar of the terminal. Fasten and seal the connection airtight. The diameter of the inlet duct must be equal to the listed size of the terminal; e.g. a duct that actually measures 8 inches must be fitted to a size 8 terminal.
- E. Inlet and outlet duct must be installed in accordance with SMACNA guidelines. Provide a minimum of 2.5 equivalent duct diameters of straight duct at the inlet.
- F. Electrical: Comply with applicable requirements in Division 26 Sections. Ground equipment. Tighten electrical connectors and terminals according to manufacturer's published torque-

tightening values. Where manufacturer's torque values are not indicated, use those specified in UL 486A and UL 486B.

3.2 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections:
 - 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. Air terminal unit will be considered defective if it does not pass tests and inspections.
- C. Prepare test and inspection reports.

3.3 STARTUP SERVICE

- A. Perform startup service.
 - 1. Complete installation and startup checks according to manufacturer's written instructions.
 - 2. Verify that inlet duct connections are as recommended by air terminal unit manufacturer to achieve proper performance.
 - 3. Verify that controls and control enclosure are accessible.
 - 4. Verify that control connections are complete.
 - 5. Verify that nameplate and identification tag are visible.
 - 6. Verify that controls respond to inputs as specified.

3.4 CLEANING

- A. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris, and repair damaged finishes.

END OF SECTION 233600

SECTION 233713 - DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following:
 - 1. Division 23 Section "Common Work Results for HVAC"
 - 2. Division 23 Section "Ductwork"
 - 3. Division 23 Section "Testing, Adjusting, and Balancing" for balancing diffusers, registers, and grilles.

1.2 SUMMARY

- A. This Section includes ceiling- and wall-mounted diffusers, registers, and grilles.

1.3 DEFINITIONS

- A. Diffuser: Circular, square, or rectangular air distribution outlet, generally located in the ceiling and comprised of deflecting members discharging supply air in various directions and planes and arranged to promote mixing of primary air with secondary room air.
- B. Grille: A louvered or perforated covering for an opening in an air passage, which can be located in a sidewall, ceiling, or floor.
- C. Register: A combination grille and damper.

1.4 SUBMITTALS

- A. Each manufacturer shall check noise level ratings for registers and diffusers to insure that the sizes selected will not produce noise to exceed 30 db, "A" scale, measured at occupant level; notify Owner's representative of problems prior to shop drawing submittal.
- B. Pressure drop, airflow and noise criteria selection is based on design equipment. Manufacturers not submitting design makes must provide written certification in front of submittal that equipment submitted has been checked against and performs equal to the design make.
- C. Product Data: For each model indicated, include the following:
 - 1. Data Sheet: For each type of air outlet and inlet, and accessory furnished; indicate construction, finish, and mounting details.

2. Performance Data: Include throw and drop, static-pressure drop, and noise ratings for each type of air outlet and inlet.
 3. Schedule of diffusers, registers, and grilles indicating drawing designation, room location, quantity, model number, size, and accessories furnished.
 4. Assembly Drawing: For each type of air outlet and inlet; indicate materials and methods of assembly of components.
- D. Coordinate locations with reflected ceiling plans and wall elevations as applicable.
- E. Coordinate mounting frame with associated mounting surface.

1.5 QUALITY ASSURANCE

- A. Product Options: Drawings and schedules indicate specific requirements of diffusers, registers, and grilles and are based on the specific requirements of the systems indicated. Other manufacturers' products with equal performance characteristics may be considered. Refer to Division 1 Section "Substitutions."
- B. NFPA Compliance: Install diffusers, registers, and grilles according to NFPA 90A, "Standard for the Installation of Air-Conditioning and Ventilating Systems."
- C. Sound pressure levels shall be determined by using AHRI Standard 885-2008 "Procedure for Estimating Occupied Space Sound Levels in the Application of Air Terminals and Outlets".

PART 2 - PRODUCTS

2.1 GENERAL

- A. Diffusers, registers, and grilles are scheduled on Drawings.
- B. Mounting type shall match the mounting surface. Coordinate with mounting conditions.
- C. Material shall match the specified ductwork. Coordinate with Section 233113 "Ductwork".
- D. Testing: Test performance according to ASHRAE 70, "Method of Testing for Rating the Performance of Air Outlets and Inlets."
- E. Grilles shall be finished in White Powder Coat, unless noted otherwise.
- F. Manufacturers
1. Price
 2. Titus
 3. Metal-Aire
 4. Anemostat
 5. Nailor

2.2 RETURN OR EXHAUST

A. Return/Exhaust Grille, 45-degree deflection

1. Material: Aluminum (Price 630 Series)
2. Provide damper as scheduled.
3. Grilles of the sizes indicated on the plans. Grilles shall be 45 degree deflection fixed louver type with blades spaced 3/4" on center.

B. Return/Exhaust Grille, 0-degree deflection

1. Material: Aluminum (Price 610Z Series)
2. Provide damper as scheduled.
3. Grilles of the sizes indicated on the plans. Grilles shall be 0 degree deflection fixed louver type with blades spaced 3/4" on center.

2.3 SUPPLY

A. Double-deflection Supply Register

1. Material: steel (Price 520D Series) or aluminum (Price 620D Series)
2. Grilles of the sizes indicated on the plans.
3. Registers shall be double deflection type with two sets of fully adjustable deflection blades spaced 3/4" on center. The front set of blades shall run parallel to the short dimension of the register.
4. The integral volume control damper shall be of the opposed blade type. Material shall match the register material. The damper shall be operable from the register face.

B. Square ceiling diffusers, Adjustable pattern

1. Material: steel (Price Model SCDA)
2. Diffusers shall consist of a precision formed back cone of one piece seamless construction which incorporates a round inlet collar of sufficient length for connecting rigid or flexible duct.
3. The diffuser shall integrate with all duct sizes shown on the plans without affecting the face size and appearance of the unit. An inner cone assembly shall consist of 3 cones (or optional 4 cones) which drop below the ceiling plane to assure optimal VAV air diffusion performance.
4. The inner cone assembly shall be completely removable from the diffuser face to allow full access to any dampers or other ductwork components located near the diffuser neck.
5. Non-protrusive airflow directional tabs shall be provided on the back of the inner cones which may be positioned for either horizontal or vertical discharge.

C. Drum Louvers

1. Price Model HCD1 supply outlets of the sizes and models indicated on the plans and outlet schedule. The outlets shall consist of individually adjustable spread control vanes housed within a rotatable drum. Curved outer drum and vanes extruded aluminum, other components shall be steel. The drum pivot mechanism shall incorporate a positive positioning detent device to hold field adjusted drum angles of up to 30° off center.

2. Adjustable vanes are to pivot and maintain blade setting The border shall be constructed of formed steel with welded, reinforced corners for extra strength. Screw holes shall be countersunk for aesthetic appeal.
3. The integral volume control damper shall be of the opposed blade type and shall be constructed of cold rolled steel. The damper shall be operable from the register face. The damper shall be coated steel.

PART 3 - EXECUTION

3.1 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. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install diffusers, registers, and grilles level and plumb, according to manufacturer's written instructions, Coordination Drawings, original design, and referenced standards.
- B. 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 practicable. For units installed in lay-in ceiling panels, locate units in the center of the 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 connection to ducts.

3.3 ADJUSTING

- A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.
- B. Adjustable outlet diffuser: adjust pattern for draft-free air distribution.

3.4 CLEANING

- A. After installation of diffusers, registers, and grilles, inspect exposed finish. Clean exposed surfaces to remove burrs, dirt, and smudges. Replace diffusers, registers, and grilles that have damaged finishes.

END OF SECTION 233713

SECTION 237200 - AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Section 230901 "Variable Frequency Drives".
- C. Section 230993 - Sequence OF Operations for HVAC Controls

1.2 SUMMARY

- A. Section Includes Energy Recovery Units.

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, furnished specialties, and accessories.
 - 1. Complete fan performance curves for both Supply Air and Exhaust Air, with system operating conditions indicated, as tested in an AMCA Certified Chamber.
 - 2. Sound performance data for both Supply Air and Exhaust Air, as tested in an AMCA Certified chamber.
 - 3. Energy recovery performance data for both summer and winter operation.
 - 4. AHRI Certified coil performance ratings with system operating conditions indicated. Ratings shall be in accordance with Standard 410.
 - 5. Motor ratings, electrical characteristics and motor and fan accessories.
 - 6. Material types and gauges of all component pieces and assemblies.
 - 7. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
 - 8. Estimated gross weight of each installed unit.
 - 9. Microprocessor Controller specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
 - 10. Color chart including a palette of available standard paint finishes
- B. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For air-to-air energy recovery equipment to include in maintenance manuals.

1.4 QUALITY ASSURANCE

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. ARI Compliance: Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Rating Air-to-Air Energy Recovery Equipment."
- C. UL Compliance: UL 1812.
- D. Blowers shall be AMCA Certified for air flow.

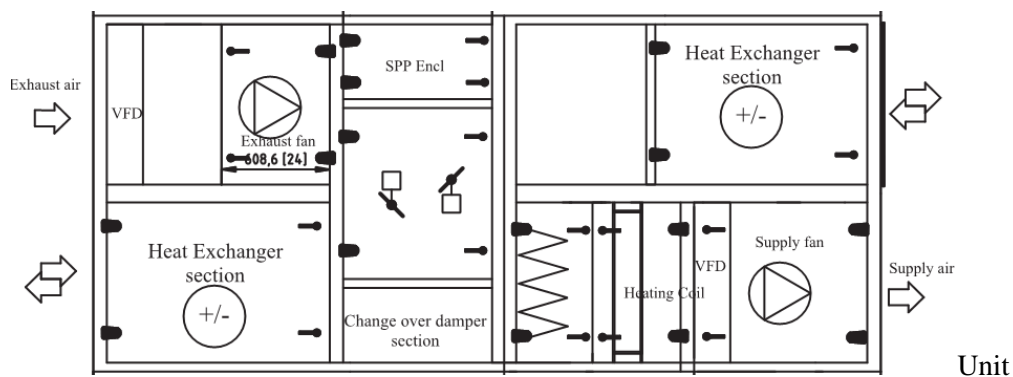
1.5 COORDINATION

- A. Coordinate layout and installation of air-to-air energy recovery equipment 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.
- B. Coordinate sizes and locations of roof supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.1 DUAL CORE ENERGY RECOVERY UNIT

- A. The following manufacturers are approved for use.
 - 1. Tempeff North America - Dual Core - Basis of Design
 - 2. BKM Reverse Flow



- B. Construction
 - 1. Fabricate unit with extruded aluminum channel posts and galvanized panels secured with mechanical fasteners. All access doors shall be sealed with permanently applied bulb-type gasket.

2. Panels and access doors shall be constructed as a 2-inch (50-mm) nominal thick; with injected polyurethane foam insulation. R value shall be 6.5 per inch of wall thickness. The outer panel shall be constructed of G90 galvanized steel. The inner liner shall be constructed of G90 galvanized steel. Module to module assembly shall be accomplished with self-adhering foam gaskets. Manufacturer shall supply test data demonstrating less than L/240 deflection for an unsupported under 30" W.C pressure. Units that cannot demonstrate this deflection are unacceptable.
3. Access Doors shall be flush mounted to cabinetry, with minimum of two hinges, locking latch and full size handle assembly.

C. Supply / Return Fans

1. Provide direct-drive airfoil plenum fans. Fan assemblies including fan, motor and sheaves shall be dynamically balanced by the manufacturer on all three planes and at all bearing supports. Manufacturer must ensure maximum fan RPM is below the first critical speed.
2. Bearings shall be self-aligning, grease lubricated, ball or roller bearings with extended copper lubrication lines to access side of unit. Grease fittings shall be attached to the fan base assembly near access door. If not supplied at the factory, contractor shall mount copper lube lines in the field.
3. Bearings: Basic load rating computed in accordance with AFBMA - ANSI Standards, L-50 life at 200,000 hours, heavy duty pillow block type, self-aligning, grease-lubricated ball bearings.
4. Fan and motor shall be mounted internally on a steel base. Provide access to motor, drive, and bearings through hinged access door. Fan and motor assembly shall be mounted on 2" deflection spring vibration type isolators inside cabinetry. Seismic snubbers shall be provided.
5. Shafts shall be solid, hot rolled steel, ground and polished, keyed to shaft, and protectively coated with lubricating oil. Hollow shafts are not acceptable.

D. Electrical

1. The air handler shall bear an ETL listing label for the entire assembly. Units with only components bearing third party safety listing are unacceptable.
2. All controls shall be located on the side of the unit for ease of servicing.
3. Wiring Termination: Provide terminal lugs to match branch circuit conductor quantities, sizes, and materials indicated. All wires shall be number tagged and cross-referenced to the wiring diagram for ease of troubleshooting.
4. Motors shall be premium efficiency. Electrical characteristics shall be as shown in schedule.
5. Supplier shall provide and mount ABB or Danfoss variable speed drives with electrical characteristics as shown on project schedule. Provide in accordance with Section 230901 "Variable Frequency Drives".
6. Air handler manufacturer shall provide and mount a damper hand-off-auto (HOA) switch.

E. Energy Recovery

1. Unit shall be equipped with Dual Core energy recovery technology. The unit shall be 90% efficient (sensible +-5%) at equal airflow in winter and up to 80% sensible in summer. It shall also provide up to 70% latent recovery. Unit shall accomplish this recovery without a defrost cycle that will reduce the effectiveness of the device. Devices employing defrost cycles that bypass the energy recovery device, or reduce the

effectiveness are not acceptable. Energy recovery device shall not require frost protection in applications down to -40 degrees.

2. Energy Cores shall be Generation 3, comprised of precisely corrugated high grade aluminum. Maximum allowable face velocity across heat exchangers shall be 450 fpm. Heat exchanger face velocities exceeding 450 fpm are not acceptable.
3. Switchover damper section shall be comprised of multi section low leakage dampers operated by fast acting electric actuators. Damper switching times shall be 1.5 seconds or less. Dampers that do not switch within the specified times without objectionable noise are not acceptable. Single blade damper sections are not acceptable. Each damper shall control one of the 4 airways, upper-horizontal, lower-horizontal, forward-vertical and rear-vertical. Dampers shall be capable of orienting to close off outside air to the building without needing external shut off dampers.
4. Dampers shall also be capable of orienting to allow 100% recirculation of air without using heat recovery device for off peak or unoccupied heating modes. Units incapable of these operations without extra ductwork are not acceptable.

F. Heating Coil Section

1. Provide access to coils from opposite side of unit for service and cleaning. Enclose coil headers and return bends fully within unit casing. Unit shall be provided with coil connections that extend a minimum of 5" beyond unit casing for ease of installation. Drain and vent connections shall be provided exterior to unit casing. Coil connections must be factory sealed with grommets on interior and exterior and gasket sleeve between outer wall and liner where each pipe extends through the unit casing to minimize air leakage and condensation inside panel assembly. If not factory packaged, Contractor must supply all coil connection grommets and sleeves. Coils shall be removable through side and/or top panels of unit without the need to remove and disassemble the entire section from the unit.
2. Water Coils:
 - a. Certification - Acceptable water coils are to be certified in accordance with ARI Standard 410 and bear the ARI label. Coils exceeding the scope of the manufacturer's certification and/or the range of ARI's standard rating conditions will be considered provided the manufacturer is a current member of the ARI Air-Cooling and Air-Heating Coils certification programs and that the coils have been rated in accordance with ARI Standard 410. Manufacturer must be ISO 9002 certified.
 - b. Headers shall consist of seamless copper tubing to assure compatibility with primary surface. Headers to have intruded tube holes to provide maximum brazing surface for tube to header joint, strength, and inherent flexibility. Header diameter should vary with fluid flow requirements.
 - c. Fins shall have a minimum thickness of aluminum plate construction. Fins shall have full drawn collars to provide a continuous surface cover over the entire tube for maximum heat transfer. Tubes shall be mechanically expanded into the fins to provide a continuous primary to secondary compression bond over the entire finned length for maximum heat transfer rates. Bare copper tubes shall not be visible between fins.
 - d. Coil tubes shall be 5/8 inch OD seamless copper, 0.035 nominal tube wall thickness, expanded into fins, brazed at joints. Soldered U-bends shall be provided to minimize the effects of erosion and premature failure having a minimum tube wall thickness of .025".

- e. Coil connections shall sweat copper with connection size to be determined by manufacturer based upon the most efficient coil circuiting. Vent and drain fittings shall be furnished on the connections, exterior to the air handler. Vent connections provided at the highest point to assure proper venting. Drain connections shall be provided at the lowest point to insure complete drainage and prevent freeze-up.
- f. Coil casings shall be a formed channel frame of galvanized steel. Water heating coils, 1 & 2 row only shall be furnished as uncased to allow for thermal movement and slide into a pitched track for fluid drainage.

G. Particulate Filters

1. Filter section with filter racks and guides with hinged and latching access doors on either, or both sides, for side loading and removal of filters.
2. Filter media shall be UL 900 listed, Class I or Class II.
3. Angle arrangement with 2" MERV 8 filters.

H. Provide a BACnet controller.

1. Listings: UL-916 (Canadian Std C22.2 No. 205-M1983), CE, FCC Part 15-Subpart B - Class A. BTL (BACnet Test Labs) - BACnet Building Controller (B-BC) - BTL Listed Product
2. OEM Control Model I/O Pro 812u; fully capable of operating in a 100% stand-alone control mode, the controller shall also connect to the BAS using BACnet IP. The point mapping shall be pre-set, so that the protocol and baud rates desired can be easily field-selected without the need for any additional downloads or technician assistance. The controller shall provide ample input/output capacity on the base controller, plus support for multiple expansion boards if additional I/O capacity is needed.
3. Battery: CR123A has a life of 10 years with 720 hours of cumulative power outage
4. Protection Surge and transient protection circuitry for power and communications

I. BACnet points:

1. GT1 Setpoint
2. GT2 Setpoint
3. GT3 Setpoint
4. HWC Setpoint
5. Enable/Disable
6. Heat Recovery/Free Cooling
7. Standard/Recirculation
8. GT1 Temperature
9. GT2 Temperature
10. GT3 Temperature
11. GT4 Temperature
12. OA Temperature
13. SA Blower Running
14. SA Blower Setpoint
15. EA Blower Running
16. EA Blower Setpoint
17. Vertical Damper Position
18. Horizontal Damper Position
19. SA VFD Alarming
20. EA VFD Alarming
21. Fan Alarm

22. Damper Alarm
23. Low VAV
24. Mid VAV

J. Sequence Of Operation

1. Testing Damper Actuators

- a. The damper motors can be tested by using the changeover switch S1 in the damper control panel.
- b. The normal position of the S1 switch is 0 where the actuators follow the signals from a central control system (BMS)
- c. If S1 is in position 1 the damper actuator M7 runs continuously, and in position 2 actuator M6 runs continuously

2. Recovery cycles shall be controlled by internal programmed thermostats measuring both supply and exhaust air, and optimizing performance of both heat recovery and economizer free cooling modes.

3. Set the changeover switch S2 in the M position (manual)

- a. The damper is now controlled by the 2 internal thermostats GT1 in the supply air and GT2 in the exhaust air, and an enable/disable contact. GT1 is set to 59°F and GT2 is set to 68°F.
- b. When the unit is enabled, the damper section starts and an internal relay is activated, enabling the VFD's to start the motors.
- c. High/Low volume control signal required to unit mounted VFD's by external contact.
- d. The sequence will now be:
 - 1) If exhaust air < 68°F = heat recovery (cycling every 60 seconds)
 - 2) If exhaust air > 68°F and supply air > 59°F = economizer free cooling (cycling every 3 hours)
 - 3) If exhaust air > 68°F and supply air < 59°F = heat recovery until supply air > 59°F then it will revert to economizer free cooling mode.

4. When the S2 switch is in position 0 = shut off = the internal relays will disable the VFD's while enabling the damper to continue to cycle for 1 min, to prevent damage to the damper unit.

5. In all cases ensure that damper section is first on and last off, (after supply and exhaust blower section) to prevent damage to internal damper section.

2.2 ROOF CURB

- A. Not needed: Unit will sit on steel dunnage, with perimeter insulation. Coordinate physical dimensions required.
- B. Roof Curb Vibration Isolation Strips: Provide a strips (no gaps) between the ERV and the steel dunnage. The ultraviolet resistant, neoprene and ABS plastic layered pad shall provide dampening over a wide range of frequencies. The strips will serve two functions: (1) vibration isolation and (2) sealing of the plenum below the unit, to keep cold air out.

1. Kellet Enterprises #LP-13 Shake Absorber Roof Curb Isolation Strips
2. Width: 2"
3. Thickness: 3/8"
4. Length: entire perimeter. The intent is to create a tight cavity/plenum below the unit, no air gaps.
5. Shore Durometers from 50 - 70
6. Temperature ranges from -40° up to 200°+ Fahrenheit
7. Oil , Abrasion, Flame, and UV Resistant

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Prior to start of installation, examine area and conditions to verify correct location for compliance with installation tolerances and other conditions affecting unit performance. See unit IOM.
- B. Examine roughing-in of plumbing, electrical and HVAC services to verify actual location and compliance with unit requirements. See unit IOM.
- C. Proceed with installation only after all unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Provide in accordance with manufacturer's instructions.
- B. Unit Support: Install unit level on structural steel. Provide vibration isolation strips.
- C. Install units with clearances for service and maintenance.
- D. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.3 CONNECTIONS

- A. Comply with requirements for piping specified in Division 23 Section "Hydronic Piping." Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Comply with requirements for ductwork specified in Division 23 Section "Ductwork."
- C. Install piping adjacent to machine to allow service and maintenance.
- D. Provide condensate drain piping per manufacturer's instructions.

3.4 FIELD QUALITY CONTROL

- A. Do not operate units for any purpose, temporary or permanent, until ductwork is clean, filters are in place, bearings lubricated, and fan has been test run under observation.
- B. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.
- C. Tests and Inspections:
 - 1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
 - 3. Set initial temperature and humidity set points.
 - 4. Set field-adjustable switches and circuit-breaker trip ranges as indicated.
- D. Prepare test and inspection reports.

3.5 DEMONSTRATION

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain air-to-air energy recovery units.

END OF SECTION 237200

SECTION 238126 – VARIABLE REFRIGERANT VOLUME SYSTEM

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 Variable Refrigerant Volume (VRV) split-system air-conditioning consisting of separate fan coil (indoor unit) and condensing unit (outdoor unit).
- B. Mechanical contractor shall provide the low voltage wiring.**

1.3 SUBMITTALS

- A. Product Data: For each type of product indicated. Include rated capacities, operating characteristics, and furnished specialties and accessories. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances; method of field assembly, components, and location and size of each field connection.
 - 2. Wiring Diagrams: For power, signal, and control wiring.
- C. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

1.4 QUALITY ASSURANCE

- A. The units shall be tested by a Nationally Recognized Testing Laboratory (NRTL), in accordance with ANSI/UL 1995 – Heating and Cooling Equipment and bear the Listed Mark.
- B. All wiring shall be in accordance with the National Electric Code (NEC).
- C. The system will be produced in an ISO 9001 and ISO 14001 facility, which are standards set by the International Standard Organization (ISO). The system shall be factory tested for safety and function.

- D. Mechanical equipment for wind-born debris regions shall be designed in accordance with ASCE 7-2010 and installed to resist the wind pressures on the equipment and the supports.
- E. The condensing unit will be factory charged with R-410A.
- F. Fabricate and label refrigeration system to comply with ASHRAE 15, "Safety Standard for Refrigeration Systems."

1.5 COORDINATION

- A. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases.
- B. Unit shall be stored and handled according to the manufacturer's recommendations.

1.6 WARRANTY

- A. Special Warranty: Manufacturer shall warrant original owner that under normal use and maintenance for comfort cooling and conditioning applications such products (the "Products") will be free from defects in material and workmanship. This warranty applies to compressor and all parts and is limited in duration to ten (10) years starting from the "installation date" which is one of the two dates below:
 - 1. The installation date is the date that the unit is originally commissioned, but no later than 18 months after the manufacture date noted on the unit's rating plate.
 - 2. If the date the unit is originally commissioned cannot be verified, the installation date is three months after the manufacture date.

1.7 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.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Daikin. (Basis of Design: Briggs Equipment Sales, Inc. Gray, ME)
 - 2. Mitsubishi
 - 3. Fujitsu
 - 4. Trane

5. Samsung
6. Johnson Controls

- B. The HVAC equipment basis of design is Daikin North America. All bidders shall furnish the minimum system standards as defined by the base bid model numbers, model families or as otherwise specified herein. In any event, the contractor shall be responsible for all specified items and intents of this document without further compensation.

2.2 SYSTEM DESCRIPTION

- A. The variable capacity, air conditioning system shall be a Daikin Variable Refrigerant Volume Series (heat and cool model) split system as specified. The system shall consist of multiple evaporators, REFNET™ joints and headers, a three pipe refrigeration distribution system using PID control and Daikin VRV-IV condenser unit. The condenser shall be a direct expansion (DX), air-cooled, multi-zone heating/air-conditioning system with variable speed inverter driven compressors using R-410A refrigerant. The condensing unit may connect an indoor evaporator capacity up to 200% of the condensing unit capacity. All zones are each capable of operating separately with individual temperature control. A dedicated hot gas pipe shall be required to ensure optimum heating operation performance.
- B. The Daikin condensing unit shall be interconnected to indoor units. The indoor units shall be connected to the condensing unit utilizing Daikin's REFNET™ specified piping joints and headers to ensure correct refrigerant flow and balancing. T style joints are not acceptable for a variable refrigerant system.
- C. Each indoor unit or group of indoor units shall be independently controlled.

2.3 VRV IV FEATURES AND BENEFITS

- A. Advanced Zoning – A single system shall provide for up to 64 zones. Independent Control – Each indoor unit shall use a dedicated electronic expansion valve with 2000 positions for independent control.
- B. VFD Inverter Control and Variable Refrigerant Temperature – Each condensing unit shall use high efficiency, variable speed all “inverter” compressor(s) coupled with inverter fan motors to optimize part load performance. The system capacity and refrigerant temperatures shall be modulated automatically to set suction and condensing pressures while varying the refrigerant volume for the needs of the cooling or heating loads. The control will be automatic and customizable depending on load and weather conditions.
- C. Indoor units shall use PID to control superheat to deliver a comfortable room temperature condition and optimize efficiency.
- D. Configurator software – Each system shall be available with configurator software package to allow for remote configuration of operational settings and also for assessment of operational data and error codes. If this software is not provided by an

alternate manufacturer, for each individual outdoor unit the contractor shall do the settings manually and keep detailed records for future maintenance purposes.

- E. Auto-charging – Each system shall have a refrigerant auto-charging function.
- F. Defrost Heating – Multiple condenser VRV systems shall maintain continuous heating during defrost operation. Reverse cycle (cooling mode) defrost operation shall not be permitted due to the potential reduction in space temperature.
- G. Oil Return Heating – Multiple condenser VRV systems shall maintain continuous heating during oil return operation. Reverse cycle (cooling mode) oil return during heating operation shall not be permitted due to the potential reduction in space temperature.
- H. Independent Control – Each indoor unit shall use a dedicated electronic expansion valve for independent control.
- I. Flexible Design –
 - 1. Systems shall be capable of up to 540ft (623ft equivalent) of linear piping between the condensing unit and furthest located indoor unit.
 - 2. Systems shall be capable of up to 3,280ft total “one-way” piping in the piping network.
 - 3. Systems shall have a vertical (height) separation of up to 295ft between the condensing unit and the indoor units.
 - 4. Systems shall be capable of up to 295ft from the first REFNET™ / branch point.
 - 5. The condensing unit shall have the ability to connect an indoor unit evaporator capacity of up to 200% of the condensing unit capacity.
 - 6. Systems shall be capable of 98ft vertical separation between indoor units.
 - 7. Condensing units shall be supported with a fan motor ESP up to 0.32” WG as standard to allow connection of discharge ductwork and to prevent discharge air short circuiting.
- J. Oil Return – Each system shall be furnished with a centrifugal oil separator and active oil recovery cycle
- K. Simple Wiring – Systems shall use 16/18 AWG, 2 wire, multi-stranded, non-shielded and non-polarized daisy chain control wiring.
- L. Advanced Diagnostics – Systems shall include a self-diagnostic, auto-check function to detect a malfunction and display the type and location.
- M. Each condensing unit shall incorporate contacts for electrical demand shedding with optional 3 stage demand control with 12 customizable demand settings.
- N. Advanced Controls – Each system shall have at least one remote controller capable of controlling up to 16 indoor units.
- O. Each system shall be capable of integrating with open protocol BACnet building management systems.

- P. Low Sound Levels – Each system shall use indoor and condensing units with quiet operation as low as 27 dB(A).

2.4 PERFORMANCE.

- A. Provide as scheduled.
- B. Low Ambient –Each system shall be capable of low ambient heating to -13°F.
- C. Cooling mode indoor room temperature range will be 57°F-77°F WB.
- D. Heating mode indoor room temperature range will be 59°F-80°F DB.
- E. The system shall be capable of refrigerant piping up to 540 actual feet or 623 equivalent feet from the condensing unit to the furthest indoor unit, a total combined liquid line length of 3,280 feet of piping between the condensing and indoor units with 295 feet maximum vertical difference, without any oil traps.
- F. REFNET™ piping joints and headers shall be used to ensure proper refrigerant balance and flow for optimum system capacity and performance. T style joints shall not be acceptable as this will negatively impact proper refrigerant balance and flow for optimum system capacity and performance.

2.5 CONDENSING UNIT

- A. General: The condensing unit is designed specifically for use with VRV IV series components.
 - 1. The condensing unit shall be factory assembled in the USA and pre-wired with all necessary electronic and refrigerant controls. The refrigeration circuit of the condensing unit shall consist of Daikin inverter scroll compressors, motors, fans, condenser coil, electronic expansion valves, solenoid valves, 4-way valve, distribution headers, capillaries, filters, shut off valves, oil separators, service ports, liquid receiver and suction accumulator.
 - 2. High/low pressure gas line, liquid and suction lines must be individually insulated between the condensing and indoor units.
 - 3. The condensing unit can be wired and piped with access from the left, right, rear or bottom.
 - 4. The connection ratio of indoor units to condensing unit shall be permitted up to 200%.
 - 5. Each condensing system shall be able to support the connection of up to 64 indoor units dependent on the model of the condensing unit.
 - 6. The sound pressure level standard shall be that value as listed in the Daikin engineering manual for the specified models at 3 feet from the front of the unit. The condensing unit shall be capable of operating automatically at further reduced noise during night time or via an external input.
 - 7. The system will automatically restart operation after a power failure and will not cause any settings to be lost, thus eliminating the need for reprogramming.

8. The unit shall incorporate an auto-charging feature. Manual charging should be support with a minimum of 2 hours of system operation data to ensure correct operation.
 9. The condensing unit shall be modular in design and should allow for side-by-side installation with minimum spacing.
 10. The following safety devices shall be included on the condensing unit; high pressure sensor and switch, low pressure sensor, control circuit fuses, crankcase heaters, fusible plug, overload relay, inverter overload protector, thermal protectors for compressor and fan motors, over current protection for the inverter and anti-recycling timers.
 11. To ensure the liquid refrigerant does not flash when supplying to the various indoor units, the circuit shall be provided with a sub-cooling feature.
 12. Oil recovery cycle shall be automatic occurring 2 hours after start of operation and then every 8 hours of operation. Each system shall maintain continuous heating during oil return operation.
 13. The condensing unit shall be capable of heating operation at -13°F wet bulb ambient temperature without additional low ambient controls or an auxiliary heat source.
 14. The multiple condenser VRV systems shall continue to provide heat to the indoor units in heating operation while in the defrost mode.
- B. Unit Cabinet: The condensing unit shall be completely weatherproof and corrosion resistant. The unit shall be constructed from rust-proofed mild steel panels coated with a baked enamel finish.
- C. Snow Hoods: Provide protective hoods to allow for operation during snow storms and cold weather. The hoods shall be designed to protect the fan guard from hail damage and snow buildup. The side wind baffles protect unit coil surfaces from snow and improve defrost efficiency in windy conditions. See below for required hoods:

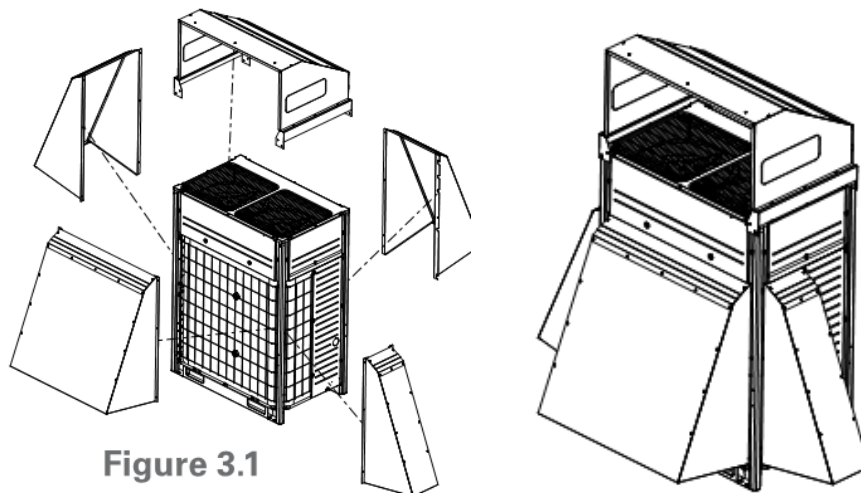


Figure 3.1

- D. Fan:
1. The condensing unit shall consist of one or more propeller type, direct-drive 350 or 750 W fan motors that have multiple speed operation via a DC (digitally commutating) inverter.

2. The condensing unit fan motor shall have multiple speed operation of the DC (digitally commutating) inverter type, and be of high external static pressure and shall be factory set as standard at 0.12 in. WG. A field setting switch to a maximum 0.32 in. WG pressure is available to accommodate field applied duct for indoor mounting of condensing units.
3. The fan shall be a vertical discharge configuration with a nominal airflow maximum range of 5,544 CFM to 24,684 CFM dependent on model specified.
4. Nominal sound pressure levels shall be 70dB(A) sound pressure level or lower.
5. The fan motor shall have inherent protection and permanently lubricated bearings and be mounted.
6. The fan motor shall be provided with a fan guard to prevent contact with moving parts.
7. Night setback control of the fan motor for low noise operation by way of automatically limiting the maximum speed shall be a standard feature. Operation sound level shall be selectable from 3 steps.

E. Condenser Coil:

1. The condenser coil shall be manufactured from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The heat exchanger coil shall be of a waffle louver fin and rifled bore tube design to ensure high efficiency performance.
3. The heat exchanger on the condensing units shall be manufactured from Hi-X seamless copper tube with N-shape internal grooves mechanically bonded on to aluminum fins to an e-Pass Design.
4. The fins are to be covered with an anti-corrosion Ulta Gold coating as standard with a salt spray test rating of 1000hr (ASTM B117 & Blister Rating:10), Acetic acid salt spray test: 500hr (ASTM G85 & Blister Rating:10)
5. The pipe plates shall be treated with powdered polyester resin for corrosion prevention. The thickness of the coating must be between 2.0 to 3.0 microns.
6. The outdoor coil shall have three-circuit heat exchanger design eliminating the need for bottom plate heater. The lower part of the coil shall be used for inverter cooling and be on or off during heating operation enhancing the defrost operation.

F. Compressor:

1. The Daikin inverter scroll compressors shall be variable speed (PVM inverter) controlled which is capable of changing the speed to follow the variations in total cooling and heating load as determined by the suction gas pressure as measured in the condensing unit. In addition, samplings of evaporator and condenser temperatures shall be made so that the high/low pressures detected are read every 20 seconds and calculated. With each reading, the compressor capacity (INV frequency) shall be controlled to eliminate deviation from target value. Non inverter-driven compressors, which may cause starting motor current to exceed the nominal motor current (RLA) and require larger wire sizing, shall not be allowed.
2. The inverter driven compressor in each condensing unit shall be of highly efficient reluctance DC (digitally commutating), hermetically sealed scroll "G-type" or "J-type".

3. Neodymium magnets shall be adopted in the rotor construction to yield a higher torque and efficiency in the compressor instead of the normal ferrite magnet type. At complete stop of the compressor, the neodymium magnets will position the rotor into the optimum position for a low torque start.
4. The capacity control range shall be as low as 3% to 100%.
5. The compressors' motors shall have a cooling system using discharge gas, to avoid sudden changes in temperature resulting in significant stresses on winding and bearings.
6. Each compressor shall be equipped with a crankcase heater, high pressure safety switch, and internal thermal overload protector.
7. Oil separators shall be standard with the equipment together with an intelligent oil management system.
8. The compressor shall be spring mounted to avoid the transmission of vibration eliminating the standard need for spring insulation.
9. Unit shall have multiple compressors, all inverter controlled.
10. In the event of compressor failure the remaining compressors shall continue to operate and provide heating or cooling as required at a proportionally reduced capacity. The microprocessor and associated controls shall be designed to specifically address this condition.
11. In the case of multiple condenser modules, conjoined operation hours of the compressors shall be balanced by means of the Duty Cycling Function, ensuring sequential starting of each module at each start/stop cycle, completion of oil return, completion of defrost or every 8 hours and extending the operating life of the system. When connected to a central control system, sequential start is activated for all system on each DIII network.

G. Electrical:

1. The power supply to the condensing unit shall be 208-230 volts, 3 phase, 60 hertz +/- 10%.
2. The control voltage between the indoor and condensing unit shall be 16VDC non-shielded, stranded 2 conductor cable.
3. The control wiring shall be a two-wire multiplex transmission system, making it possible to connect multiple indoor units to one condensing unit with one 2-cable wire, thus simplifying the wiring installation.

2.6 VRV INDOOR UNITS

A. General: Indoor units shall be a wall mounted or concealed-ducted as scheduled, operable with refrigerant R-410A, equipped with an electronic expansion valve, for installation onto a wall within a conditioned space. Computerized PID control shall be used to control superheat to deliver a comfortable room temperature condition. A mildew-proof, polystyrene condensate drain pan and resin net mold resistant filter shall be provided. The indoor units sound pressure shall range from 31 dB(A) to 41 dB(A) at low speed measured at 3.3 feet below and from the unit.

B. Indoor Unit:

1. The indoor unit shall be completely factory assembled and tested. Included in the unit is factory wiring, piping, electronic proportional expansion valve, control

circuit board, fan motor thermal protector, flare connections, condensate drain pan, self-diagnostics, auto-restart function, 3-minute fused time delay, and test run switch.

2. Wall units: The unit shall have an auto-swing louver which ensures efficient air distribution, which closes automatically when the unit stops. The remote controller shall be able to set five (5) steps of discharge angle. The front grille shall be easily removed for washing. The discharge angle shall automatically set at the same angle as the previous operation upon restart.
3. The drain pipe can be fitted to from either left or right sides.
4. Indoor unit and refrigerant pipes will be charged with dehydrated air prior to shipment from the factory.
5. Both refrigerant lines shall be insulated from the outdoor unit.
6. Return air shall be through a resin net mold resistant filter.
7. The indoor units shall be equipped with a condensate pan.
8. The indoor units shall be equipped with a return air thermistor.

C. Unit Cabinet:

1. The cabinet shall be affixed to a factory supplied wall mounting template and located in the conditioned space.
2. The cabinet shall be constructed with sound absorbing foamed polystyrene and polyethylene insulation.

D. Fan:

1. The fan shall be a direct-drive cross-flow fan, statically and dynamically balanced impeller with high and low fan speeds available.
2. The airflow rate shall be available in high and low settings.
3. The fan motor shall be thermally protected.

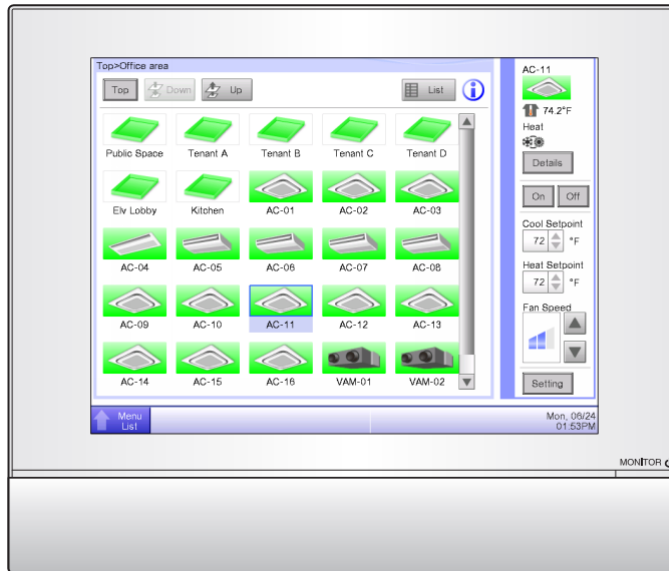
E. C-oil:

1. Coils shall be of the direct expansion type constructed from copper tubes expanded into aluminum fins to form a mechanical bond.
2. The coil shall be of a waffle louver fin and high heat exchange, rifled bore tube design to ensure highly efficient performance.
3. The coil shall be a 2-row cross fin copper evaporator coil with 14 fpi design completely factory tested.
4. The refrigerant connections shall be flare connections and the condensate will be PVC.
5. A thermistor will be located on the liquid and gas line.
6. A condensate pan shall be located in the unit.

2.7 CONTROLS

- A. Control contractor and equipment manufacturer shall coordinate all controls required to interface with the BMS system. Coordinate with Section 230900. Provide in accordance with 230900.

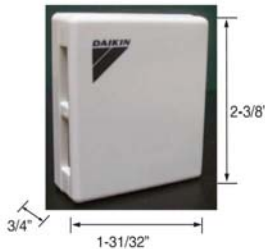
- B. The unit shall have controls provided by VRV manufacturer to perform input functions necessary to operate the system.
- C. The advanced multi-zone controller shall be made from plastic materials with a neutral color. Each control shall have a LCD (Liquid Crystal Display) that shows On/Off, setpoint, room temperature, mode of operation (Cool/Heat/Dry/Fan/Auto), louver position, and fan speed.
- D. The advanced multi-zone controller will require 24 VAC to power the controller. The advanced multi-zone controller shall supply 16 VDC to the communication bus on the F1F2 (out-out) terminal of the outdoor unit. The voltage may rise or fall in relation to the transmission packets that are sent and received.
- E. **VRV Control Wiring: Provided by mechanical contractor (not the control contractor).** Power wiring by Division 26.
 - 1. The advanced multi-zone controller communication wiring shall be terminated in a daisy chain design at the outdoor unit, then daisy chained to each indoor unit in the system and terminating at the farthest indoor unit. The termination of the wiring shall be non-polar. The remote control wiring shall run from the indoor unit control terminal block to the remote controller connected with that indoor unit.
 - 2. Wiring shall be non-shielded, 2-conductor sheathed vinyl cord or cable, and 18 AWG stranded copper wire. Provide in accordance with Division 26 requirements.
- F. The VRV Controls Network is made up of local remote controllers, multi-zone controllers, advanced multi-zone controllers, and open protocol network devices that transmit information via the communication bus. The VRV Controls Network shall also have the ability to be accessed via a networked PC. The VRV Controls Network supports operation monitoring, scheduling, error e-mail distribution, general user software, fault detection & diagnostics, maintenance support, and integration with Building Management Systems (BMS) using open protocol via BACnet[®] interface; all of which blend to provide the optimal control strategy for the best HVAC comfort solution.
- G. DCM601A71: intelligent Touch Manager (iTM)



1. The intelligent Touch Manager shall provide control for VRV with the use of the KRP928BB2S RA Modbus adapter. It shall be capable of controlling a maximum of 64 indoor unit groups and 128 indoor units connected to a maximum of 10 outdoor units. The intelligent Touch Manager shall support operations superseding that of the local remote controller, system configuration, daily/weekly scheduling, monitoring of operation status, and malfunction monitoring.
2. The controller wiring shall consist of a non-polar two-wire connection to the indoor unit at terminals F1F2 (out-out) of the outdoor unit. The intelligent Touch Manager shall be wall mounted and can be adjusted to maintain the optimal operation of the connected indoor units.
3. The intelligent Touch Manager shall be equipped with two RJ-45 Ethernet ports for 100 Mbps network communication to support interconnection with a network PC via the Internet, Local Area Network (LAN), or connection with a non-networked PC after completed installation.
4. Web access functions shall be available so that facility staff can securely log into each Intelligent Touch Manager via the PC's web browser to support monitoring, scheduling, error recognition, and general user functions. Error emails are also sent to designated email addresses.
5. Display Features:
 - a. The intelligent Touch Manager shall be approximately 11.42" x 9.57" x 1.97" in size with a backlit 10.4" LCD display.
 - b. Display information shall be selectable from English.
 - c. The Controller shall display On/Off, Operation Mode, Setpoint, Space Temperature, Louver Position, Fan Speed for each Area or Group.
 - d. The Controller shall display date (mm/dd/yyyy) and day of the week along with the time of day (12hr or 24hr display selectable).
 - e. The Controller shall adjust for daylight savings time (DST) automatically.

- H. Fault Detection and Diagnostics: Provide malfunction codes for detecting the following conditions:
1. Malfunction of sensor system
 2. Malfunction of liquid pipe thermistor for heat exchanger
 3. Malfunction of evaporator fan motor
 4. Malfunction of electronic expansion valve
 5. Inverter compressor motor or overheat
 6. Overcurrent of inverter compressor
 7. Malfunction of compressor motor overload thermistor
 8. Malfunction of compressor input system
 9. Malfunction of outdoor unit fan motor system
 10. Malfunction of outdoor unit fan motor signal
- I. Staggered start: To avoid KW demand peaks, systems must be started (after power failure, morning warm up, or systems start) sequentially in a staggered timeframe. Do not start all contending units simultaneously.
- J. Provide the DCM014A51: BACnet Server Gateway: The iTM BACnet Server Gateway Option shall be capable of making the intelligent Touch Manager work as a BACnet gateway using the BACnet/IP protocol. The iTM BACnet Server Gateway shall be programed to expose indoor unit management points as BACnet objects to the (BMS). The iTM BACnet Server/Gateway shall be programmed to allow the BMS to monitor and control indoor units BACnet objects. The control contractor will provide wiring to the Gateway.
- K. Remote Zone Sensor: Provide a wired remote wall sensor for each indoor unit. Daikin Model KRCS01-1A.

Remote Sensor KRCS01-1A



- L. Controls shall include but not limited to all control wiring, controllers, programmable space sensors, and appurtenances to provide a complete functioning system.
- 2.8 OUTDOOR UNIT SUPPORT STANDS
- A. Provide for systems that provide year round operation.
- B. Quick-Sling Model QSSSVRF/VRV - SUPER STANDS, or approved equal.



1. 1.5" x 1.5" 11-gauge square steel tubing powder coated for outdoor use.
2. 24" height; sized to match the condensing unit, adjustable.
3. Each foot shall be 6"x6" 11 gauge steel, adjustable up to 1.25" in height. Provide four (4) 3/8" holes, bolt the unit to the subsurface support.
4. Securely fasten to roof sleepers with corrosion resistant fasteners.
5. Adjustable in height in 1/4" and 1/2" increments.
6. Provide all required hardware.

- C. Seismic Loading Criteria: Stand performance shall be checked and verified for the following conditions assuming the feet are bolted down to a foundation or structure with sufficient capacity to withstand the conditions described herein: ASCE 7-10 Section 13.6.5 assuming a maximum unit weight of 800 lbs., a 0.2s Spectral Response Acceleration $S_s=2.0$ (Figure 22-1) and Site Class E

PART 3 - EXECUTION

3.1 INSTALLATION

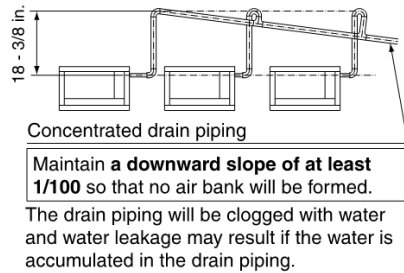
- A. Provide in accordance with manufacturer's instructions.
- B. Install units level and plumb.
- C. Install indoor unit components using manufacturer's standard mounting devices securely fastened to building structure.

3.2 CONNECTIONS

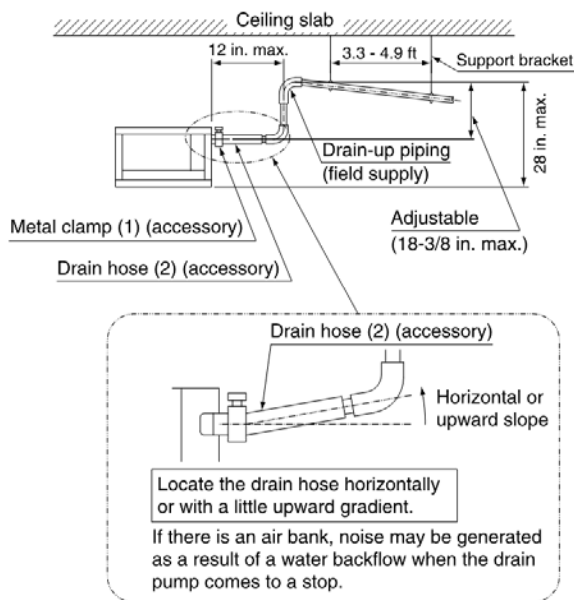
- A. Where piping is installed adjacent to unit, allow space for service and maintenance of unit.
- B. Provide wiring per NEC and manufacturer's instructions.

- C. Provide piping in accordance with Section 23 23 00.
- D. Provide condensate piping and traps per manufacturer's recommendations. For example, cassette units shown below:

- Take the procedure shown in the following illustration to perform concentrated drain piping.



- Select the diameter of the concentrated drain piping to suit the capacity of equipment connecting to the concentrated drain piping (see the equipment design sheet).



- (2) Check the smooth draining of the piping on completion of the installation of the piping.

3.3 FIELD QUALITY CONTROL

- ~~A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.~~
- B. Tests and Inspections: See "waynflete lower school - VRF specification with VE changes noted" in bid folder.
 - 1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

2. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Prepare test and inspection reports.

3.4 STARTUP SERVICE

- A. Engage a factory-authorized service representative to perform startup service.
- B. Complete installation and startup checks according to manufacturer's written instructions.
- C. If the factory field service technician finds any problems with the installation, the mechanical contractor shall take any required corrective measures immediately and be responsible for any start-up expenses.

3.5 DEMONSTRATION & TRAINING

- A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain units.
- B. Provide a minimum of eight (8) hours of training by the factory field service technician during the startup procedure.
 1. Basic system function.
 2. Adjustments to the intelligent touch controller
 3. Temperature settings
 4. Schedule changes

END OF SECTION 238126

SECTION 238239 - UNIT HEATERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

- A. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
- B. Related Sections include the following: Division 23 Section "Common Work Results for Mechanical"

1.2 SUMMARY

- A. This Section includes hydronic unit heaters and fan convectors.

1.3 SUBMITTALS

- A. Product Data: Include specialties and accessories for each unit type and configuration.
 - 1. Plans, elevations, sections, and details.
 - 2. Power, signal, and control wiring diagrams. Differentiate between manufacturer-installed and field-installed wiring.
 - 3. Equipment schedules to include rated capacities; shipping, installed, and operating weights; furnished specialties; and accessories.
 - 4. Cabinet Unit Heater color samples for initial selection: Manufacturer's color charts showing the full range of colors available for units with factory-applied color finishes.
- B. Maintenance Data: For unit heaters to include in maintenance manuals specified in Division 1. Include maintenance schedules and repair parts lists for motors, coils, integral controls, and filters.

1.4 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.

1.5 COORDINATION

- A. Coordinate layout and installation of unit heaters and suspension system components
- B. Coordinate wall construction and conditions with recessed or semi-recessed cabinet unit heater installation requirements.

1.6 EXTRA MATERIALS

- A. Furnish extra materials described below that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.
 - 1. Cabinet Unit Heater Filters: Furnish one set of spare filter for each filter installed.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provide products by one of the following:
 - 1. Carrier Corp.
 - 2. Trane
 - 3. McQuay
 - 4. Sterling
 - 5. Vulcan
 - 6. Modine
 - 7. Rittling
 - 8. Smith

2.2 CABINET UNIT HEATERS

- A. Description: An assembly including filter, chassis, coil, fan, and motor in blow-through configuration with heating coil.
- B. Cabinet: configuration as scheduled.
 - 1. Hideaway ducted.
 - 2. Horizontal recessed ceiling cabinet.
- C. Chassis: Galvanized steel, with flanged edges and unit-leveling bolts.
- D. Coil Section Insulation: 1-inch duct liner complying with ASTM C 1071 and attached with adhesive complying with ASTM C 916. Fire-Hazard Classification: Duct liner and adhesive shall have a maximum flame-spread rating of 25 and smoke-developed rating of 50 when tested according to ASTM E 84.
- E. Cabinet: Galvanized steel, with removable panels.
- F. Cabinet Finish: Cabinet parts and exposed recessed panels shall be cleaned, bonderized, phosphatized, and painted with a baked powder finish available in six colors. Finish shall meet ASTM B117 specifications (salt spray test).
- G. Hot-Water Coil: Copper tube, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and with manual air vent. Coils shall be rated for a minimum working pressure of 300 psig and a maximum entering water temperature of 275 deg F, with manual air vent.

- H. Filters: 1-inch- thick, MERV 8.
- I. Fan: Centrifugal, with forward-curved, double-width wheels and fan scrolls made of galvanized steel or thermoplastic material; directly connected to motor.
- J. An ECM blower motor shall be provided on all units. Factory motor wiring shall be set for optimum fan performance. The unit shall be shipped at one fixed setting. The ECM motor shall utilize a permanent magnet rotor, which is connected to the shaft through resilient rings to absorb high frequency torque ripple. ECM motor shall be programmed for constant CFM. ECM blower motor shall be 3 speeds, single phase with means for proportional field adjustment of each speed.
- K. Provide a Low-Voltage, Interface Board (LV board) for use interface with the building automation system (BAS).
 - 1. Three 24-volt relays with line voltage contactors to operate fan motor speeds
 - 2. A factory wired and installed transformer
 - 3. Terminal connections for interfacing to:
 - a. A wall-mounted thermostat
 - b. Low-voltage actuators for heating valves
 - c. A return air sensor
- L. Provide a unit-mounted disconnect switch.

2.3 FAN CONVECTORS

- A. Smith PSU/PWU.
- B. Construction. The one piece chassis and grille is manufactured from high grade zinc coated steel. The grille and exposed parts of the chassis are painted with a neutral color baked enamel finish.
- C. Heat Exchanger. A highly efficient, headered coil, made of copper tubes expanded into smooth aluminum plate fins (10 FPI), tested at 300 PSI, and sealed for quality. The heat exchanger is positioned in the unit for maximum heat transfer over the coil.
- D. Fan and Motor Assembly. High spec tangential SEL fan and motor assembly consists of high static fan wheel and scroll, detachable motor, replaceable “easy glide” sleeve bearings, and the fan and motor cut out are protected to UL/CSA specifications. This fan and the motor assembly are designed to run whisper quiet without vibration.
- E. Controls. The units have integral two speed, max.-off-min., fan switches. The units shall be set with the fans at minimum position.
- F. The LTC – low limit aquastat is also a high spec item with a close tolerance designed to close on a rise to 110°F+/-3°F and open at 90°F+/-3°F.

- G. Water Connections. Supply and return connections are 1/2" sweat connections located to the left of the unit as you face the grille. A water vent with wide convenient screwdriver slot is accessible through the grille.
- H. Electrical Connections. 120/60/1 power supply is required. All that's required is to knock out the junction box hole you want to use and wire to the L1 and L2 leads. There is a convenient one screw access plate on the top of the unit to get at the ground.
- I. Provide an "EZ hanger" wall bracket.

2.4 SOURCE QUALITY CONTROL

- A. Test unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to unit heaters for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in for piping and electrical connections to verify actual locations before cabinet unit heater installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install unit heaters level and plumb.
- B. Install unit heaters to comply with NFPA 90A.
- C. Hung unit heaters shall be suspended from structure with rubber-in-shear vibration isolators (rubber hangers).

3.3 CONNECTIONS

- A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.
- B. Unless otherwise indicated, install shutoff valve and union or flange at each connection.
- C. Install piping adjacent to machine to allow service and maintenance.

3.4 FIELD QUALITY CONTROL

- A. Testing: Perform the following field quality-control testing and report results in writing:
 - 1. After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
 - 2. Test and adjust controls and safeties.
- B. Repair or replace malfunctioning units. Retest as specified above after repairs or replacements are made.

3.5 CLEANING

- A. After installing units, inspect unit cabinet for damage to finish. Remove paint splatters and other spots, dirt, and debris. Repair damaged finish to match original finish.
- B. After installing units, clean unit heaters internally according to manufacturers written instructions.
- C. Install new filters in each cabinet unit heater within two weeks after Substantial Completion.

END OF SECTION 238239

SECTION 260100 - BASIC ELECTRICAL REQUIREMENTS

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. General requirements applicable to all Division 26 sections.
 - 2. Allowances for Utility Construction Charges

1.3 TEMPORARY POWER AND LIGHTING

- A. Provide a separately metered temporary electrical service for the construction area.
- B. Power Distribution: Provide weatherproof, grounded circuits with ground-fault interruption features, with proper power characteristics and either permanently wired or plug-in connections as appropriate for intended use. Provide overload-protected disconnect switch for each circuit at distribution panel. Space 4-gang convenience outlets (20 amp circuit) so that every portion of work can be reached with 100' extension cord.
- C. Temporary Lighting: Provide lighting of intensity and quality sufficient for proper and safe performance of the work and for access thereto and security thereof, minimum average illumination level in every room shall be 20 footcandles.

1.4 ALLOWANCES FOR UTILITY CONSTRUCTION CHARGES

- A. Provide a \$35,000 allowance as specified in Division 01 for electric utility company utility construction charges associated with the electric service.

1.5 GENERAL REQUIREMENTS APPLICABLE TO ALL DIVISION 26 SECTIONS

- A. Regulatory Requirements:
 - 1. Conform to the requirements of all laws and regulations applicable to the work.
 - 2. Conform to the requirements of Federal State and Municipal Building Codes.
 - 3. Cooperate with all authorities having jurisdiction.
 - 4. Compliance with laws and regulations governing the work on this project does not relieve the Contractor from compliance with more restrictive requirements contained in these specifications.

5. If the Contract Documents are found to be at variance with any law or regulation, the Contractor shall notify the Architect/Engineer promptly in writing. The Contractor shall assume full responsibility for any work contrary to law or regulation, and shall bear all costs for the corrections thereof.
6. Minimum Requirements: The more stringent of the 2014 National Electrical Code (NEC) or the edition enforced by the local Authority Having Jurisdiction, Underwriters Laboratories, Inc. (UL), the National Fire Codes, and National Fire Protection Association (NFPA) are a minimum requirement for work under this section. Design drawings and other specification sections shall govern in those instances where requirements are greater than those required by code.

B. REFERENCES

1. The publications listed below form a part of this specification to the extent referenced. The publications are referenced in the text by the basic designation only.
 - a. National Fire Protection Association (NFPA).
 - b. National Electrical Code (NEC)
 - c. National Electrical Safety Code (NESC)
 - d. Underwriters Laboratories, Inc. (UL)
 - e. American National Standards Institute (ANSI)
 - f. Certified Ballast Manufacturers Association (CBM)
 - g. National Electrical Manufacturers Association (NEMA)
 - h. International Municipal Signal Association (IMSA)
 - i. Institute of Electrical and Electronic Engineers (IEEE)
 - j. American Society for Testing Materials Specifications (ASTM)
 - k. National Bureau of Standards Handbook (NBS)
 - l. Occupational Safety and Health Administration (OSHA)
 - m. Americans with Disabilities Act (ADA)
 - n. Insulated Power Cable Engineers Association Specifications (IPCEA)

C. Permits, Fees, and Inspections:

1. Secure and pay for all permits, fees, licenses, inspections, etc., required for the work under Division 26.
2. Schedule and pay for all legally required inspections and cooperate with inspecting officers.
3. Provide Certificates of Inspection and Approval from all regulatory authorities having jurisdiction over the work in Division 26.

D. The Contractor shall study all drawings and specifications and acquaint itself 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 familiarize itself with the conditions and extent of the proposed work.

E. Measure indicated mounting heights to bottom of unit for suspended items and to center of unit for wall-mounting items.

F. 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.

1.6 EFFICIENCY MAINE

- A. This project intends to pursue Efficient Maine prescriptive and/or custom incentives. The contractor shall be an Efficiency Maine Qualified Partner and shall participate in the activities associated with Efficiency Maine incentive pre-approval and approval process including but not limited to; preparation and submission of required incentive application(s) and the tracking and submission of measure specific invoices to Efficiency Maine within 60 days of the completion of the work.
- B. The contractor shall also:
 - 1. Become familiar with the Efficiency Maine Business Program including available incentives and the application and review process.
 - 2. Review plans and specifications for any and all incentive opportunities, prescriptive and custom.
- C. The project schedule shall reflect and accommodate the time required to achieve application preapproval from EM. No equipment shall be purchased until preapproval is received from EM.
- D. All invoices shall be forwarded to EM within 60 days of the completion of work. This deliverable shall be shown on the project schedule as a milestone date and coordinated with all contractors to assure compliance with this requirement.
- E. Efficiency Maine is available to assist in the application process and can be reached at 866-376-2463

1.7 COORDINATION

- A. Provide coordination drawings in accordance with Division 01.
- B. Coordinate the work of Division 26 with other Divisions, the Owner, and utility companies.
- C. 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, cable trays, and busways will be clear of obstructions and of the working and access space of other equipment.
- D. Coordinate installation of required supporting devices and set sleeves in cast-in-place concrete, masonry walls, and other structural components as they are constructed.
- E. Coordinate location of access panels and doors for electrical items that are behind finished surfaces or otherwise concealed. Access doors and panels are specified in Division 08.

- F. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07.

PART 2 - PRODUCTS – Not Used

PART 3 - EXECUTION – Not Used

END OF SECTION 260100

SECTION 260519 - LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Building wires and cables rated 600 V and less.
 - 2. Connectors, splices, and terminations rated 600 V and less.
- B. Related Sections include the following:
 - 1. Division 26 Section "Conductors and Cables for Electronic Safety and Security" for cabling used for electronic safety and security systems.
 - 2. Division 27 for cabling used for voice and data circuits.

1.3 DEFINITIONS

- A. EPDM: Ethylene-propylene-diene terpolymer rubber.
- B. NBR: Acrylonitrile-butadiene rubber.

1.4 QUALITY ASSURANCE

- A. 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.
- 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.

PART 2 - PRODUCTS

2.1 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. Aluminum and Copper Conductors: Comply with NEMA WC 70.
- C. Conductor Insulation: Comply with NEMA WC 70
- D. Multiconductor Cable: Comply with NEMA WC 70 for metal-clad cable, Type MC
- E. Power-limited cable: Type CMP for plenum applications, type CMR for non-plenum applications.

2.2 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.

PART 3 - EXECUTION

3.1 CONDUCTOR MATERIAL APPLICATIONS

- A. Feeders: Copper for feeders smaller than No. 4 AWG; copper or aluminum for feeders No. 4 AWG and larger. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.
1. Use copper for all sizes where required by manufacturer's instructions for equipment supplied by feeders.

- B. Branch Circuits: Copper. Solid for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.2 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

- A. Exposed Feeders: Type THHN-THWN, single conductors in raceway
- B. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspace: Type THHN-THWN, single conductors in raceway
- C. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- D. Exposed Branch Circuits: Type THHN-THWN, single conductors in raceway
- E. Branch Circuits Concealed in Ceilings, Walls, and Partitions: Type THHN-THWN, single conductors in raceway or metal-clad cable, Type MC
- F. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-THWN, single conductors in raceway
- G. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.
- H. Class 1 Control Circuits: Type THHN-THWN, in raceway. Type MC cable shall be permitted where concealed in building finishes.
- I. Class 2 Control Circuits: Type THHN-THWN, in raceway

3.3 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."

3.4 CONNECTIONS

- A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A 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.
 - 1. Use oxide inhibitor in each splice and tap conductor for aluminum conductors.
- C. Wiring at Outlets: Install conductor at each outlet, with at least **12 inches** of slack.

3.5 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

- A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Division 26 Section "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.6 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 "Penetration Firestopping."

3.7 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
- C. Test Reports: Prepare a written report to record the following:
 - 1. Test procedures used.
 - 2. Test results that comply with requirements.
 - 3. Test results that do not comply with requirements and corrective action taken to achieve compliance with requirements.
- D. Remove and replace malfunctioning units and retest as specified above.

END OF SECTION 260519

SECTION 260526 - GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes grounding and bonding systems and equipment, plus the following special applications:
 - 1. Foundation steel electrodes.

1.3 ACTION SUBMITTALS

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

1.4 INFORMATIONAL SUBMITTALS

- A. As-Built Data: Plans showing dimensioned as-built locations of grounding features specified in "Field Quality Control" Article, including the following:
 - 1. Test wells.
 - 2. Ground rods.
 - 3. Grounding arrangements and connections for separately derived systems.
- B. Qualification Data: For testing agency and testing agency's field supervisor.
- C. Field quality-control reports.

1.5 QUALITY ASSURANCE

- A. Testing Agency Qualifications: Certified by NETA.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. [Burndy; Part of Hubbell Electrical Systems.](#)
2. [ERICO International Corporation.](#)
3. [ILSCO.](#)
4. [O-Z/Gedney; a brand of Emerson Industrial Automation.](#)
5. [Thomas & Betts Corporation; A Member of the ABB Group.](#)

2.2 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 467 for grounding and bonding materials and equipment.

2.3 CONDUCTORS

- A. Insulated Conductors: Copper or tinned-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. Tinned Conductors: ASTM B 33.
 4. Bonding Cable: 28 kcmil, 14 strands of No. 17 AWG conductor, **1/4 inch (6 mm)** in diameter.
 5. Bonding Conductor: No. 4 or No. 6 AWG, stranded conductor.
 6. Bonding Jumper: Copper tape, braided conductors terminated with copper ferrules; **1-5/8 inches (41 mm)** wide and **1/16 inch (1.6 mm)** thick.
 7. Tinned Bonding Jumper: Tinned-copper tape, braided conductors terminated with copper ferrules; **1-5/8 inches (41 mm)** wide and **1/16 inch (1.6 mm)** thick.
- C. Grounding Bus: Predrilled rectangular bars of annealed copper, **1/4 by 4 inches (6.3 by 100 mm)** in cross section, not less than 12 inches long, with **9/32-inch (7.14-mm)** holes spaced **1-1/8 inches (28 mm)** apart. Stand-off insulators for mounting shall comply with UL 891 for use in switchboards, 600 V and shall be Lexan or PVC, impulse tested at 5000 V.

2.4 CONNECTORS

- A. Listed and labeled by an NRTL acceptable to authorities having jurisdiction for applications in which used and for specific types, sizes, and combinations of conductors and other items connected.
- B. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.
- C. Bus-Bar Connectors: Compression type, copper or copper alloy, with two wire terminals.

- D. Beam Clamps: Mechanical type, terminal, ground wire access from four directions, with dual, tin-plated or silicon bronze bolts.
- E. Cable-to-Cable Connectors: Compression type, copper or copper alloy.
- F. Cable Tray Ground Clamp: Mechanical type, zinc-plated malleable iron.
- G. Conduit Hubs: Mechanical type, terminal with threaded hub.
- H. Ground Rod Clamps: Mechanical type, copper or copper alloy, terminal with hex head bolt.
- I. Lay-in Lug Connector: Mechanical type, copper rated for direct burial terminal with set screw.
- J. Service Post Connectors: Mechanical type, bronze alloy terminal, in short- and long-stud lengths, capable of single and double conductor connections.
- K. Straps: Solid copper, cast-bronze clamp. Rated for 600 A.
- L. U-Bolt Clamps: Mechanical type, copper or copper alloy, terminal listed for direct burial.
- M. Water Pipe Clamps:
 - 1. Mechanical type, two pieces with zinc-plated bolts.
 - a. Material: Tin-plated aluminum.
 - b. Listed for direct burial.
 - 2. U-bolt type with malleable-iron clamp and copper ground connector.

2.5 GROUNDING ELECTRODES

- A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

PART 3 - EXECUTION

3.1 APPLICATIONS

- A. Conductors: Install solid or stranded conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger unless otherwise indicated.
- B. Underground Grounding Conductors: Install barecopper conductor, No. 2/0 AWG minimum.
 - 1. Bury at least 24 inches (600 mm) below grade.
- C. Grounding Bus: Install in electrical equipment rooms, in rooms housing service equipment, and elsewhere as indicated.
 - 1. Install bus horizontally, on insulated spacers 2 inches (50 mm) minimum from wall, 6 inches (150 mm) above finished floor unless otherwise indicated.

D. 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.

3.2 GROUNDING AT THE SERVICE

- A. Equipment grounding conductors and grounding electrode conductors shall be connected to the ground bus. Install a main bonding jumper between the neutral and ground buses.

3.3 GROUNDING SEPARATELY DERIVED SYSTEMS

- A. Transformers: Comply with NEC 250.

3.4 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

- A. Comply with utility company grounding requirements.
- B. Grounding Manholes and Handholes: Install a driven ground rod through manhole or handhole floor, close to wall, and set rod depth so 4 inches (100 mm) will extend above finished floor. If necessary, install ground rod before manhole is placed and provide No. 1/0 AWG bare, tinned-copper conductor from ground rod into manhole through a waterproof sleeve in manhole wall. Protect ground rods passing through concrete floor with a double wrapping of pressure-sensitive insulating tape or heat-shrunk insulating sleeve from 2 inches (50 mm) above to 6 inches (150 mm) below concrete. Seal floor opening with waterproof, nonshrink grout.
- C. Grounding Connections to Manhole Components: Bond exposed-metal parts such as inserts, cable racks, pulling irons, ladders, and cable shields within each manhole or handhole, to ground rod or grounding conductor. Make connections with No. 4 AWG minimum, stranded, hard-drawn copper bonding conductor. Train conductors level or plumb around corners and fasten to manhole walls. Connect to cable armor and cable shields according to written instructions by manufacturer of splicing and termination kits.

3.5 EQUIPMENT GROUNDING

- A. Install insulated equipment grounding conductors with all feeders and branch circuits.
- B. 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.

- C. 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.
- D. 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.
- E. 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.

3.6 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. Ground Rods: Drive rods until tops are 2 inches (50 mm) below finished floor or final grade unless otherwise indicated.
 - 1. Interconnect ground rods with grounding electrode conductor below grade and as otherwise indicated. Make connections without exposing steel or damaging coating if any.
 - 2. For grounding electrode system, install at least three rods spaced at least one-rod length from each other and located at least the same distance from other grounding electrodes, and connect to the service grounding electrode conductor.
- C. Test Wells: Ground rod driven through drilled hole in bottom of handhole. Handholes are specified in Section 260543 "Underground Ducts and Raceways for Electrical Systems," and shall be at least 12 inches (300 mm) deep, with cover.
 - 1. Install at least one test well for each service unless otherwise indicated. Install at the ground rod electrically closest to service entrance. Set top of test well flush with finished grade or floor.
- D. Bonding Straps and Jumpers: Install in locations accessible for inspection and maintenance except where routed through short lengths of conduit.
 - 1. Bonding to Structure: Bond straps directly to basic structure, taking care not to penetrate any adjacent parts.
 - 2. Bonding to Equipment Mounted on Vibration Isolation Hangers and Supports: Install bonding so vibration is not transmitted to rigidly mounted equipment.
 - 3. Use exothermic-welded connectors for outdoor locations; if a disconnect-type connection is required, use a bolted clamp.

E. Grounding and Bonding for Piping:

1. Metal Water Service Pipe: Install insulated copper grounding conductors, in conduit, from building's main service equipment, or grounding bus, to main metal water service entrances to building. Connect grounding conductors to main metal water service pipes; use a bolted clamp connector or bolt a lug-type connector to a pipe flange by using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

F. 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.

G. 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.

H. Concrete-Encased Grounding Electrode (Ufer Ground): Provide using one of the following methods:

1. Fabricate according to NFPA 70; use a minimum of **20 feet (6 m)** of bare copper conductor not smaller than No. 4 AWG.
 - a. If concrete foundation is less than **20 feet (6 m)** long, coil excess conductor within base of foundation.
 - b. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.
2. Concrete-Encased Grounding Electrode (Ufer Ground): Fabricate according to NFPA 70; using electrically conductive coated steel reinforcing bars or rods, at least **20 feet (6.0 m)** long. If reinforcing is in multiple pieces, connect together by the usual steel tie wires or exothermic welding to create the required length.

3.7 FIELD QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

B. Tests and Inspections:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Inspect physical and mechanical condition. Verify tightness of accessible, bolted, electrical connections with a calibrated torque wrench according to manufacturer's written instructions.

3. Test completed grounding system at each location where a maximum ground-resistance level is specified, at service disconnect enclosure grounding terminal, at ground test wells. Make tests at ground rods before any conductors are connected.
 - a. Measure ground resistance no fewer than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
 - b. Perform tests by fall-of-potential method according to IEEE 81.
 4. Prepare dimensioned Drawings locating each test well, ground rod and ground-rod assembly, and other grounding electrodes. Identify each by letter in alphabetical order, and key to the record of tests and observations. Include the number of rods driven and their depth at each location, and include observations of weather and other phenomena that may affect test results. Describe measures taken to improve test results.
- C. Grounding system will be considered defective if it does not pass tests and inspections.
- D. Prepare test and inspection reports.
- E. Report measured ground resistances that exceed the following values:
1. Power and Lighting Equipment or System with Capacity of 500 kVA and Less: 10 ohms.
 2. Power and Lighting Equipment or System with Capacity of 500 to 1000 kVA: 5 ohms.
- F. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION 260526

SECTION 260529 - HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Hangers and supports for electrical equipment and systems.
 - 2. Construction requirements for concrete bases.
- B. Related Sections include the following:
 - 1. Division 26 Section "Vibration And Seismic Controls For Electrical Systems" for products and installation requirements necessary for compliance with seismic criteria.

1.3 DEFINITIONS

- A. EMT: Electrical metallic tubing.
- B. IMC: Intermediate metal conduit.
- C. RMC: Rigid metal conduit.

1.4 PERFORMANCE REQUIREMENTS

- A. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.
- B. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.
- C. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of 5 times the applied force.

1.5 QUALITY ASSURANCE

- A. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

- A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.
 - 1. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
 - 2. Fittings and Accessories: Products of channel and angle manufacturer and designed for use with those items.
 - 3. Fitting and Accessory Materials: Same as channels and angles
 - 4. Rated Strength: Selected to suit applicable load criteria.
- B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.
- C. Conduit and Cable Support Devices: steel hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.
- D. 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.
- E. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.
- F. 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.
 - 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.
 - 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.

2.2 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

- A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.
- B. Materials: Comply with requirements in Division 05 Section "Metal Fabrications" for steel shapes and plates.

PART 3 - EXECUTION

3.1 APPLICATION

- A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.
- B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as required by NFPA 70. Minimum rod size shall be **1/4 inch (6 mm)** in diameter.
- C. Multiple Raceways or Cables: Install trapeze-type supports fabricated with steel slotted support system, sized so capacity can be increased by at least 25 percent in future without exceeding specified design load limits.
 1. Secure raceways and cables to these supports with two-bolt conduit clamps.

3.2 SUPPORT INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.
- B. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus **200 lb (90 kg)**.
- C. 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.
 7. To Light Steel: Sheet metal screws.
 8. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.
- D. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.3 INSTALLATION OF FABRICATED METAL SUPPORTS

- A. Comply with installation requirements in Division 05 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.

3.4 PAINTING

- A. 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.
- B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION 260529

SECTION 260533 - RACEWAYS AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Metal conduits, tubing, and fittings.
 - 2. Metal wireways and auxiliary gutters.
 - 3. Surface raceways.
 - 4. Cable trays.
 - 5. Boxes, enclosures, and cabinets.

1.3 DEFINITIONS

- A. ARC: Aluminum rigid conduit.
- B. GRC: Galvanized rigid steel conduit.
- C. IMC: Intermediate metal conduit.

1.4 ACTION SUBMITTALS

- A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

1.5 INFORMATIONAL SUBMITTALS

- A. Source quality-control reports.

PART 2 - PRODUCTS

2.1 METAL CONDUITS, TUBING, AND FITTINGS

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

1. [AFC Cable Systems, Inc.](#)
2. [Allied Tube & Conduit; a Tyco International Ltd. Co.](#)
3. [Anamet Electrical, Inc.](#)
4. [Electri-Flex Company.](#)
5. [O-Z/Gedney; a brand of EGS Electrical Group.](#)
6. [Southwire Company.](#)
7. [Thomas & Betts Corporation.](#)
8. [Wheatland Tube Company; a division of John Maneely Company.](#)

- B. Listing and Labeling: Metal conduits, tubing, and fittings shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- C. GRC: Comply with ANSI C80.1 and UL 6.
- D. ARC: Comply with ANSI C80.5 and UL 6A.
- E. IMC: Comply with ANSI C80.6 and UL 1242.
- F. EMT: Comply with ANSI C80.3 and UL 797.
- G. FMC: Comply with UL 1; zinc-coated steel or aluminum.
- H. LFMC: Flexible steel conduit with PVC jacket and complying with UL 360.
- I. Fittings for Metal Conduit: Comply with NEMA FB 1 and UL 514B.
1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886 and NFPA 70.
 2. Fittings for EMT:
 - a. Material: Steel.
 - b. Type: Setscrew or compression.
 3. Expansion Fittings: PVC or steel to match conduit type, complying with UL 651, rated for environmental conditions where installed, and including flexible external bonding jumper.

2.2 METAL WIREWAYS AND AUXILIARY GUTTERS

- A. [Manufacturers](#): Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. [Cooper B-Line, Inc.](#)
 2. [Hoffman; a Pentair company.](#)
 3. [Square D; a brand of Schneider Electric.](#)
- B. Description: Sheet metal, complying with UL 870 and NEMA 250, Type 1 unless otherwise indicated, and sized according to NFPA 70.

- C. Fittings and Accessories: Include covers, couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.
- D. Wireway Covers: Screw-cover type unless otherwise indicated.
- E. Finish: Manufacturer's standard enamel finish.

2.3 SURFACE METAL RACEWAYS

- A. Listing and Labeling: Surface raceways shall be listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Surface Metal Raceways: Galvanized steel with snap-on covers complying with UL 5. Manufacturer's standard enamel finish in color selected by Architect.
 - 1. Basis of design is Wiremold 4000 series.

2.4 CABLE TRAYS

- A. General Requirements for Cable Trays
 - 1. Cable Trays and Accessories: Identified as defined in NFPA 70 and marked for intended location, application, and grounding.
 - a. Source Limitations: Obtain cable trays and components from single manufacturer.
 - 2. Structural Performance: See individual cable tray types for specific values for the following parameters:
 - a. Uniform Load Distribution: Capable of supporting a uniformly distributed load on the indicated support span when supported as a simple span and tested according to NEMA VE 1.
 - b. Concentrated Load: A load applied at midpoint of span and centerline of tray.
 - 1) Load and Safety Factors: Applicable to both side rails and rung capacities.

2.5 WIRE-BASKET CABLE TRAYS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Cooper B-Line, Inc.
 - 2. Allied Tube & Conduit; a Tyco International Ltd. Co.
 - 3. Mono-Systems, Inc.
 - 4. MP Husky.

B. Description:

1. Configuration: Wires are formed into a standard **2-by-4-inch (50-by-100-mm)** wire mesh pattern with intersecting wires welded together. Mesh sections must have at least one bottom longitudinal wire along entire length of section.
2. Materials: High-strength-steel longitudinal wires with no bends.
3. Safety Provisions: Wire ends along wire-basket sides (flanges) rounded during manufacturing to maintain integrity of cables and installer safety.
4. Sizes:
 - a. Straight sections shall be furnished in standard **118-inch (3000-mm)** lengths.
 - b. Wire-Basket Depth: **2-inch (50-mm)** usable loading depth by **12 inches (300 mm)** wide.
5. Connector Assemblies: Bolt welded to plate shaped to fit around adjoining tray wires and mating plate. Mechanically joins adjacent tray wires to splice sections together or to create horizontal fittings.
6. Connector Assembly Capacity: Splices located within support span shall not diminish rated loading capacity of cable tray.
7. Hardware and Fasteners: Steel, zinc plated according to ASTM B 633.

2.6 BOXES, ENCLOSURES, AND CABINETS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. O-Z/Gedney; a brand of EGS Electrical Group.
 2. RACO; a Hubbell Company.
 3. Thomas & Betts Corporation.
 4. Wiremold / Legrand.
- B. General Requirements for Boxes, Enclosures, and Cabinets: Boxes, enclosures, and cabinets installed in wet locations shall be listed for use in wet locations.
- C. Sheet Metal Outlet and Device Boxes: Comply with NEMA OS 1 and UL 514A.
- D. Cast-Metal Outlet and Device Boxes: Comply with NEMA FB 1, aluminum, Type FD, with gasketed cover.
- E. Luminaire Outlet Boxes: Nonadjustable, designed for attachment of luminaire weighing **50 lb (23 kg)**. Outlet boxes designed for attachment of luminaires weighing more than **50 lb (23 kg)** shall be listed and marked for the maximum allowable weight.
- F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.
- G. Cast-Metal Access, Pull, and Junction Boxes: Comply with NEMA FB 1 and UL 1773, cast aluminum with gasketed cover.
- H. Box extensions used to accommodate new building finishes shall be of same material as recessed box.

- I. Device Box Dimensions: 4 inches square by 2-1/8 inches deep (100 mm square by 60 mm deep).
- J. Hinged-Cover Enclosures: Comply with UL 50 and NEMA 250, Type 1 with continuous-hinge cover with flush latch unless otherwise indicated.
 - 1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
 - 2. Interior Panels: Steel; all sides finished with manufacturer's standard enamel.
- K. Cabinets:
 - 1. NEMA 250, Type 1 unless otherwise noted galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
 - 2. Hinged door in front cover with flush latch and concealed hinge.
 - 3. Key latch to match panelboards.
 - 4. Metal barriers to separate wiring of different systems and voltage.
 - 5. Accessory feet where required for freestanding equipment.

PART 3 - EXECUTION

3.1 RACEWAY APPLICATION

- A. Indoors: Apply raceway products as specified below unless otherwise indicated:
 - 1. Exposed, Not Subject to Physical Damage: EMT.
 - 2. Exposed and Subject to Severe Physical Damage: GRC or IMC. Raceway locations include the following:
 - a. Loading dock.
 - b. Corridors used for traffic of mechanized carts, forklifts, and pallet-handling units.
 - 3. Concealed in Ceilings and Interior Walls and Partitions: EMT.
 - 4. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
 - 5. Damp or Wet Locations: GRC or IMC.
 - 6. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4 stainless steel in institutional and commercial kitchens and damp or wet locations.
- B. Minimum Raceway Size: [1/2-inch (16-mm)] [3/4-inch (21-mm)] trade size.
- C. Raceway Fittings: Compatible with raceways and suitable for use and location.
 - 1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings unless otherwise indicated. Comply with NEMA FB 2.10.
 - 2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with this type of conduit. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer and apply in thickness and number of coats recommended by manufacturer.

3. EMT: Use setscrew or compression, steel fittings. Comply with NEMA FB 2.10.
4. Flexible Conduit: Use only fittings listed for use with flexible conduit. Comply with NEMA FB 2.20.

D. Install surface raceways only where indicated on Drawings.

3.2 INSTALLATION

- A. Comply with NECA 1 and NECA 101 for installation requirements except where requirements on Drawings or in this article are stricter. Comply with NECA 102 for aluminum conduits. Comply with NFPA 70 limitations for types of raceways allowed in specific occupancies and number of floors.
- B. Keep raceways at least **6 inches (150 mm)** away from parallel runs of flues and steam or hot-water pipes. Install horizontal raceway runs above water and steam piping.
- C. Complete raceway installation before starting conductor installation.
- D. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems" for hangers and supports.
- E. Arrange stub-ups so curved portions of bends are not visible above finished slab.
- F. Install no more than the equivalent of three 90-degree bends in any conduit run except for control wiring conduits, for which fewer bends are allowed. Support within **12 inches (300 mm)** of changes in direction.
- G. Conceal conduit and EMT within finished walls, ceilings, and floors unless otherwise indicated. Install conduits parallel or perpendicular to building lines.
- H. Support conduit within **12 inches (300 mm)** of enclosures to which attached.
- I. Stub-ups to Above Recessed Ceilings:
 1. Use EMT, IMC, or RMC for raceways.
 2. Use a conduit bushing or insulated fitting to terminate stub-ups not terminated in hubs or in an enclosure.
- J. 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.
- K. Terminate threaded conduits into threaded hubs or with locknuts on inside and outside of boxes or cabinets. Install bushings on conduits up to **1-1/4-inch (35mm)** trade size and insulated throat metal bushings on **1-1/2-inch (41-mm)** trade size and larger conduits terminated with locknuts. Install insulated throat metal grounding bushings on service conduits.
- L. Install raceways square to the enclosure and terminate at enclosures with locknuts. Install locknuts hand tight plus 1/4 turn more.

- M. Do not rely on locknuts to penetrate nonconductive coatings on enclosures. Remove coatings in the locknut area prior to assembling conduit to enclosure to assure a continuous ground path.
- N. Cut conduit perpendicular to the length. For conduits **2-inch (53-mm)** trade size and larger, use roll cutter or a guide to make cut straight and perpendicular to the length.
- O. Install pull wires in empty raceways. Use polypropylene or monofilament plastic line with not less than **200-lb (90-kg)** tensile strength. Leave at least **12 inches (300 mm)** of slack at each end of pull wire. Cap underground raceways designated as spare above grade alongside raceways in use.
- P. Surface Raceways:
1. Install surface raceway with a minimum **2-inch (50-mm)** radius control at bend points.
 2. Secure surface raceway with screws or other anchor-type devices at intervals not exceeding **48 inches (1200 mm)** and with no less than two supports per straight raceway section. Support surface raceway according to manufacturer's written instructions. Tape and glue are not acceptable support methods.
- Q. Install raceway sealing fittings at accessible locations according to NFPA 70 and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings according to NFPA 70.
- R. Install devices to seal raceway interiors at accessible locations. Locate seals so no fittings or boxes are between the seal and the following changes of environments. Seal the interior of all raceways at the following points:
1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
 2. Where an underground service raceway enters a building or structure.
 3. Where otherwise required by NFPA 70.
- S. Comply with manufacturer's written instructions for solvent welding RNC and fittings.
- T. Expansion-Joint Fittings:
1. Install in each run of aboveground RNC that is located where environmental temperature change may exceed **30 deg F (17 deg C)** and that has straight-run length that exceeds **25 feet (7.6 m)**. Install in each run of aboveground RMC and EMT conduit that is located where environmental temperature change may exceed **100 deg F (55 deg C)** and that has straight-run length that exceeds **100 feet (30 m)**.
 2. Install type and quantity of fittings that accommodate temperature change listed for each of the following locations:
 - a. Outdoor Locations Not Exposed to Direct Sunlight: **125 deg F (70 deg C)** temperature change.
 - b. Outdoor Locations Exposed to Direct Sunlight: **155 deg F (86 deg C)** temperature change.
 - c. Indoor Spaces Connected with Outdoors without Physical Separation: **125 deg F (70 deg C)** temperature change.

3. Install fitting(s) that provide expansion and contraction for at least **0.00041 inch per foot of length of straight run per deg F** (**0.06 mm per meter of length of straight run per deg C**) of temperature change for PVC conduits. Install fitting(s) that provide expansion and contraction for at least **0.000078 inch per foot of length of straight run per deg F** (**0.0115 mm per meter of length of straight run per deg C**) of temperature change for metal conduits.
 4. Install expansion fittings at all locations where conduits cross building or structure expansion joints.
 5. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at time of installation. Install conduit supports to allow for expansion movement.
- U. Flexible Conduit Connections: Comply with NEMA RV 3. Use a maximum of **72 inches (1830 mm)** of flexible conduit for recessed and semirecessed luminaires, equipment subject to vibration, noise transmission, or movement; and for transformers and motors.
1. Use LFMC in damp or wet locations.

V. CABLE TRAY INSTALLATION

1. Install cable trays according to NEMA VE 2.
2. Install cable trays as a complete system, including fasteners, hold-down clips, support systems, barrier strips, adjustable horizontal and vertical splice plates, elbows, reducers, tees, crosses, cable dropouts, adapters, covers, and bonding.
3. Install cable trays so that the tray is accessible for cable installation and all splices are accessible for inspection and adjustment.
4. Remove burrs and sharp edges from cable trays.
5. Fasten cable tray supports to building structure and install seismic restraints.
6. Design fasteners and supports to carry cable tray, the cables, and a concentrated load of **200 lb (90 kg)**. Comply with requirements in Section 260529 "Hangers and Supports for Electrical Systems." Comply with seismic-restraint details according to Section 260548 "Vibration and Seismic Controls for Electrical Systems."
7. Place supports so that spans do not exceed maximum spans on schedules and provide clearances shown on Drawings. Install intermediate supports when cable weight exceeds the load-carrying capacity of the tray rungs.
8. Construct supports from channel members, threaded rods, and other appurtenances furnished by cable tray manufacturer. Arrange supports in trapeze or wall-bracket form as required by application.
9. Support bus assembly to prevent twisting from eccentric loading.
10. Locate and install supports according to NEMA VE 2. Do not install more than one cable tray splice between supports.
11. Support wire-basket cable trays with trapeze hangers.
12. Support trapeze hangers for wire-basket trays with **3/8-inch- (10-mm-)** diameter rods.
13. Install expansion connectors where cable trays cross building expansion joints and in cable tray runs that exceed dimensions recommended in NEMA VE 2. Space connectors and set gaps according to applicable standard.
14. Make changes in direction and elevation using manufacturer's recommended fittings.
15. Make cable tray connections using manufacturer's recommended fittings.
16. Seal penetrations through fire and smoke barriers. Comply with requirements in Division 07
17. Install cable trays with enough workspace to permit access for installing cables.

W. CABLE TRAY GROUNDING

1. Ground cable trays according to NFPA 70 unless additional grounding is specified. Comply with requirements in Section 260526 "Grounding and Bonding for Electrical Systems."
2. Cable trays with communications cable shall be bonded together with splice plates listed for grounding purposes or with listed bonding jumpers.
3. When using epoxy- or powder-coat painted cable trays as a grounding conductor, completely remove coating at all splice contact points or ground connector attachment. After completing splice-to-grounding bolt attachment, repair the coated surfaces with coating materials recommended by cable tray manufacturer.

X. Mount boxes at heights indicated on Drawings. If mounting heights of boxes are not individually indicated, give priority to ADA requirements. Install boxes with height measured to center of box unless otherwise indicated.

Y. Horizontally separate boxes mounted on opposite sides of walls so they are not in the same vertical channel.

Z. Locate boxes so that cover or plate will not span different building finishes.

AA. Support boxes of three gangs or more from more than one side by spanning two framing members or mounting on brackets specifically designed for the purpose.

BB. Fasten junction and pull boxes to or support from building structure. Do not support boxes by conduits.

3.3 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.4 FIRESTOPPING

A. Install firestopping at penetrations of fire-rated floor and wall assemblies. Comply with requirements in Division 07.

3.5 PROTECTION

A. Protect coatings, finishes, and cabinets from damage and deterioration.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.

END OF SECTION 260533

SECTION 260543 - UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Direct-buried conduit, ducts, and duct accessories.
2. Concrete-encased conduit, ducts, and duct accessories.
3. Handholes and boxes.
4. Manholes.

1.3 DEFINITIONS

- A. Trafficways: Locations where vehicular or pedestrian traffic is a normal course of events.

1.4 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include duct-bank materials, including separators and miscellaneous components.
2. Include ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Include accessories for manholes, handholes, boxes, and other utility structures.
4. Include warning tape.

B. Shop Drawings:

1. Precast or Factory-Fabricated Underground Utility Structures:
 - a. Include plans, elevations, sections, details, attachments to other work, and accessories.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include reinforcement details.
 - d. Include frame and cover design and manhole frame support rings.
 - e. Include grounding details.
 - f. Include dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
 - g. Include joint details.

2. Factory-Fabricated Handholes and Boxes Other Than Precast Concrete:
 - a. Include dimensioned plans, sections, and elevations, and fabrication and installation details.
 - b. Include duct entry provisions, including locations and duct sizes.
 - c. Include cover design.
 - d. Include grounding details.
 - e. Include dimensioned locations of cable rack inserts, and pulling-in and lifting irons.

1.5 INFORMATIONAL SUBMITTALS

- A. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.
- B. Qualification Data: For professional engineer and testing agency responsible for testing nonconcrete handholes and boxes.
- C. Source quality-control reports.
- D. Field quality-control reports.

1.6 FIELD 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 Owner no fewer than five days in advance of proposed interruption of electrical service.
 2. Do not proceed with interruption of electrical service without Owner's written permission.
- B. Ground Water: Assume ground-water level is 36 inches (900 mm) below ground surface unless a higher water table is noted on Drawings.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR DUCTS AND RACEWAYS

- A. Comply with ANSI C2.

2.2 CONDUIT

- A. Rigid Steel Conduit: Galvanized. Comply with ANSI C80.1.

- B. RNC: NEMA TC 2, Type EPC-40-PVC and Type EPC-80-PVC, UL 651, with matching fittings, complying with NEMA TC 3 and UL 514B.

2.3 NONMETALLIC DUCTS AND DUCT ACCESSORIES

- A. Underground Plastic Utilities Duct: NEMA TC 2, UL 651, ASTM F 512, Type EPC-80 and Type EPC-40, with matching fittings complying with NEMA TC 3.
- B. Duct Accessories:
 - 1. Duct Separators: Factory-fabricated rigid PVC interlocking spacers, sized for type and size of ducts with which used, and selected to provide minimum duct spacing indicated while supporting ducts during concreting or backfilling.
 - 2. Warning Tape: Underground-line warning tape specified in Section 260553 "Identification for Electrical Systems."

2.4 PRECAST CONCRETE HANDHOLES AND BOXES

- A. Comply with ASTM C 858 for design and manufacturing processes.
- B. Comply with utility company specifications for each service.
- C. Description: Factory-fabricated, reinforced-concrete, monolithically poured walls and bottom unless open-bottom enclosures are indicated. Frame and cover shall form top of enclosure and shall have load rating consistent with that of handhole or box.
 - 1. Frame and Cover: Weatherproof cast-iron frame, with cast-iron cover with recessed cover hook eyes and tamper-resistant, captive, cover-securing bolts.
 - 2. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - 3. Cover Legend: Molded lettering, As indicated for each service.
 - 4. Configuration: Units shall be designed for flush burial and have integral closed bottom unless otherwise indicated.
 - 5. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.
 - 6. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional **12 inches (300 mm)** vertically and horizontally to accommodate alignment variations.
 - a. Windows shall be located no less than **6 inches (150 mm)** from interior surfaces of walls, floors, or frames and covers of handholes, but close enough to corners to facilitate racking of cables on walls.
 - b. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.
 - c. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.

7. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have inserts for cable racks and pulling-in irons installed before concrete is poured.

2.5 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. General Requirements for Handholes and Boxes: Comply with SCTE 77. Comply with tier requirements in "Underground Enclosure Application" Article.
 1. Color: Gray.
 2. Configuration: Units shall be designed for flush burial and have open bottom unless otherwise indicated.
 3. Cover: Weatherproof, secured by tamper-resistant locking devices and having structural load rating consistent with enclosure.
 4. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 5. Cover Legend: Molded lettering, As indicated for each service.
- B. Polymer Concrete Handholes and Boxes with Polymer Concrete Cover: Molded of sand and aggregate, bound together with a polymer resin, and reinforced with steel or fiberglass or a combination of the two.
 1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - a. Armorcast Products Company.
 - b. Carson Industries LLC.
 - c. Quazite: Hubbell Power System, Inc.

2.6 PRECAST MANHOLES

- A. Comply with ASTM C 858.
- B. Comply with utility company specifications for each service.
- C. Structural Design Loading: Comply with requirements in "Underground Enclosure Application" Article.
- D. Precast Manholes: One-piece units and units with interlocking mating sections, complete with accessories, hardware, and features.
- E. Windows: Precast openings in walls, arranged to match dimensions and elevations of approaching ducts and duct banks, plus an additional 12 inches (300 mm) vertically and horizontally to accommodate alignment variations.
 1. Windows shall be located no less than 6 inches (150 mm) from interior surfaces of walls, floors, or roofs of manholes, but close enough to corners to facilitate racking of cables on walls.
 2. Window opening shall have cast-in-place, welded-wire fabric reinforcement for field cutting and bending to tie in to concrete envelopes of duct banks.

3. Window openings shall be framed with at least two additional No. 3 steel reinforcing bars in concrete around each opening.
- F. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.
- G. Ground Rod Sleeve: Provide a 3-inch (75-mm) PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.
- H. Joint Sealant: Asphaltic-butyl material with adhesion, cohesion, flexibility, and durability properties necessary to withstand maximum hydrostatic pressures at the installation location with the ground-water level at grade.

2.7 UTILITY STRUCTURE ACCESSORIES

- A. Manhole Frames, Covers, and Chimney Components: Comply with structural design loading specified for manhole.
 1. Frame and Cover: Weatherproof, gray cast iron complying with ASTM A 48/A 48M, Class 30B with milled cover-to-frame bearing surfaces; diameter, 29 inches (725 mm).
 - a. Cover Finish: Nonskid finish shall have a minimum coefficient of friction of 0.50.
 - b. Special Covers: Recess in face of cover designed to accept finish material in paved areas.
 2. Cover Legend: Cast in. Selected to suit system.
 - a. Legend: "ELECTRIC-LV" for duct systems with power wires and cables for systems operating at 600 V and less.
 - b. Legend: "ELECTRIC-HV" for duct systems with medium-voltage cables.
 3. Manhole Chimney Components: Precast concrete rings with dimensions matched to those of roof opening.
 - a. Mortar for Chimney Ring and Frame and Cover Joints: Comply with ASTM C 270, Type M, except for quantities less than 2.0 cu. ft. (60 L) where packaged mix complying with ASTM C 387, Type M, may be used.
- B. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.
- C. Pulling Eyes in Concrete Walls: Eyebolt with reinforcing-bar fastening insert, 2-inch- (50-mm-) diameter eye, and 1-by-4-inch (25-by-100-mm) bolt.
 1. Working Load Embedded in 6-Inch (150-mm), 4000-psi (27.6-MPa) Concrete: 13,000-lbf (58-kN) minimum tension.
- D. Pulling Eyes in Nonconcrete Walls: Eyebolt with reinforced fastening, 1-1/4-inch- (31-mm-) diameter eye, rated 2500-lbf (11-kN) minimum tension.

- E. Pulling-In and Lifting Irons in Concrete Floors: 7/8-inch- (22-mm-) diameter, hot-dip galvanized, bent steel rod; stress relieved after forming; and fastened to reinforcing rod. Exposed triangular opening.
 - 1. Ultimate Yield Strength: 40,000-lbf (180-kN) shear and 60,000-lbf (270-kN) tension.
- F. Bolting Inserts for Concrete Utility Structure Cable Racks and Other Attachments: Flared, threaded inserts of noncorrosive, chemical-resistant, nonconductive thermoplastic material; 1/2-inch (13-mm) ID by 2-3/4 inches (69 mm) deep, flared to 1-1/4 inches (31 mm) minimum at base.
 - 1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.
- G. Ground Rod Sleeve: 3-inch (75-mm), PVC conduit sleeve in manhole floors 2 inches (50 mm) from the wall adjacent to, but not underneath, the ducts routed from the facility.
- H. Expansion Anchors for Installation after Concrete Is Cast: Zinc-plated, carbon-steel-wedge type with stainless-steel expander clip with 1/2-inch (13-mm) bolt, 5300-lbf (24-kN) rated pullout strength, and minimum 6800-lbf (30-kN) rated shear strength.
- I. Duct-Sealing Compound: Nonhardening, safe for contact with human skin, not deleterious to cable insulation, and workable at temperatures as low as 35 deg F (2 deg C). Capable of withstanding temperature of 300 deg F (150 deg C) without slump and adhering to clean surfaces of plastic ducts, metallic conduits, conduit coatings, concrete, masonry, lead, cable sheaths, cable jackets, insulation materials, and common metals.

2.8 SOURCE QUALITY CONTROL

- A. Test and inspect precast concrete utility structures according to ASTM C 1037.
- B. Nonconcrete Handhole and Pull-Box Prototype Test: Test prototypes of boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.
 - 1. Strength tests of complete boxes and covers shall be by either an independent testing agency or manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.
 - 2. Testing machine pressure gages shall have current calibration certification, complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.1 PREPARATION

- A. Coordinate layout and installation of ducts, manholes, handholes, and boxes with final arrangement of other utilities, site grading, and surface features as determined in the field. Notify Architect if there is a conflict between areas of excavation and existing structures or archaeological sites to remain.

- B. Coordinate elevations of ducts and duct-bank entrances into manholes, handholes, and boxes with final locations and profiles of ducts and duct banks, as determined by coordination with other utilities, underground obstructions, and surface features. Revise locations and elevations as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.
- C. Clear and grub vegetation to be removed, and protect vegetation to remain according to Division 31. Remove and stockpile topsoil for reapplication according to Division 31.

3.2 UNDERGROUND DUCT APPLICATION

- A. Ducts for Electrical Cables More than 600 V: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank under paved areas and direct buried under non-paved areas unless otherwise indicated.
- B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA [**Type EPC-80**] [**Type EPC-40**] [**Type EB-20**]-PVC, in concrete-encased duct bank unless otherwise indicated.
- C. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-80 for emergency systems and Type EPC-40-PVC, for non-emergency systems in direct-buried duct bank unless otherwise indicated.
- D. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank unless otherwise indicated.
- E. Underground Ducts Crossing Paved Paths, Walks and Driveways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.3 UNDERGROUND ENCLOSURE APPLICATION

- A. Handholes and Boxes for 600 V and Less:
 - 1. Units in Roadways and Other Deliberate Traffic Paths: Precast concrete. AASHTO HB 17, H-20 structural load rating.
 - 2. Units in Driveway, Parking Lot, and Off-Roadway Locations, Subject to Occasional, Nondeliberate Loading by Heavy Vehicles: Polymer concrete, SCTE 77, Tier 15 structural load rating.
 - 3. Units in Sidewalk and Similar Applications with a Safety Factor for Nondeliberate Loading by Vehicles: Polymer concrete units, SCTE 77, Tier 8 structural load rating.
 - 4. Cover design load shall not exceed the design load of the handhole or box.
- B. Manholes: Precast concrete.
 - 1. Units Located in Roadways and Other Deliberate Traffic Paths by Heavy or Medium Vehicles: H-20 structural load rating according to AASHTO HB 17.
 - 2. Units Not Located in Deliberate Traffic Paths by Heavy or Medium Vehicles: H-10 load rating according to AASHTO HB 17.

3.4 EARTHWORK

- A. Excavation and Backfill: Comply with Division 31, but do not use heavy-duty, hydraulic-operated, compaction equipment.
- B. Restore surface features at areas disturbed by excavation, and re-establish original grades unless otherwise indicated. Replace removed sod immediately after backfilling is completed.
- C. Restore areas disturbed by trenching, storing of dirt, cable laying, and other work. Restore vegetation and include necessary topsoiling, fertilizing, liming, seeding, sodding, sprigging, and mulching. Comply with Division 32.
- D. Cut and patch existing pavement in the path of underground ducts and utility structures according to Division 01.

3.5 DUCT INSTALLATION

- A. Install ducts according to NEMA TCB 2.
- B. Slope: Pitch ducts a minimum slope of 1:300 down toward manholes and handholes and away from buildings and equipment. Slope ducts from a high point in runs between two manholes, to drain in both directions.
- C. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured standard sweep bends both horizontally and vertically, at other locations unless otherwise indicated.
- D. Joints: Use solvent-cemented joints in ducts and fittings and make watertight according to manufacturer's written instructions. Stagger couplings so those of adjacent ducts do not lie in same plane.
- E. Installation Adjacent to High-Temperature Steam Lines: Where duct banks are installed parallel to underground steam lines, perform calculations showing the duct bank will not be subject to environmental temperatures above 40 deg C. Where environmental temperatures are calculated to rise above 40 deg C, and anywhere the duct bank crosses above an underground steam line, install insulation blankets listed for direct burial to isolate the duct bank from the steam line.
- F. Duct Entrances to Manholes and Concrete and Polymer Concrete Handholes: Use end bells, spaced approximately 10 inches (250 mm) o.c. for 5-inch (125-mm) ducts, and vary proportionately for other duct sizes.
 - 1. Begin change from regular spacing to end-bell spacing 10 feet (3 m) from the end bell without reducing duct line slope and without forming a trap in the line.
 - 2. Direct-Buried Duct Banks: Install an expansion and deflection fitting in each conduit in the area of disturbed earth adjacent to manhole or handhole. Install an expansion fitting near the center of all straight line direct-buried duct banks with calculated expansion of more than 3/4 inch (19 mm).
 - 3. Grout end bells into structure walls from both sides to provide watertight entrances.

- G. Building Wall Penetrations: Make a transition from underground duct to rigid steel conduit at least **10 feet (3 m)** outside the building wall, without reducing duct line slope away from the building, and without forming a trap in the line. Use fittings manufactured for duct-to-conduit transition. Install conduit penetrations of building walls as specified in Section 260544 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."
- H. Sealing: Provide temporary closure at terminations of ducts that have cables pulled. Seal spare ducts at terminations. Use sealing compound and plugs to withstand at least **15-psig (1.03-MPa)** hydrostatic pressure.
- I. Pulling Cord: Install **100-lbf (445-N-)** test nylon cord in empty ducts.
- J. Concrete-Encased Ducts: Support ducts on duct separators.
1. Excavate trench bottom to provide firm and uniform support for duct bank. Prepare trench bottoms as specified in Division 31 for pipes less than **6 inches (150 mm)** in nominal diameter.
 2. Width: Excavate trench **3 inches (75 mm)** wider than duct bank on each side.
 3. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
 4. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than four spacers per **20 feet (6 m)** of duct. Secure separators to earth and to ducts to prevent floating during concreting. Stagger separators approximately **6 inches (150 mm)** between tiers. Tie entire assembly together using fabric straps; do not use tie wires or reinforcing steel that may form conductive or magnetic loops around ducts or duct groups.
 5. Elbows: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment, at building entrances through floor, and at changes of direction in duct run.
 - a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with **3 inches (75 mm)** of concrete.
 - b. Stub-Ups to Equipment: For fixtures and equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of **60 inches (1500 mm)** from edge of base. Install insulated grounding bushings on terminations at equipment.
 6. Reinforcement: Reinforce concrete-encased duct banks where they cross disturbed earth and where indicated. Arrange reinforcing rods and ties without forming conductive or magnetic loops around ducts or duct groups.
 7. Forms: Use walls of trench to form side walls of duct bank where soil is self-supporting and concrete envelope can be poured without soil inclusions; otherwise, use forms.
 8. Concrete Cover: Install a minimum of **3 inches (75 mm)** of concrete cover at top and bottom, and a minimum of **2 inches (50 mm)** on each side of duct bank.
 9. Concreting Sequence: Pour each run of envelope between manholes or other terminations in one continuous operation.
 - a. Start at one end and finish at the other, allowing for expansion and contraction of ducts as their temperature changes during and after the pour. Use expansion fittings installed according to manufacturer's written recommendations, or use other specific measures to prevent expansion-contraction damage.

3.6 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

- A. Precast Concrete Handhole and Manhole Installation:
1. Comply with ASTM C 891 unless otherwise indicated.
 2. Install units level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances.
 3. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1-inch (25-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
- B. Elevations:
1. Manhole Roof: Install with rooftop at least **15 inches (375 mm)** below finished grade.
 2. Manhole Frame: In paved areas and trafficways, set frames flush with finished grade. Set other manhole frames **1 inch (25 mm)** above finished grade.
 3. Install handholes with bottom below frost line.
 4. Handhole Covers: In paved areas and trafficways, set surface flush with finished grade. Set covers of other handholes **1 inch (25 mm)** above finished grade.
 5. Where indicated, cast handhole cover frame integrally with handhole structure.
- C. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.
- D. Manhole Access: Circular opening in manhole roof; sized to match cover size.
1. Install chimney, constructed of precast concrete collars and rings, to support cast-iron frame to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for frame to chimney.
- E. Waterproofing: Apply waterproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Waterproofing materials and installation are specified in Division 07. After ducts have been connected and grouted, and before backfilling, waterproof joints and connections, and touch up abrasions and scars. Waterproof exterior of manhole chimneys after mortar has cured at least three days.
- F. Dampproofing: Apply dampproofing to exterior surfaces of manholes and handholes after concrete has cured at least three days. Dampproofing materials and installation are specified in Division 07. After ducts are connected and grouted, and before backfilling, dampproof joints and connections, and touch up abrasions and scars. Dampproof exterior of manhole chimneys after mortar has cured at least three days.
- G. Hardware: Install removable hardware, including pulling eyes and cable stanchions as required for installation and support of cables and conductors and as indicated.
- H. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than **3-7/8 inches (97 mm)** for manholes and **2 inches (50 mm)** for handholes, for anchor bolts installed in the field. Use a minimum of two anchors for each cable stanchion.

3.7 INSTALLATION OF HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

- A. Install handholes and boxes level and plumb and with orientation and depth coordinated with connecting ducts, to minimize bends and deflections required for proper entrances. Use box extension if required to match depths of ducts, and seal joint between box and extension as recommended by manufacturer.
- B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from **1/2-inch (12.5-mm)** sieve to **No. 4 (4.75-mm)** sieve and compacted to same density as adjacent undisturbed earth.
- C. Elevation: In paved areas and trafficways, set cover flush with finished grade. Set covers of other handholes **1 inch (25 mm)** above finished grade.
- D. Install handholes and boxes with bottom below frost line.
- E. Install removable hardware, including pulling eyes, cable stanchions, cable arms, and insulators, as required for installation and support of cables and conductors and as indicated. Select arm lengths to be long enough to provide spare space for future cables, but short enough to preserve adequate working clearances in enclosure.
- F. Field cut openings for ducts and conduits according to enclosure manufacturer's written instructions. Cut wall of enclosure with a tool designed for material to be cut. Size holes for terminating fittings to be used, and seal around penetrations after fittings are installed.
- G. For enclosures installed in asphalt paving and subject to occasional, nondeliberate, heavy-vehicle loading, provide structural protection as recommended by handhole or box manufacturer.

3.8 GROUNDING

- A. Ground underground ducts and utility structures according to Section 260526 "Grounding and Bonding for Electrical Systems."

3.9 FIELD QUALITY CONTROL

- A. Perform the following tests and inspections and prepare test reports:
 - 1. Demonstrate capability and compliance with requirements on completion of installation of underground ducts and utility structures.
 - 2. Pull solid aluminum or wood test mandrel through duct to prove joint integrity and adequate bend radii, and test for out-of-round duct. Provide a minimum **6-inch- (150-mm-)** long mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
 - 3. Test manhole and handhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 260526 "Grounding and Bonding for Electrical Systems."
- B. Correct deficiencies and retest as specified above to demonstrate compliance.

3.10 CLEANING

- A. Pull leather-washer-type duct cleaner, with graduated washer sizes, through full length of ducts. Follow with rubber duct swab for final cleaning and to assist in spreading lubricant throughout ducts.
- B. Clean internal surfaces of manholes, including sump. Remove foreign material.

END OF SECTION 260543

SECTION 260544 - SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

A. Section Includes:

1. Sleeves for raceway and cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

B. Related Requirements:

1. Division 07 for penetration firestopping installed in fire-resistance-rated walls, horizontal assemblies, and smoke barriers, with and without penetrating items.

1.3 ACTION SUBMITTALS

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

PART 2 - PRODUCTS

2.1 SLEEVES

A. Wall Sleeves:

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

- B. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies: Galvanized-steel sheet; 0.0239-inch (0.6-mm) minimum thickness; round tube closed with welded longitudinal joint, with tabs for screw-fastening the sleeve to the board.

C. Sleeves for Rectangular Openings:

1. Material: Galvanized sheet steel.
2. Minimum Metal Thickness:
 - a. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and with no side larger than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
 - b. For sleeve cross-section rectangle perimeter 50 inches (1270 mm) or more and one or more sides larger than 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

2.2 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Subject to compliance with requirements, provide a product by one of the following or approved equal:
 - a. Advance Products & Systems, Inc.
 - b. CALPICO, Inc.
 - c. Metraflex Company (The).
 - d. Pipeline Seal and Insulator, Inc.
 - e. Proco Products, Inc.
2. Sealing Elements: EPDM rubber interlocking links shaped to fit surface of pipe. Include type and number required for pipe material and size of pipe.
3. Pressure Plates: Carbon steel
4. Connecting Bolts and Nuts: Carbon steel, with corrosion-resistant coating of length required to secure pressure plates to sealing elements.

2.3 SLEEVE-SEAL FITTINGS

A. Description: Manufactured plastic, sleeve-type, waterstop assembly made for embedding in concrete slab or wall. Unit shall have plastic or rubber waterstop collar with center opening to match piping OD.

2.4 GROUT

- A. Description: Nonshrink; recommended for interior and exterior sealing openings in non-fire-rated walls or floors.
- B. Standard: ASTM C 1107/C 1107M, Grade B, post-hardening and volume-adjusting, dry, hydraulic-cement grout.
- C. Design Mix: 5000-psi (34.5-MPa), 28-day compressive strength.

- D. Packaging: Premixed and factory packaged.

2.5 SILICONE SEALANTS

- A. Silicone Sealants: Single-component, silicone-based, neutral-curing elastomeric sealants of grade indicated below.
1. Grade: Pourable (self-leveling) formulation for openings in floors and other horizontal surfaces that are not fire rated.
 2. Sealant shall comply with the testing and product requirements of the California Department of Health Services' "Standard Practice for the Testing of Volatile Organic Emissions from Various Sources Using Small-Scale Environmental Chambers."
- B. Silicone Foams: Multicomponent, silicone-based liquid elastomers that, when mixed, expand and cure in place to produce a flexible, nonshrinking foam.

PART 3 - EXECUTION

3.1 SLEEVE INSTALLATION FOR NON-FIRE-RATED ELECTRICAL PENETRATIONS

- A. Comply with NECA 1.
- B. Comply with NEMA VE 2 for cable tray and cable penetrations.
- C. Sleeves for Conduits Penetrating Above-Grade Non-Fire-Rated Concrete and Masonry-Unit Floors and Walls:
1. Interior Penetrations of Non-Fire-Rated Walls and Floors:
 - a. Seal annular space between sleeve and raceway or cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07 Section "Joint Sealants."
 - b. Seal space outside of sleeves with mortar or grout. Pack sealing material solidly between sleeve and wall so no voids remain. Tool exposed surfaces smooth; protect material while curing.
 2. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.
 3. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway or cable unless sleeve seal is to be installed or unless seismic criteria require different clearance.
 4. Install sleeves for wall penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of walls. Cut sleeves to length for mounting flush with both surfaces of walls. Deburr after cutting.
 5. Install sleeves for floor penetrations. Extend sleeves installed in floors 2 inches (50 mm) above finished floor level. Install sleeves during erection of floors.

- D. Sleeves for Conduits Penetrating Non-Fire-Rated Gypsum Board Assemblies:
 - 1. Use circular metal sleeves unless penetration arrangement requires rectangular sleeved opening.
 - 2. Seal space outside of sleeves with approved joint compound for gypsum board assemblies.
- E. Roof-Penetration Sleeves: Seal penetration of individual raceways and cables with flexible boot-type flashing units applied in coordination with roofing work.
- F. Aboveground, Exterior-Wall Penetrations: Seal penetrations using 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.

3.2 SLEEVE-SEAL-SYSTEM INSTALLATION

- A. Install sleeve-seal systems in sleeves in exterior concrete walls and slabs-on-grade at raceway entries into building.
- B. Install type and number of sealing elements recommended by manufacturer for raceway or cable material and size. Position raceway or cable in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway or cable and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.3 SLEEVE-SEAL-FITTING INSTALLATION

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

END OF SECTION 260544

SECTION 260548 - VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:

1. Isolation pads.
2. Spring isolators.
3. Restrained spring isolators.
4. Channel support systems.
5. Restraint cables.
6. Hanger rod stiffeners.
7. Anchorage bushings and washers.

- B. Related Sections include the following:

1. Section 260529 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.3 DEFINITIONS

- A. The IBC: International Building Code.
- B. ICC-ES: ICC-Evaluation Service.

1.4 PERFORMANCE REQUIREMENTS

- A. Building Code

1. Maine Uniform Building And Energy Code
2. International Building Code, 2009 Edition
3. International Existing Building Code, 2009 Edition
4. ASCE 7-05 Minimum Design Loads For Buildings And Other Structures

- B. Wind-Restraint Loading (outdoor equipment):

1. Basic Wind Speed: See Structural drawings.
2. Wind Load Importance Factor (Iw): See Structural drawings.

3. Wind Exposure: See Structural drawings.
4. Internal Pressure Coefficient: See Structural drawings.

C. Design Seismic Loading:

1. Equivalent Lateral Force Procedure
2. Seismic Use Group: See Structural drawings.
3. Seismic Importance Factor (I_e): See Structural drawings.
4. Mapped Spectral Response Accelerations:
 - a. S_s : See Structural drawings.
 - b. S_1 : See Structural drawings.
5. Seismic Site Class: C
6. Spectral Response Coefficients:
 - a. S_d : See Structural drawings.
 - b. S_{d1} : See Structural drawings.
7. Seismic Design Category: See Structural drawings.
8. Importance Factor (I_p): A factor assigned to each structure according to its occupancy category as prescribed in Section 11.5.1 of ASCE/SEI 7-05. The following components are $I_p = 1.5$:
 - a. Fire alarm system

1.5 ACTION SUBMITTALS

A. Product Data: For the following:

1. Include rated load, rated deflection, and overload capacity for each vibration isolation device.
2. Illustrate and indicate style, material, strength, fastening provision, and finish for each type and size of seismic-restraint component used.
 - a. Tabulate types and sizes of seismic restraints, complete with report numbers and rated strength in tension and shear as evaluated by an agency acceptable to authorities having jurisdiction.
 - b. Annotate to indicate application of each product submitted and compliance with requirements.
3. Restrained-Isolation Devices: Include ratings for horizontal, vertical, and combined loads.

B. Delegated-Design Submittal: For vibration isolation and seismic-restraint details indicated to comply with performance requirements and design criteria, including analysis data signed and sealed by the qualified professional engineer responsible for their preparation.

1. Design Calculations: Calculate static and dynamic loading due to equipment weight and operation, seismic forces required to select vibration isolators and seismic restraints.

- a. Coordinate design calculations with wind-load calculations required for equipment mounted outdoors. Comply with requirements in other electrical Sections for equipment mounted outdoors.
2. Indicate materials and dimensions and identify hardware, including attachment and anchorage devices.
3. Field-fabricated supports.
4. Seismic-Restraint Details:
 - a. Design Analysis: To support selection and arrangement of seismic restraints. Include calculations of combined tensile and shear loads.
 - b. Details: Indicate fabrication and arrangement. Detail attachments of restraints to the restrained items and to the structure. Show attachment locations, methods, and spacings. Identify components, list their strengths, and indicate directions and values of forces transmitted to the structure during seismic events. Indicate association with vibration isolation devices.
 - c. Preapproval and Evaluation Documentation: By an agency acceptable to authorities having jurisdiction, showing maximum ratings of restraint items and the basis for approval (tests or calculations).

1.6 INFORMATIONAL SUBMITTALS

- A. Coordination Drawings: Show coordination of seismic bracing for electrical components with other systems and equipment in the vicinity, including other supports and seismic restraints.
- B. Qualification Data: For professional engineer.
- C. Welding certificates.
- D. Field quality-control test reports.

1.7 QUALITY ASSURANCE

- A. Comply with seismic-restraint requirements in the IBC unless requirements in this Section are more stringent.
- B. Welding: Qualify procedures and personnel according to AWS D1.1/D1.1M, "Structural Welding Code - Steel."
- C. Seismic-restraint devices shall have horizontal and vertical load testing and analysis and shall bear anchorage preapproval OPA number from OSHPD, preapproval by ICC-ES, or preapproval by another agency acceptable to authorities having jurisdiction, showing maximum seismic-restraint ratings. Ratings based on independent testing are preferred to ratings based on calculations. If preapproved ratings are not available, submittals based on independent testing are preferred. Calculations (including combining shear and tensile loads) to support seismic-restraint designs must be signed and sealed by a qualified professional engineer.
- D. Comply with NFPA 70.

PART 2 - PRODUCTS

2.1 VIBRATION ISOLATORS

- 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. [Ace Mountings Co., Inc.](#)
 2. [Amber/Booth Company, Inc.](#)
 3. [California Dynamics Corporation.](#)
 4. [Isolation Technology, Inc.](#)
 5. [Kinetics Noise Control.](#)
 6. [Mason Industries.](#)
 7. [Vibration Eliminator Co., Inc.](#)
 8. [Vibration Isolation.](#)
 9. [Vibration Mountings & Controls, Inc.](#)
- B. Pads: Arrange in single or multiple layers of sufficient stiffness for uniform loading over pad area, molded with a nonslip pattern and galvanized-steel baseplates, and factory cut to sizes that match requirements of supported equipment.
1. Resilient Material: Oil- and water-resistant neoprene, rubber, or hermetically sealed compressed fiberglass.
- C. Spring Isolators: Freestanding, laterally stable, open-spring isolators.
1. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 2. Minimum Additional Travel: 50 percent of the required deflection at rated load.
 3. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
 4. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
 5. Baseplates: Factory drilled for bolting to structure and bonded to **1/4-inch- (6-mm-)** thick, rubber isolator pad attached to baseplate underside. Baseplates shall limit floor load to **500 psig (3447 kPa)**.
 6. Top Plate and Adjustment Bolt: Threaded top plate with adjustment bolt and cap screw to fasten and level equipment.
- D. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic or limit-stop restraint.
1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to weight being removed; factory-drilled baseplate bonded to **1/4-inch- (6-mm-)** thick, neoprene or rubber isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
 2. Restraint: Seismic or limit-stop as required for equipment and authorities having jurisdiction.
 3. Outside Spring Diameter: Not less than 80 percent of the compressed height of the spring at rated load.
 4. Minimum Additional Travel: 50 percent of the required deflection at rated load.

5. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
6. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.

2.2 SEISMIC-RESTRAINT DEVICES

- 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. [Amber/Booth Company, Inc.](#)
 2. [California Dynamics Corporation.](#)
 3. [Cooper B-Line, Inc.; a division of Cooper Industries.](#)
 4. [Hilti Inc.](#)
 5. [Loos & Co.; Seismic Earthquake Division.](#)
 6. [Mason Industries.](#)
 7. [TOLCO Incorporated; a brand of NIBCO INC.](#)
 8. [Unistrut; Tyco International, Ltd.](#)
- B. General Requirements for Restraint Components: Rated strengths, features, and application requirements shall be as defined in reports by an agency acceptable to authorities having jurisdiction.
 1. Structural Safety Factor: Allowable strength in tension, shear, and pullout force of components shall be at least four times the maximum seismic forces to which they will be subjected.
- C. Channel Support System: MFMA-3, shop- or field-fabricated support assembly made of slotted steel channels with accessories for attachment to braced component at one end and to building structure at the other end and other matching components and with corrosion-resistant coating; and rated in tension, compression, and torsion forces.
- D. Restraint Cables: ASTM A 603 galvanized-steel cables with end connections made of steel assemblies with thimbles, brackets, swivels, and bolts designed for restraining cable service; and with a minimum of two clamping bolts for cable engagement.
- E. Hanger Rod Stiffener: Steel tube or steel slotted-support-system sleeve with internally bolted connections or Reinforcing steel angle clamped to hanger rod. Do not weld stiffeners to rods.
- F. Bushings for Floor-Mounted Equipment Anchor: Neoprene bushings designed for rigid equipment mountings, and matched to type and size of anchors and studs.
- G. Bushing Assemblies for Wall-Mounted Equipment Anchorage: Assemblies of neoprene elements and steel sleeves designed for rigid equipment mountings, and matched to type and size of attachment devices.
- H. Resilient Isolation Washers and Bushings: One-piece, molded, oil- and water-resistant neoprene, with a flat washer face.
- I. Mechanical Anchor: Drilled-in and stud-wedge or female-wedge type in zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchors with strength

required for anchor and as tested according to ASTM E 488. Minimum length of eight times diameter.

- J. Adhesive Anchor: Drilled-in and capsule anchor system containing polyvinyl or urethane methacrylate-based resin and accelerator, or injected polymer or hybrid mortar adhesive. Provide anchor bolts and hardware with zinc-coated steel for interior applications and stainless steel for exterior applications. Select anchor bolts with strength required for anchor and as tested according to ASTM E 488.

2.3 FACTORY FINISHES

- A. Finish: Manufacturer's standard paint applied to factory-assembled and -tested equipment before shipping.
 - 1. Powder coating on springs and housings.
 - 2. All hardware shall be galvanized. Hot-dip galvanize metal components for exterior use.
 - 3. Baked enamel or powder coat for metal components on isolators for interior use.
 - 4. Color-code or otherwise mark vibration isolation and seismic-control devices to indicate capacity range.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and equipment to receive vibration isolation and seismic-control devices for compliance with requirements for installation tolerances and other conditions affecting performance.
- B. Examine roughing-in of reinforcement and cast-in-place anchors to verify actual locations before installation.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 APPLICATIONS

- A. Multiple Raceways or Cables: Secure raceways and cables to trapeze member with clamps approved for application by an agency acceptable to authorities having jurisdiction.
- B. Strength of Support and Seismic-Restraint Assemblies: Select sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.3 SEISMIC-RESTRAINT DEVICE INSTALLATION

A. Equipment and Hanger Restraints:

1. Install restrained isolators on electrical equipment where specified in other Division 26 sections.
2. Install resilient, bolt-isolation washers on equipment anchor bolts where clearance between anchor and adjacent surface exceeds **0.125 inch (3.2 mm)**.
3. Install seismic-restraint devices using methods approved by an agency acceptable to authorities having jurisdiction providing required submittals for component.

B. Install bushing assemblies for mounting bolts for wall-mounted equipment, arranged to provide resilient media where equipment or equipment-mounting channels are attached to wall.

C. Attachment to Structure: If specific attachment is not indicated, anchor bracing to structure at flanges of beams, at upper truss chords of bar joists, or at concrete members.

D. Drilled-in Anchors:

1. Identify position of reinforcing steel and other embedded items prior to drilling holes for anchors. Do not damage existing reinforcing or embedded items during coring or drilling. Notify the structural engineer if reinforcing steel or other embedded items are encountered during drilling. Locate and avoid prestressed tendons, electrical and telecommunications conduit, and gas lines.
2. Do not drill holes in concrete or masonry until concrete, mortar, or grout has achieved full design strength.
3. Wedge Anchors: Protect threads from damage during anchor installation. Heavy-duty sleeve anchors shall be installed with sleeve fully engaged in the structural element to which anchor is to be fastened.
4. Adhesive Anchors: Clean holes to remove loose material and drilling dust prior to installation of adhesive. Place adhesive in holes proceeding from the bottom of the hole and progressing toward the surface in such a manner as to avoid introduction of air pockets in the adhesive.
5. Set anchors to manufacturer's recommended torque, using a torque wrench.
6. Install zinc-coated steel anchors for interior and stainless-steel anchors for exterior applications.

3.4 ACCOMMODATION OF DIFFERENTIAL SEISMIC MOTION

- #### A. Install flexible connections in runs of raceways, cables, wireways, cable trays, and busways where they cross seismic joints, where adjacent sections or branches are supported by different structural elements, and where they terminate with connection to equipment that is anchored to a different structural element from the one supporting them as they approach equipment.

3.5 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Tests and Inspections:
 - 1. Provide evidence of recent calibration of test equipment by a testing agency acceptable to authorities having jurisdiction.
 - 2. Schedule test with Owner, through Architect, before connecting anchorage device to restrained component (unless postconnection testing has been approved), and with at least seven days' advance notice.
 - 3. Obtain Architect's approval before transmitting test loads to structure. Provide temporary load-spreading members.
 - 4. Test at least four of each type and size of installed anchors and fasteners selected by Architect.
 - 5. Test to 90 percent of rated proof load of device.
 - 6. Measure isolator restraint clearance.
 - 7. Measure isolator deflection.
 - 8. Verify snubber minimum clearances.
 - 9. If a device fails test, modify all installations of same type and retest until satisfactory results are achieved.
- C. Remove and replace malfunctioning units and retest as specified above.
- D. Prepare test and inspection reports.

3.6 ADJUSTING

- A. Adjust isolators after isolated equipment is at operating weight.
- B. Adjust limit stops on restrained spring isolators to mount equipment at normal operating height. After equipment installation is complete, adjust limit stops so they are out of contact during normal operation.
- C. Adjust active height of spring isolators.
- D. Adjust restraints to permit free movement of equipment within normal mode of operation.

END OF SECTION 260548

SECTION 260553 - IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Identification for conductors.
 - 2. Warning labels and signs.
 - 3. Instruction signs.
 - 4. Equipment identification labels.
 - 5. Miscellaneous identification products.

1.3 SUBMITTALS

- A. Product Data: For each electrical identification product indicated.

1.4 QUALITY ASSURANCE

- A. Comply with ANSI A13.1 and IEEE C2.
- B. Comply with NFPA 70.
- C. Comply with 29 CFR 1910.144 and 29 CFR 1910.145.
- D. Comply with ANSI Z535.4 for safety signs and labels.
- E. Adhesive-attached labeling materials, including label stocks, laminating adhesives, and inks used by label printers, shall comply with UL 969.

1.5 COORDINATION

- A. Coordinate identification names, abbreviations, colors, and other features with requirements in other Sections requiring identification applications, Drawings, 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

2.1 CONDUCTOR 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. Self-Adhesive Vinyl Labels: Preprinted, flexible label laminated with a clear, weather- and chemical-resistant coating and matching wraparound adhesive tape for securing ends of legend label.

2.2 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.

2.3 INSTRUCTION SIGNS

- A. Engraved, laminated acrylic or melamine plastic, minimum 1/16 inch (1.6 mm) thick for signs up to 20 sq. inches (129 sq. cm) and 1/8 inch (3.2 mm) thick for larger sizes.
 - 1. Engraved legend with black letters on white face.
 - 2. Punched or drilled for mechanical fasteners.
 - 3. Framed with mitered acrylic molding and arranged for attachment at applicable equipment.

2.4 EQUIPMENT IDENTIFICATION LABELS

- A. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).
- B. Stenciled Legend for outdoor installations: In nonfading, waterproof, black ink or paint. Minimum letter height shall be 1 inch (25 mm).

2.5 CABLE TIES

- A. General-Purpose Cable Ties: Fungus inert, self extinguishing, one piece, self locking, Type 6/6 nylon.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 12,000 psi (82.7 MPa).
 - 3. Temperature Range: Minus 40 to plus 185 deg F (Minus 40 to plus 85 deg C).
 - 4. Color: Black except where used for color-coding.

- B. Plenum-Rated Cable Ties: Self extinguishing, UV stabilized, one piece, self locking.
 - 1. Minimum Width: 3/16 inch (5 mm).
 - 2. Tensile Strength at 73 deg F (23 deg C), According to ASTM D 638: 7000 psi (48.2 MPa).
 - 3. UL 94 Flame Rating: 94V-0.
 - 4. Temperature Range: Minus 50 to plus 284 deg F (Minus 46 to plus 140 deg C).
 - 5. Color: Black.

2.6 MISCELLANEOUS IDENTIFICATION PRODUCTS

- A. Paint: Comply with requirements in Division 09 painting Sections for paint materials and application requirements. Select paint system applicable for surface material and location (exterior or interior).

- B. Fasteners for Labels and Signs: Self-tapping, stainless-steel screws or stainless-steel machine screws with nuts and flat and lock washers.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. 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. System Identification Color-Coding Bands for Raceways and Cables: Each color-coding 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.

- E. Aluminum Wraparound Marker Labels and Metal Tags: Secure tight to surface of conductor or cable at a location with high visibility and accessibility.
- F. Cable Ties: For attaching tags. Use general-purpose type, except as listed below:
 - 1. Outdoors: UV-stabilized nylon.
 - 2. In Spaces Handling Environmental Air: Plenum rated.
- G. Painted Identification: Comply with requirements in Division 09 painting Sections for surface preparation and paint application.

3.2 IDENTIFICATION SCHEDULE

- A. Power-Circuit Conductor Identification, 600 V or Less: For conductors in vaults, pull and junction boxes, manholes, and handholes, use color-coding conductor tape to identify the phase.
 - 1. Color-Coding for Phasem Identification, 600 V or Less: Use colors listed below for ungrounded conductors.
 - a. Color shall be factory applied.
 - b. Colors for 208/120-V Circuits:
 - 1) Phase A: Black.
 - 2) Phase B: Red.
 - 3) Phase C: Blue.
- B. Warning Labels for Indoor Cabinets, Boxes, and Enclosures for Power and Lighting: Self-adhesive warning labels
 - 1. Comply with 29 CFR 1910.145.
 - 2. Identify system voltage with black letters on an orange background.
 - 3. Apply to exterior of door, cover, or other access.
 - 4. For equipment with multiple power or control sources, apply to door or cover of equipment including, but not limited to, the following:
 - a. Power transfer switches.
 - b. Controls with external control power connections.
 - 5. Equipment to Be Labeled:
 - 6. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be engraved melamine label
 - a. Enclosures and electrical cabinets.
 - b. Access doors and panels for concealed electrical items.
 - c. Emergency system boxes and enclosures.
 - d. Enclosed switches and enclosed circuit breakers.
 - e. Enclosed controllers.
 - f. Variable-speed controllers.
 - g. Push-button stations.

- h. Power transfer equipment.
- i. Contactors, Remote-controlled switches, dimmer modules, and control devices.

END OF SECTION 260553

SECTION 260923 - LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

- 1. Standalone daylight-harvesting switching controls.
- 2. Indoor occupancy sensors.

- B. Related Requirements:

- 1. Section 262726 "Wiring Devices" for wall-box dimmers, wall-switch occupancy sensors, and manual light switches.

1.3 ACTION SUBMITTALS

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

- B. Shop Drawings: Show installation details for occupancy and light-level sensors.

- 1. Interconnection diagrams showing field-installed wiring.
- 2. Include diagrams for power, signal, and control wiring.

1.4 INFORMATIONAL SUBMITTALS

- A. Field quality-control reports.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For each type of lighting control device to include in emergency, operation, and maintenance manuals.

PART 2 - PRODUCTS

2.1 DAYLIGHT-HARVESTING DIMMING CONTROLS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. [Hubbell Building Automation, Inc.](#) – Basis of Design
 2. [Cooper Industries, Inc.](#)
 3. [Leviton Manufacturing Co., Inc.](#)
 4. [Lithonia Lighting; Acuity Brands Lighting, Inc.](#)
- B. System Description: Sensing daylight levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.
1. Lighting control set point is based on two lighting conditions:
 - a. When no daylight is present (target level).
 - b. When significant daylight is present.
- C. Ceiling-Mounted Dimming Controls: Solid-state, light-level sensor unit, with separate controller unit, to detect changes in lighting levels that are perceived by the eye.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Sensor Output: 0- to 10-V dc to operate electronic dimming drivers. Sensor is powered by controller unit.
 3. Power Pack: Sensor has 24-V dc, Class 2 power source, as defined by NFPA 70.

2.2 INDOOR OCCUPANCY SENSORS

- A. **Manufacturers:** Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to the following:
1. [Hubbell Building Automation, Inc.](#) – Basis of Design
 2. [Cooper Industries, Inc.](#)
 3. [Leviton Manufacturing Co., Inc.](#)
 4. [Lithonia Lighting; Acuity Brands Lighting, Inc.](#)
 5. [Philips Lighting Controls.](#)
 6. [Sensor Switch, Inc.](#)
- B. General Requirements for Sensors: Wall- or ceiling-mounted, solid-state indoor occupancy sensors with a separate power pack.
1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
 2. Operation: Unless otherwise indicated, turn lights on when coverage area is occupied, and turn them off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.

3. Sensor Output: Contacts rated to operate the connected relay, complying with UL 773A. Sensor is powered from the power pack.
 4. Power Pack: 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. Sensor has 24-V dc, 150-mA, Class 2 power source, as defined by NFPA 70.
 5. 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.
 6. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
 7. Bypass Switch: Override the "on" function in case of sensor failure.
 8. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.
- C. Dual-Technology Type: Ceiling mounted; detect occupants in coverage area using PIR and ultrasonic detection methods. The particular technology or combination of technologies that control on-off functions is selectable in the field by operating controls on unit.
1. 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.

2.3 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 260519 "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 Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cable: Multiconductor cable with stranded-copper conductors not smaller than No. 14 AWG. Comply with requirements in Section 260519 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.1 SENSOR INSTALLATION

- 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 systems, and partition assemblies.
- B. Install and aim sensors in locations to achieve not less than 90 percent coverage of areas indicated. Do not exceed coverage limits specified in manufacturer's written instructions.

3.2 WIRING INSTALLATION

- A. Wiring Method: Comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is **1/2 inch (13 mm)**.
- B. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-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.

3.3 IDENTIFICATION

- A. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."
 - 1. Identify controlled circuits in lighting contactors.
 - 2. Identify circuits and luminaires controlled by photoelectric and occupancy sensors at daylight harvesting controller.

3.4 FIELD QUALITY CONTROL

- A. Manufacturer's Field Service: For daylight harvesting controls, Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.
- B. Perform the following tests and inspections.
 - 1. Operational Test: After installing switches and sensors, and after electrical circuitry has been energized, start units to confirm proper unit operation.
 - 2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Lighting control devices will be considered defective if they do not pass tests and inspections.

- D. Prepare test and inspection reports.

3.5 ADJUSTING

- A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting sensors to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.
 - 1. For occupancy and motion sensors, verify operation at outer limits of detector range. Set time delay to suit Owner's operations.
 - 2. For daylighting controls, adjust set points and deadband controls to suit Owner's operations.

3.6 DEMONSTRATION

- A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 260943.13 "Addressable-Fixture Lighting Controls" and Section 260943.23 "Relay-Based Lighting Controls."
- B. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION 260923

SECTION 260943 - NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes manually operated lighting controls with relays, time clock, photocell control, external source relays and control module.
- B. Related Sections:
 - 1. Section 260923 "Lighting Control Devices" for photoelectric sensors, occupancy sensors, and multipole contactors.

1.3 MANDATORY PROGRAMMING MEETING

- 1.4 Lighting control system programming shall be mapped out at a meeting between the owner, engineer, and contractor. This meeting shall be scheduled by the Contractor and shall be completed before product is ordered. Action Submittals for this section shall not be returned to the Contractor before this meeting is completed.

1.5 DEFINITIONS

- A. BACnet: A networking communication protocol that complies with ASHRAE 135.
- B. BAS: Building automation system.
- C. LonWorks: A control network technology platform for designing and implementing interoperable control devices and networks.
- D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control, signaling and power-limited circuits.
- E. 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.
- F. PC: Personal computer; sometimes plural as "PCs."

- G. Power Line Carrier: Use of radio-frequency energy to transmit information over transmission lines whose primary purpose is the transmission of power.
- H. RS-485: A serial network protocol, similar to RS-232, complying with TIA-485-A.
- I. UTP: Unshielded twisted pair.

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for control modules, power distribution components, manual switches and plates, and conductors and cables.
- B. Shop Drawings: Include plans, elevations, sections, details, and attachments to other work.
 - 1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
 - 2. Outline Drawings: Indicate dimensions, weights, arrangement of components, and clearance and access requirements.
 - 3. 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.
 - 4. Wiring Diagrams: For power, signal, and control wiring. Coordinate nomenclature and presentation with a block diagram.

1.7 INFORMATIONAL SUBMITTALS

- A. 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.
- B. Field quality-control reports.
- C. Software licenses and upgrades required by and installed for operation and programming of digital and analog devices.
- D. Warranty: Sample of special warranty.

1.8 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For lighting controls to include in emergency, operation, and maintenance manuals.
- B. 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.

1.9 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, by a qualified testing agency, and marked for intended location and application.
- C. Comply with 47 CFR, Subparts A and B, for Class A digital devices.
- D. Comply with NFPA 70.

1.10 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.
- B. Coordinate lighting control components specified in this Section with components specified in Section 262416 "Panelboards."

1.11 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.

3. Extended Warranty Period Failure Due to Transient Voltage Surges: five years.
4. Extended Warranty Period for Electrically Held Relays: 10 years from date of Substantial Completion.

1.12 SOFTWARE SERVICE AGREEMENT

- A. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of the software.
 1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. **Basis-of-Design Product:** Subject to compliance with requirements, provide Hubbell LX series or comparable product by one of the following:
 1. Acuity Brands Lighting, Inc.; Lithonia Lighting brand.
 2. Cooper Controls
 3. Leviton Mfg. Company Inc.
 4. Lighting Control & Design, Inc.
 5. Lightolier Controls; a division of Genlyte Group, LLC.
 6. Lutron Electronics Co., Inc.
 7. Wattstopper, project-specific custom solution.

2.2 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. 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 network-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.

2.3 CONTROL MODULE

- A. Control Module Description: Comply with UL 508 (CAN/CSA C22.2, No. 14); microprocessor-based, networked, control unit; mounted in preassembled, modular relay panel. Low-voltage-controlled, latching-type, single-pole lighting circuit relays shall be prime output circuit devices. Where indicated, a limited number of digital or analog, low-voltage control-circuit outputs shall be supported by control unit and circuit boards associated with relays. Control units shall be capable of receiving inputs from sensors and other sources. Line-voltage components and wiring shall be separated from low-voltage components and wiring by barriers. Control module shall be locally programmable.

2.4 POWER DISTRIBUTION COMPONENTS

- A. Modular Relay Panel: Comply with UL 508, UL 916, and UL 924; 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 or field-mounting surge suppressors that comply with Section 264313 "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for Category A locations.

2.5 MANUAL ANALOG SWITCHES AND PLATES

- A. Push-Button or key-operated type switches as indicated on the drawings: Modular, momentary-contact, low-voltage type.
 - 1. Match color specified in Section 262726 "Wiring Devices."
 - 2. Integral green LED pilot light to indicate when circuit is on.
 - 3. Where key operated switches are indicated, the Owner shall have the option of choosing, at the mandatory programming meeting, push-button switches that are programmed to be inoperative during school hours.

- B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 262726 "Wiring Devices."
- C. Wall Plates: Single and multigang plates as specified in Section 262726 "Wiring Devices."
- D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.6 FIELD-MOUNTED DIGITAL CONTROLS AND PLATES

- A. Connection Type: RS-485 protocol, category 5e UTP cable, using RJ45 connectors. Power shall be from the control unit.
- B. Pushbutton Switches: Modular, solid-state, programmable, digital, momentary contact, designed to connect to a microprocessor based control unit as a manual control source.
 - 1. Mounting: Standard single-gang recessed switchbox, using device plates specified in Section 262726 "Wiring Devices."
 - 2. Multi-Gang Mounting: One to six pushbuttons per gang.

2.7 CONDUCTORS AND CABLES

- A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- B. Classes 2 and 3 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 18 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- C. Class 1 Control Cables: Stranded copper, complying with UL 83, multiconductor cable with copper conductors not smaller than No. 14 AWG, complying with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
- D. Structured Network Digital and Multiplexed Signal Cables: UTP cable with copper conductors, complying with TIA/EIA-568-B.2, Category 5e for horizontal copper cable and with Section 267400 "Telecommunications."
- E. RS-485 Cables:
 - 1. Standard Cable: NFPA 70, Type CMR.
 - a. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - b. PVC insulation.
 - c. Unshielded.
 - d. PVC jacket.
 - e. Flame Resistance: Comply with UL 1581.

PART 3 - EXECUTION

3.1 WIRING INSTALLATION

- A. Comply with NECA 1.
- B. Wiring Method: Install wiring in raceways except where installed in accessible ceilings. Minimum conduit size shall be **1/2 inch (13 mm)**.
 - 1. For power wiring comply with Section 260519 "Low-Voltage Electrical Power Conductors and Cables."
 - 2. For digital data transmission and low-voltage (operating at less than 50 V) remote control and signaling cables, comply with Section 260523 "Control-Voltage Electrical Power Cables."
- 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. Install field-mounting transient voltage suppressors for lighting control devices in Category A locations that do not have integral line-voltage surge protection.
- E. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.
- F. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in terminal cabinets, equipment enclosures, and in junction, pull, and outlet boxes.
- G. Identify components and power and control wiring according to Section 260553 "Identification for Electrical Systems."

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 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.
- C. Lighting controls will be considered defective if they do not pass tests and inspections.

- D. Prepare test and inspection reports.

3.3 SOFTWARE INSTALLATION

- A. Install and program software with initial settings of adjustable values. Make backup copies of software and user-supplied values. Provide current licenses for software.

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. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain lighting controls and software training for PC-based control systems. See Division 01 for further information.

END OF SECTION 260943

SECTION 262416 - PANELBOARDS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:
 - 1. Lighting and appliance branch-circuit panelboards.

1.3 DEFINITIONS

- A. SVR: Suppressed voltage rating.
- B. TVSS: Transient voltage surge suppressor.

1.4 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. Include evidence of NRTL listing for series rating of installed devices.
 - 6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
 - 7. Include wiring diagrams for power, signal, and control wiring.
 - 8. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graph paper; include selectable ranges for each type of overcurrent protective device.

- C. 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.
- D. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.
- E. 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.

1.5 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 panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.
- C. 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.
- D. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- E. Comply with NEMA PB 1.
- F. Comply with NFPA 70.

1.6 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.

1.7 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 23 deg F (minus 5 deg C) to plus 104 deg F (plus 40 deg C).
 - b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 1, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

1.8 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.

1.9 WARRANTY

- A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace transient voltage suppression devices that fail in materials or workmanship within specified warranty period.
1. Warranty Period: Five years from date of Substantial Completion.

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. Keys: Two spares for each type of panelboard cabinet lock.
 2. Circuit Breakers: As scheduled
 3. Fuses for Fused Switches: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.
 4. Fuses for Fused Power-Circuit Devices: 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

2.1 GENERAL REQUIREMENTS FOR PANELBOARDS

- A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- B. Enclosures: Flush- and surface-mounted cabinets as scheduled.
 - 1. Rated for environmental conditions at installed location.
 - a. Indoor Dry and Clean Locations: NEMA 250, Type 1.
 - b. Outdoor Locations: NEMA 250, Type 3R.
 - c. Wash-Down Areas: NEMA 250, Type 4X, stainless steel.
 - 2. Hinged Front Cover: Entire front trim hinged to box and with standard door within hinged trim cover.
 - 3. Finishes:
 - a. Panels and Trim: Steel and galvanized steel, factory finished immediately after cleaning and pretreating with manufacturer's standard two-coat, baked-on finish consisting of prime coat and thermosetting topcoat.
 - b. Back Boxes: Galvanized steel or same finish as panels and trim.
 - 4. Directory Card: Inside panelboard door, mounted in transparent card holder.
- C. Incoming Mains Location: Top or bottom to match incoming feeder..
- D. Phase, Neutral, and Ground Buses:
 - 1. Material: Tin-plated aluminum.
 - 2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.
 - 3. Extra-Capacity Neutral Bus: Neutral bus rated 200 percent of phase bus and UL listed as suitable for nonlinear loads.
- E. Conductor Connectors: Suitable for use with conductor material and sizes.
 - 1. Material: Tin-plated aluminum.
 - 2. Main and Neutral Lugs: Mechanical type.
 - 3. Ground Lugs and Bus-Configured Terminators: Mechanical type.
 - 4. Feed-Through Lugs: Mechanical type, suitable for use with conductor material. Locate at opposite end of bus from incoming lugs or main device.
 - 5. Subfeed (Double) Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 6. Gutter-Tap Lugs: Mechanical type suitable for use with conductor material. Locate at same end of bus as incoming lugs or main device.
 - 7. Extra-Capacity Neutral Lugs: Rated 200 percent of phase lugs mounted on extra-capacity neutral bus.

- F. Service Equipment Label: NRTL labeled for use as service equipment for panelboards or load centers with one or more main service disconnecting and overcurrent protective devices.
- G. Future Devices: Mounting brackets, bus connections, filler plates, and necessary appurtenances required for future installation of devices.
- H. Panelboard Short-Circuit Current Rating: Fully rated to interrupt symmetrical short-circuit current available at terminals.

2.2 LIGHTING AND APPLIANCE BRANCH-CIRCUIT PANELBOARDS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. 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: as indicated on schedules. Provide sub feed lugs where indicated.
- D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.
- E. Contactors in Main Bus: NEMA ICS 2, Class A, electrically held, general-purpose controller, with same short-circuit interrupting rating as panelboard.
 - 1. Internal Control-Power Source: Control-power transformer, with fused primary and secondary terminals, connected to main bus ahead of contactor connection.
- F. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.
- G. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

2.3 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. 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. Adjustable Instantaneous-Trip Circuit Breakers: Magnetic trip element with front-mounted, field-adjustable trip setting.
 3. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replaceable electronic trip; and the following field-adjustable settings:
 - a. Instantaneous trip.
 - b. Long- and short-time pickup levels.
 - c. Long- and short-time time adjustments.
 - d. Ground-fault pickup level, time delay, and I^2t response.
 4. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
 5. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
 6. Arc-Fault Circuit Interrupter (AFCI) Circuit Breakers: Comply with UL 1699; 120/240-V, single-pole configuration.
 7. 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. Shunt Trip: trip coil energized from separate circuit, set to trip at 55 percent of rated voltage.
 - e. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
 - f. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts and "b" contacts operate in reverse of circuit-breaker contacts.
 - g. Alarm Switch: Single-pole, normally open contact that actuates only when circuit breaker trips.
 - h. Multipole units enclosed in a single housing or factory assembled to operate as a single unit.
 - i. Handle Padlocking Device: Fixed attachment, for locking circuit-breaker handle in on position.
 - j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.4 PANELBOARD SUPPRESSORS – provide integral mounted for panel MDP

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
1. Current Technology; a subsidiary of Danahar Corporation.
 2. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
 3. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
 4. Liebert Corporation.
 5. Siemens Energy & Automation, Inc.
 6. Square D; a brand of Schneider Electric.
- B. Surge Protection Device: IEEE C62.41-compliant, integrally mounted, solid-state, parallel-connected, non-modular type, with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the panelboard short-circuit rating, and with the following features and accessories:
1. Accessories:
 - a. LED indicator lights for power and protection status.
 - b. Audible alarm, with silencing switch, to indicate when protection has failed.
 - c. One set of dry contacts rated at 5 A and 250-V ac, for remote monitoring of protection status.

2.5 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

3.1 EXAMINATION

- A. Receive, inspect, handle, and store panelboards according to NECA 407.
- B. Examine panelboards before installation. Reject panelboards that are damaged or rusted or have been subjected to water saturation.
- C. Examine elements and surfaces to receive panelboards for compliance with installation tolerances and other conditions affecting performance of the Work.
- D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."

- B. Mount top of trim 90 inches (2286 mm) above finished floor unless otherwise indicated.
- C. 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.
- D. Install overcurrent protective devices and controllers not already factory installed.
 - 1. Set field-adjustable, circuit-breaker trip ranges.
- E. Install filler plates in unused spaces.
- F. Stub four 1-inch (27-GRC) empty conduits from panelboard into accessible ceiling space or space designated to be ceiling space in the future. Stub four 1-inch (27-GRC) empty conduits into raised floor space or below slab not on grade.
- G. Arrange conductors in gutters into groups and bundle and wrap with wire ties.
- H. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Division 26 Section "Identification for Electrical Systems."
- B. Create a directory to indicate installed circuit loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.
- C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
- D. Device Nameplates: Label each branch circuit device in distribution panelboards with a nameplate complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
 - 1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.
- B. Tests and Inspections:
 - 1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 2. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

- C. Panelboards will be considered defective if they do not pass tests and inspections.
- D. Prepare test and inspection reports, including a certified report that identifies panelboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.5 ADJUSTING

- A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.
- B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION 264216

SECTION 262713 - ELECTRICITY METERING

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes work to accommodate utility company revenue meters, and Owner's electricity meters used to manage the electrical power system.

1.3 DEFINITIONS

- A. A.KY or KYZ Pulse: Term used by the metering industry to describe a method of measuring consumption of electricity (kWh) that is based on a relay opening and closing in response to the rotation of the disk in the meter. Electronic meters generate pulses electronically.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For electricity-metering equipment.
 - 1. Dimensioned plans and sections or elevation layouts.

1.5 QUALITY ASSURANCE

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

1.6 WARRANTY

- A. Special Warranty: Manufacturer agrees to repair or replace components of metering equipment that fail in materials or workmanship within specified warranty period.
 - 1. Failures include, but are not limited to, the following:
 - a. Damage from transient voltage surges.
 - 2. Warranty Period: Cost to repair or replace any parts for two years from date of Substantial Completion.
 - 3. Extended Warranty Period: Cost of replacement parts (materials only, f.o.b. the nearest shipping point to Project site), for eight years, that failed in service due to transient voltage surges.

1.7 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 Owner no fewer than five days in advance of proposed interruption of electrical service.
 - 2. Do not proceed with interruption of electrical service without Owner's written permission.

1.8 COORDINATION

- A. Electrical Service Connections: Coordinate with utility companies and components they furnish as follows:
 - 1. Comply with requirements of utilities providing electrical power services.
 - 2. Coordinate installation and connection of utilities and services, including provision for electricity-metering components.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

- A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
- B. Comply with UL 916.

2.2 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

- A. Meters will be furnished by utility company.
- B. Meter Sockets and Instrument Transformers and Enclosures: Comply with requirements of electrical-power utility company.

2.3 ELECTRICITY METERS

- A. System Description: Able to meter designated activity loads, with or without external alarm, control, and communication capabilities, or other optional features.
 - 1. Provide meter to monitor Panel MDP.
- B. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Eaton.
 - 2. E-Mon.

3. General Electric Company.
4. SIEMENS Industry, Inc.; Energy Management Division.

C. General Requirements for Meters:

1. Meters Accuracy: 0.2 percent of reading, complying with ANSI C12.20.
2. Certify that meters comply with ANSI C12.20 requirements by a laboratory accredited by the National Voluntary Laboratory Accreditation Program (NVLAP) of the National Institute of Standards and Technology (NIST). The laboratory shall use test equipment that is certified annually and is traceable to NIST standards.
3. Enclosure: Supplied by meter manufacturer, NEMA 250, Type 1 minimum unless otherwise noted, with provisions for locking or sealing.
4. Identification: Comply with requirements in Section 260553 "Identification for Electrical Systems."
5. Onboard Nonvolatile Data Storage: kWh, until reset.
6. Sensors: Current-sensing type, supplied by electronic meter manufacturer, with current or voltage output, selected for optimum range and accuracy for meters indicated for this application.
 - a. Type: Split and solid core, complying with recommendation of meter manufacturer.

D. kWhd Meter: Electronic three-phase meters, measuring electricity use and demand. Demand shall be integrated over a 15-minute interval.

1. Voltage and Phase Configuration: Meter shall be designed for use on circuits with voltage rating and phase configuration indicated for its application.
2. Display: LCD with characters not less than 0.25 inch (6 mm) high, indicating the following:
 - a. Accumulative kWh.
 - b. Current time and date.
 - c. Current demand.
 - d. Historic peak demand.
 - e. Time and date of historic peak demand.
3. Retain accumulated kWh and historic peak demand in a nonvolatile memory, until reset.

E. Remote Reading Options:

1. Pulse Output: KY or KYZ, complete with optical sensor and interface devices.
2. Serial Interface: RS-485, with Modbus RTU protocol.

PART 3 - EXECUTION

3.1 INSTALLATION

- A. Comply with equipment installation requirements in NECA 1.

- B. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."

- 1. Equipment Identification Labels: Adhesive film labels with clear protective overlay.

3.2 FIELD QUALITY CONTROL

- A. Perform tests and inspections with the assistance of a factory-authorized service representative.

- B. Tests and Inspections:

- 1. Equipment and Software Setup:

- a. Set meter date and time clock.
 - b. Test, calibrate, and connect pulse metering system.
 - c. Set and verify demand interval for demand meters.
 - d. Report settings and calibration results.

- 2. Connect a load of known kilowatt rating, 1.5 kW minimum, to a circuit supplied by metered feeder.
 - 3. Turn off circuits supplied by metered feeder and secure them in off condition.
 - 4. Run test load continuously for eight hours minimum, or longer, to obtain a measurable meter indication. Use test-load placement and setting that ensures continuous, safe operation.
 - 5. Check and record meter reading at end of test period and compare with actual electricity used, based on test-load rating, duration of test, and sample measurements of supply voltage at test-load connection. Record test results.

- C. Electricity metering will be considered defective if it does not pass tests and inspections.

- D. Prepare test and inspection reports.

END OF SECTION 262713

SECTION 262726 - WIRING DEVICES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. This Section includes the following:
 - 1. Receptacles, receptacles with integral GFCI, and associated device plates.
 - 2. Twist-locking receptacles.
 - 3. Snap switches and wall-box dimmers.
 - 4. Cord and plug sets.

1.3 DEFINITIONS

- A. GFCI: Ground-fault circuit interrupter.
- B. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

1.4 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: List of legends and description of materials.
- C. Samples: One for each type of device and wall plate specified, in each color specified.
- D. Field quality-control test reports.
- E. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing label warnings and instruction manuals that include labeling conditions.

1.5 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.

1.6 COORDINATION

- A. Receptacles for Owner-Furnished Equipment: Match plug configurations.
 - 1. Cord and Plug Sets: Match equipment requirements.

1.7 EXTRA MATERIALS

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

PART 2 - PRODUCTS

2.1 STRAIGHT BLADE RECEPTACLES

- A. Convenience Duplex Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration 5-20R, and UL 498.

2.2 GFCI RECEPTACLES

- A. General Description: Straight blade, non-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 Duplex Receptacles, 125 V, 20 A:

2.3 TWIST-LOCKING RECEPTACLES

- A. Single Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 configuration L5-20R, and UL 498. Provide other configurations where indicated on plans.

2.4 CORD AND PLUG SETS

- A. Description: Match voltage and current ratings and number of conductors to requirements of equipment being connected.
 - 1. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and equipment-rating ampacity plus a minimum of 30 percent.

2. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.
- 2.5 SNAP SWITCHES must match the push button switches provided with the daylight harvesting controls and with the wall mounted occupancy switches.
- A. Comply with NEMA WD 1 and UL 20
 - B. Switches, 120/277 V, 20 A – single or two pole, three way or 4 way as indicated on plans.
 - C. Pilot Light Switches, 20 A:
 1. Description: Single pole, with neon-lighted handle, illuminated when switch is "ON."
- 2.6 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 and unfinished Spaces: Brushed stainless steel.
 3. Material for Damp Locations: Thermoplastic with spring-loaded lift cover, and listed and labeled for use in "wet locations."
 - B. Wet-Location, Weatherproof : NEMA 250, complying with type 3R enclosure
- 2.7 FINISHES
- A. Color: Wiring device catalog numbers in Section Text do not designate device color.
 1. Wiring Devices : White, unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.1 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. Pigtailling 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 (152 mm)** 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 up, 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, multigang wall plates.

- H. Adjust locations of floor service outlets and service poles to suit arrangement of partitions and furnishings.

3.2 IDENTIFICATION

- A. Comply with Division 26 Section "Identification for Electrical Systems."
 - 1. Receptacles: Identify panelboard and circuit number from which served. Provide machine-printed adhesive labels on wall plates.

3.3 FIELD QUALITY CONTROL

- A. Perform tests and inspections and prepare test reports.
 - 1. Test Instruments: Use instruments that comply with UL 1436.
 - 2. 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.

END OF SECTION 262726

SECTION 262813 - FUSES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 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.

1.3 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.

1.4 COORDINATION

- A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

1.5 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 2 of each size and type.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

- A. Manufacturers: Subject to compliance with requirements, provided products by one of the following or approved equal:
1. Cooper Bussmann, Inc.
 2. Edison Fuse, Inc.
 3. Ferraz Shawmut, Inc.
 4. Littelfuse, Inc.

2.2 CARTRIDGE FUSES

- A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

2.3 PLUG FUSES

- A. Characteristics: UL 248-11, nonrenewable plug fuses; 125-V ac.

2.4 PLUG-FUSE ADAPTERS

- A. Characteristics: Adapters for using Type S, rejection-base plug fuses in Edison-base fuseholders or sockets; ampere ratings matching fuse ratings; irremovable once installed.

2.5 SPARE-FUSE CABINET

- A. Characteristics: Wall-mounted steel unit with full-length, recessed piano-hinged door and key-coded cam lock and pull.
1. Size: Adequate for storage of spare fuses specified with 15 percent spare capacity minimum.
 2. Finish: Gray, baked enamel.
 3. Identification: "SPARE FUSES" in 1-1/2-inch- (38-mm-) high letters on exterior of door.
 4. Fuse Pullers: For each size of fuse, where applicable and available, from fuse manufacturer.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

- B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.
- C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.
- D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.
- E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 FUSE APPLICATIONS

- A. Cartridge Fuses:
 - 1. Service Entrance and Feeders: Class L, fast acting
 - 2. Motor Branch Circuits and other branch circuits: Class RK1, time delay.
 - 3. Control Circuits: Class CC, fast acting.
- B. Plug Fuses:
 - 1. Motor Branch Circuits and other branch circuits: Edison-base type, dual-element time delay.

3.3 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).

3.4 IDENTIFICATION

- A. Install labels complying with requirements for identification specified in Division 26 Section "Identification for Electrical Systems" and indicating fuse replacement information on inside door of each fused switch and adjacent to each fuse block, socket, and holder.

END OF SECTION 262813

SECTION 262816 - ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Molded-case switches.
4. Enclosures.

1.3 DEFINITIONS

- A. NC: Normally closed.
- B. NO: Normally open.
- C. SPDT: Single pole, double throw.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Enclosed switches and circuit breakers shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 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.
- 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. 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.

1.6 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.

1.7 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m).

1.8 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.

1.9 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 3 of each size and type.
 2. Fuse Pullers: two for each size and type.

PART 2 - PRODUCTS

2.1 FUSIBLE SWITCHES

- A. Basis-of-Design Product: Subject to compliance with requirements, provide product by one of the following or approved equal:
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 HD, Heavy Duty, Single Throw, 240-V ac, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.
- C. Accessories:
1. Equipment Ground Kit: Internally mounted and labeled for copper and aluminum ground conductors.
 2. Neutral Kit: Internally mounted; insulated, capable of being grounded and bonded; labeled for copper and aluminum neutral conductors.
 3. Class R Fuse Kit: Provides rejection of other fuse types when Class R fuses are specified.
 4. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
 5. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.2 NONFUSIBLE SWITCHES

- A. Type HD, Heavy Duty, Single Throw, 240 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.
- B. 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. Auxiliary Contact Kit: One NO/NC (Form "C") auxiliary contact(s), arranged to activate before switch blades open.
4. Lugs: Mechanical type, suitable for number, size, and conductor material.

2.3 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 4X
 4. Indoor Locations Subject to Dust, Falling Dirt, and Dripping Noncorrosive Liquids: NEMA 250, Type 12.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.
- B. Comply with mounting and anchoring requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Install fuses in fusible devices.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."
 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.4 FIELD QUALITY CONTROL

- A. Perform tests and inspections.
- B. Acceptance Testing Preparation:
 - 1. Test insulation resistance for each enclosed switch and circuit breaker, component, connecting supply, feeder, and control circuit.
 - 2. Test continuity of each circuit.
 - 3. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.
- C. Enclosed switches and circuit breakers will be considered defective if they do not pass tests and inspections.
- D. 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.

3.5 ADJUSTING

- A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

END OF SECTION 262816

SECTION 262913 - ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

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

1.2 SUMMARY

- A. Section includes the following enclosed controllers rated 600 V and less:
 - 1. Full-voltage manual.
 - 2. Full-voltage magnetic.

1.3 DEFINITIONS

- A. CPT: Control power transformer.
- B. MCCB: Molded-case circuit breaker.
- C. MCP: Motor circuit protector.
- D. N.C.: Normally closed.
- E. N.O.: Normally open.
- F. OCPD: Overcurrent protective device.
- G. SCR: Silicon-controlled rectifier.

1.4 SUBMITTALS

- A. Product Data: For each type of enclosed controller. Include manufacturer's technical data on features, performance, electrical characteristics, ratings, and enclosure types and finishes.
- B. Shop Drawings: For each enclosed controller. Include dimensioned plans, elevations, sections, details, and required clearances and service spaces around controller enclosures.
 - 1. Show tabulations of the following:
 - a. Each installed unit's type and details.
 - b. Factory-installed devices.
 - c. Nameplate legends.
 - d. Short-circuit current rating of integrated unit.

2. Wiring Diagrams: For power, signal, and control wiring.
- C. Field quality-control reports.
- D. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01 Section "Operation and Maintenance Data," include the following:
 1. Routine maintenance requirements for enclosed controllers and installed components.
 2. Manufacturer's written instructions for setting field-adjustable overload relays.
 3. Manufacturer's written instructions for testing, adjusting, and reprogramming reduced-voltage solid-state controllers.
- E. Load-Current and Overload-Relay Heater List: Compile after motors have been installed, and arrange to demonstrate that selection of heaters suits actual motor nameplate full-load currents.

1.5 QUALITY ASSURANCE

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

1.6 PROJECT CONDITIONS

- A. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 1. Ambient Temperature: Not less than minus 22 deg F (minus 30 deg C) and not exceeding 104 deg F (40 deg C).
 2. Altitude: Not exceeding 6600 feet (2010 m).

1.7 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 for Fused Switches and Control Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than 2 of each size and type.
 2. Indicating Lights: two of each type and color installed.
 3. Auxiliary Contacts: Furnish one spare(s) for each size and type of magnetic controller installed.
 4. Power Contacts: Furnish three spares for each size and type of magnetic contactor installed.

PART 2 - PRODUCTS

2.1 FULL-VOLTAGE CONTROLLERS

- A. General Requirements for Full-Voltage Controllers: Comply with NEMA ICS 2, general purpose, Class A.
- B. Motor-Starting Switches: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off or on.
 - 1. Surface mounting.
 - 2. Red pilot light.
- C. Fractional Horsepower Manual Controllers: "Quick-make, quick-break" toggle or push-button action; marked to show whether unit is off, on, or tripped.
 - 1. Overload Relays: Inverse-time-current characteristics; NEMA ICS 2, Class 10 tripping characteristics; heaters matched to nameplate full-load current of actual protected motor; external reset push button bimetallic type.
 - 2. Surface mounting.
 - 3. Red pilot light.
- D. Magnetic Controllers: Full voltage, across the line, electrically held.
 - 1. Contactor Coils: Pressure-encapsulated type with coil transient suppressors.
 - a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.
 - 2. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
 - 3. Control Circuits: 24 V ac; obtained from integral CPT, with primary and secondary fuses, with CPT of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.
 - a. CPT Spare Capacity: 50 VA.
 - 4. Melting Alloy Overload Relays:
 - a. Inverse-time-current characteristic.
 - b. Class 10 tripping characteristic.
 - c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.
 - d. Ambient compensated.
 - e. Automatic resetting.

5. Solid-State Overload Relay:
 - a. Switch or dial selectable for motor running overload protection.
 - b. Sensors in each phase.
 - c. Class 10 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.
 6. N.C or N.O., isolated overload alarm contact.
 7. External overload reset push button.
- E. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.
1. Fusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class J fuses.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
 2. Nonfusible Disconnecting Means:
 - a. NEMA KS 1, heavy-duty, horsepower-rated, nonfusible switch.
 - b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
 - c. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.

2.2 ENCLOSURES

- A. Enclosed Controllers: NEMA ICS 6, to comply with environmental conditions at installed location.
1. Dry and Clean Indoor Locations: Type 1.
 2. Outdoor Locations: Type 3R.
 3. Other Wet or Damp Indoor Locations: Type 4X.

2.3 ACCESSORIES

- A. General Requirements for Control Circuit and Pilot Devices: NEMA ICS 5; factory installed in controller enclosure cover unless otherwise indicated.
1. Push Buttons, Pilot Lights, and Selector Switches: Heavy-duty, oiltight type.
 - a. Push Buttons: Covered types; maintained as indicated.
 - b. Pilot Lights: LED types; colors as indicated.
 - c. Selector Switches: Rotary type.
- B. N.C./ N.O. auxiliary contact(s).

- C. Control Relays: Auxiliary and adjustable time-delay relays.
- D. Phase-Failure, Phase-Reversal, and Undervoltage and Overvoltage Relays: Solid-state sensing circuit with isolated output contacts for hard-wired connections. Provide adjustable undervoltage, overvoltage, and time-delay settings.
- E. Cover gaskets for Type 1 enclosures.
- F. Terminals for connecting power factor correction capacitors to the line side of overload relays.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas and surfaces to receive enclosed controllers, with Installer present, for compliance with requirements and other conditions affecting performance of the Work.
- B. Examine enclosed controllers before installation. Reject enclosed controllers that are wet, moisture damaged, or mold damaged.
- C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 INSTALLATION

- A. Wall-Mounted Controllers: Install enclosed controllers on walls with tops at uniform height unless otherwise indicated, and by bolting units to wall or mounting on lightweight structural-steel channels bolted to wall. For controllers not at walls, provide freestanding racks complying with Division 26 Section "Hangers and Supports for Electrical Systems."
- B. Seismic Bracing: Comply with requirements specified in Division 26 Section "Vibration and Seismic Controls for Electrical Systems."
- C. Install fuses in each fusible-switch enclosed controller.
- D. Comply with NECA 1.

3.3 IDENTIFICATION

- A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
 - 1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
 - 2. Label each enclosure with engraved nameplate.

3.4 CONTROL WIRING INSTALLATION

- A. Install wiring between enclosed controllers and remote devices. Comply with requirements in Division 26 Section "Control-Voltage Electrical Power Cables."
- B. Bundle, train, and support wiring in enclosures.
- C. Connect selector switches and other automatic-control selection devices where applicable.

3.5 FIELD QUALITY CONTROL

- A. Tests and Inspections:
 - 1. Inspect controllers, wiring, components, connections, and equipment installation.
 - 2. Test insulation resistance for each enclosed-controller element, component, connecting motor supply, feeder, and control circuits.
 - 3. Test continuity of each circuit.
 - 4. Verify that voltages at controller locations are within plus or minus 10 percent of motor nameplate rated voltages.
 - 5. Test each motor for proper phase rotation.
 - 6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
 - 7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.
- B. Enclosed controllers will be considered defective if they do not pass tests and inspections.

3.6 ADJUSTING

- A. Set field-adjustable switches, auxiliary relays, time-delay relays, timers, and overload-relay pickup and trip ranges.
- B. Adjust overload-relay heaters or settings if power factor correction capacitors are connected to the load side of the overload relays.
- C. Adjust the trip settings of MCPs and thermal-magnetic circuit breakers with adjustable instantaneous trip elements. Initially adjust to six times the motor nameplate full-load ampere ratings and attempt to start motors several times, allowing for motor cooldown between starts. If tripping occurs on motor inrush, adjust settings in increments until motors start without tripping. Do not exceed eight times the motor full-load amperes (or 11 times for NEMA Premium Efficient motors if required). Where these maximum settings do not allow starting of a motor.

3.7 DEMONSTRATION

- A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers.

END OF SECTION 262913

SECTION 265119 - LED 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 260923"Lighting Control Devices" for automatic control of lighting, including photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.

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 life, output (lumens, CCT, and CRI), and energy efficiency data.
 - 5.

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. Samples for Verification: As requested by Architect.

1. Include Samples of luminaires and accessories to verify finish selection.

C. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.5 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in operation and maintenance manuals.

1. Provide a list of all lamp module types used on Project; use ANSI and manufacturers' codes.

1.6 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. 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.

1.7 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

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. Luminaires shall be Energy Star Rated or listed by the DesignLights Consortium (DLC).

C. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

- D. Recessed Fixtures: Comply with NEMA LE 4.
- E. CRI of minimum 70. CCT as scheduled on the drawings.
- F. Rated lamp life of 50,000 hours.
- G. Lamps dimmable from 100 percent to 0 percent of maximum light output where dimming control is indicated on the drawings.
- H. Internal driver or remote driver as applicable for each scheduled luminaire.
- I. Nominal Operating Voltage: As scheduled on the drawings. .
 - 1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.2 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 (3.175 mm) 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.

2.3 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.

2.4 LUMINAIRE FIXTURE 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.
- B. Stem Hangers: **1/2-inch (13-mm)** steel tubing with swivel ball fittings and ceiling canopy. Finish shall match luminaire.
- C. Wires: ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, **12 gage (2.68 mm)** minimum.

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. Ceiling-Grid-Mounted Luminaire Supports: Use grid as a support element.
1. Install ceiling support system rods or wires, independent of the ceiling suspension devices, for each luminaire. Locate not more than **6 inches (150 mm)** from luminaire corners.
 2. Support Clips: Fasten to luminaires and to ceiling grid members at or near each luminaire corner with clips that are UL listed for the application.
 3. Luminaires of Sizes Less Than Ceiling Grid: Install as indicated on reflected ceiling plans or center in acoustical panel, and support luminaires independently with at least two metal channels spanning and secured to ceiling tees.
 4. Install at least one independent support rod or wire from structure to a tab on luminaire. Wire or rod shall have breaking strength of the luminaire weight at a safety factor of 3.
- F. 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.
- G. Wall-Mounted Luminaire Support:
1. Attached to structural members in walls
 2. Attached to a minimum 20 gauge backing plate attached to wall structural members
 3. Attached using through bolts and backing plates on either side of wall.
 4. Do not attach luminaires directly to gypsum board.
- H. Suspended Luminaire Support:
1. Pendants and Rods: Where longer than **48 inches (1200 mm)**, 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 cord for wiring at one point and wire support 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.
- I. 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 normal power supply to demonstrate proper operation. Verify transfer from normal power to emergency power and retransfer to normal.
- B. Luminaire will be considered defective if it does not pass operation tests and inspections.

3.6 STARTUP SERVICE

- A. Comply with requirements for startup specified in Section 260943 "Network Lighting Controls."

END OF SECTION 265119

SECTION 265219 - EMERGENCY AND EXIT 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. Exit signs.
 - 2. Emergency lighting units.
 - 3. Luminaire supports.

1.3 DEFINITIONS

- A. CCT: Correlated color temperature.
- B. CRI: Color Rendering Index.
- C. Fixture: See "Luminaire" Paragraph.
- D. Lumen: Measured output of lamp and luminaire, or both.
- E. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.4 ACTION SUBMITTALS

- A. Product Data: For each type of emergency lighting unit, exit sign, and emergency lighting support.
 - 1. Include data on features, accessories, and finishes.
 - 2. Include physical description of the unit and dimensions.
 - 3. Battery and charger for light units.
 - 4. Include life, output of luminaire (lumens, CCT, and CRI), and energy-efficiency data.

1.5 CLOSEOUT SUBMITTALS

- A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1.6 DELIVERY, STORAGE, AND HANDLING

- A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

PART 2 - PRODUCTS

2.1 GENERAL REQUIREMENTS FOR EMERGENCY LIGHTING

- 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: Fabricate and label emergency lighting units, exit signs, and batteries to comply with UL 924.
- C. Comply with NFPA 70 and NFPA 101.
- D. Comply with NEMA LE 4 for recessed luminaires.
- E. Internal Type Emergency Power Unit: Self-contained, modular, battery-inverter unit, factory mounted within luminaire body and compatible with ballast.
 - 1. Emergency Connection: Operate LED light engine continuously at an output of 1100 lumens each upon loss of normal power. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire ballast.
 - 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 - 3. Environmental Limitations: Rate equipment for continuous operation under the following conditions unless otherwise indicated:
 - a. Ambient Temperature: Less than 0 deg F (minus 18 deg C) or exceeding 104 deg F (40 deg C), with an average value exceeding 95 deg F (35 deg C) over a 24-hour period.
 - b. Ambient Storage Temperature: Not less than minus 4 deg F (minus 20 deg C) and not exceeding 140 deg F (60 deg C).
 - c. Humidity: More than 95 percent (condensing).
 - d. Altitude: Exceeding 3300 feet (1000 m).
 - 4. Nightlight Connection: Operate lamp continuously at 40 percent of rated light output.
 - 5. Test Push-Button and Indicator Light: Visible and accessible without opening luminaire or entering ceiling space.
 - a. Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 - b. Indicator Light: LED indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.

6. Battery: Sealed, maintenance-free, nickel-cadmium type.
 7. Charger: Fully automatic, solid-state, constant-current type with sealed power transfer relay.
 8. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 9. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.
- F. External Type: Self-contained, modular, battery-inverter unit, suitable for powering one or more lamps, remote mounted from luminaire.
1. Emergency Connection: Operate LED light engine continuously. Connect unswitched circuit to battery-inverter unit and switched circuit to luminaire.
 2. Operation: Relay automatically turns lamp on when power-supply circuit voltage drops to 80 percent of nominal voltage or below. Lamp automatically disconnects from battery when voltage approaches deep-discharge level. When normal voltage is restored, relay disconnects lamps from battery, and battery is automatically recharged and floated on charger.
 3. Nightlight Connection: Operate lamp in a remote luminaire continuously.
 4. Battery: Sealed, maintenance-free, nickel-cadmium type.
 5. Charger: Fully automatic, solid-state, constant-current type.
 6. Housing: NEMA 250, Type 1 enclosure listed for installation inside, on top of, or remote from luminaire. Remote assembly shall be located no less than half the distance recommended by the emergency power unit manufacturer, whichever is less.
 7. Test Push Button: Push-to-test type, in unit housing, simulates loss of normal power and demonstrates unit operability.
 8. LED Indicator Light: Indicates normal power on. Normal glow indicates trickle charge; bright glow indicates charging at end of discharge cycle.
 9. Remote Test: Switch in handheld remote device aimed in direction of tested unit initiates coded infrared signal. Signal reception by factory-installed infrared receiver in tested unit triggers simulation of loss of its normal power supply, providing visual confirmation of either proper or failed emergency response.
 10. Integral Self-Test: Factory-installed electronic device automatically initiates code-required test of unit emergency operation at required intervals. Test failure is annunciated by an integral audible alarm and a flashing red LED.

2.2 EXIT SIGNS

- A. General Requirements for Exit Signs: Comply with UL 924; for sign colors, visibility, luminance, and lettering size, comply with authorities having jurisdiction.
- B. Internally Lighted Signs:
1. Operating at nominal voltage of 120 V ac.
 2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.
 3. Self-Powered Exit Signs (Battery Type): Internal emergency power unit.

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:

1. Smooth operating, free of light leakage under operating conditions.
2. Designed to permit relamping without use of tools.
3. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position.

2.4 METAL FINISHES

- ### A. Appearance of Finished Work:
- Noticeable variations in same piece are not acceptable. 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.

2.5 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.
- ### B. Support Wires:
- ASTM A 641/A 641M, Class 3, soft temper, zinc-coated steel, 12 gage (2.68 mm).

PART 3 - EXECUTION

3.1 EXAMINATION

- #### A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for conditions affecting performance of luminaires.
- #### B. Examine roughing-in for luminaire to verify actual locations of luminaire and electrical connections before luminaire installation.
- #### C. Examine walls, floors, roofs, and ceilings for suitable conditions where emergency lighting luminaires will be installed.
- #### D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.2 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 and emergency power unit weight.
 - 2. Able to maintain luminaire position when testing emergency power unit.
 - 3. Provide support for luminaire and emergency power unit without causing deflection of ceiling or wall.
 - 4. Luminaire-mounting devices shall be capable of supporting a horizontal force of 100 percent of luminaire and emergency power unit weight and vertical force of 400 percent of luminaire weight.
- E. Wall-Mounted Luminaire Support:
 - 1. Attached to structural members in walls.
 - 2. Do not attach luminaires directly to gypsum board.
- F. Suspended Luminaire Support:
 - 1. Pendants and Rods: Where longer than 48 inches (1200 mm), 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. Do not use ceiling grid as support for pendant luminaires. Connect support wires or rods to building structure.
- G. Ceiling Grid Mounted Luminaires:
 - 1. Secure to any required outlet box.
 - 2. Secure emergency power unit using approved fasteners in a minimum of four locations, spaced near corners of emergency power unit.
 - 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.

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. Perform the following tests and inspections:
 - 1. 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.

3.5 STARTUP SERVICE

- A. Perform startup service:
 - 1. Charge emergency power units and batteries minimum of one hour and depress switch to conduct short-duration test.
 - 2. Charge emergency power units and batteries minimum of 24 hours and conduct one-hour discharge test.

END OF SECTION 265219

SECTION 280513 - CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

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. RS-232 cabling.
 - 2. RS-485 cabling.
 - 3. Fire alarm wire and cable.
 - 4. Identification products.

1.3 DEFINITIONS

- A. BICSI: Building Industry Consulting Service International.
- B. EMI: Electromagnetic interference.
- C. IDC: Insulation displacement connector.
- D. Low Voltage: As defined in NFPA 70 for circuits and equipment operating at less than 50 V or for remote-control and signaling power-limited circuits.
- E. Open Cabling: Passing telecommunications cabling through open space (e.g., between the studs of a wall cavity).
- F. RCDD: Registered Communications Distribution Designer.

1.4 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Pathways shall withstand the effects of earthquake motions determined according to ASCE/SEI 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.5 SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.
- C. Seismic Qualification Certificates: For pathways, 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.
- D. Field quality-control reports.
- E. Operation and Maintenance Data: For wire and cable to include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:
 - 1. Allowable pulling tension of cable.
 - 2. Cable connectors and terminations recommended by the manufacturer.

1.6 QUALITY ASSURANCE

- A. Testing Agency Qualifications: An NRTL.
 - 1. Testing Agency's Field Supervisor: Currently certified by BICSI as an RCDD to supervise on-site testing.
- 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.

1.7 PROJECT CONDITIONS

- A. Do not install conductors and cables that are wet, moisture damaged, or mold damaged.
 - 1. Indications that wire and cables are wet or moisture damaged include, but are not limited to, discoloration and sagging of factory packing materials.
- B. Environmental Limitations: Do not deliver or install UTP, optical fiber, and coaxial 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

2.1 PATHWAYS

- A. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems."
- B. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.2 RS-232 CABLE

- A. Standard Cable: NFPA 70, Type CMR.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Polypropylene insulation.
 - 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - 4. PVC jacket.
 - 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with UL 1581.
- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Plastic insulation.
 - 3. Individual aluminum foil-polyester tape shielded pairs with 100 percent shield coverage.
 - 4. Plastic jacket.
 - 5. Pairs are cabled on common axis with No. 24 AWG, stranded (7x32) tinned copper drain wire.
 - 6. Flame Resistance: Comply with NFPA 262.

2.3 RS-485 CABLE

- A. Standard Cable: NFPA 70, Type CMR.
 - 1. Paired, 2 pairs, twisted, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. PVC insulation.
 - 3. Unshielded.
 - 4. PVC jacket.
 - 5. Flame Resistance: Comply with UL 1581.

- B. Plenum-Rated Cable: NFPA 70, Type CMP.
 - 1. Paired, 2 pairs, No. 22 AWG, stranded (7x30) tinned copper conductors.
 - 2. Fluorinated ethylene propylene insulation.
 - 3. Unshielded.
 - 4. Fluorinated ethylene propylene jacket.
 - 5. Flame Resistance: NFPA 262, Flame Test.

2.4 FIRE ALARM WIRE AND CABLE

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. Comtran Corporation.
 - 2. Draka Cableteq USA.
 - 3. Genesis Cable Products; Honeywell International, Inc.
 - 4. Rockbestos-Suprenant Cable Corp.
 - 5. West Penn Wire; a brand of Belden Inc.
- B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.
- C. Signaling Line Circuits: Size as recommended by system manufacturer, but not less than No. 16 AWG. Use twisted, shielded pair where recommended by system manufacturer.
 - 1. Circuit Integrity Cable: Twisted shielded pair, NFPA 70, Article 760, Classification CI, for power-limited fire alarm signal service Type FPL. NRTL listed and labeled as complying with UL 1424 and UL 2196 for a 2-hour rating.
- 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.
 - 3. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, NRTL listed for fire alarm and cable tray installation, plenum rated, and complying with requirements in UL 2196 for a 2-hour rating.

2.5 IDENTIFICATION PRODUCTS

- A. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:
 - 1. 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."

PART 3 - EXECUTION

3.1 INSTALLATION OF PATHWAYS

- A. Comply with TIA-569-B 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.

3.2 INSTALLATION OF HANGERS AND SUPPORTS

- A. Comply with requirements in Division 26 Section "Hangers and Supports for Electrical Systems." for installation of supports for pathways, conductors and cables.

3.3 WIRING METHOD

- A. Install wiring in metal raceways and wireways. Conceal raceway except in unfinished spaces and as indicated. Minimum conduit size shall be ½ inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- B. Install wiring in raceways except in accessible indoor ceiling spaces and in interior hollow gypsum board partitions where cable may be used. Conceal raceways and wiring except in unfinished spaces and as indicated. Minimum conduit size shall be ½ inch. Control and data transmission wiring shall not share conduit with other building wiring systems.
- C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Use lacing bars and distribution spools. Separate power-limited and non-power-limited conductors as recommended in writing by manufacturer. Install conductors parallel with or at right angles to sides and back of enclosure. Connect conductors that are terminated, spliced, or interrupted in any enclosure associated with intrusion system to terminal blocks. Mark each terminal according to system's wiring diagrams. Make all connections with approved crimp-on terminal spade lugs, pressure-type terminal blocks, or plug connectors.

3.4 INSTALLATION OF CONDUCTORS AND CABLES

- A. Comply with NECA 1.
- B. Conductors: Size according to system manufacturer's written instructions unless otherwise indicated.

C. General Requirements for Cabling:

1. 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.
2. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
3. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. Open-Cable Installation:

1. Suspend copper cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1525 mm) apart.
2. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

3.5 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. 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. Fire-Rated Cables: Use of 2-hour, fire-rated fire alarm cables, NFPA 70, Types MI and CI, is permitted.
3. Signaling Line Circuits: Power-limited fire alarm cables shall not be installed in the same cable or raceway as signaling line circuits.

C. 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.

D. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

E. 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.

F. Risers: Install at least two vertical cable risers to serve the fire alarm system. Separate risers in close proximity to each other with a minimum one-hour-rated wall, so the loss of one riser does not prevent the receipt or transmission of signals from other floors or zones.

- G. Wiring to Remote Alarm Transmitting Device: 1-inch (25-mm) 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.

3.6 POWER AND CONTROL-CIRCUIT CONDUCTORS

- A. 120-V Power Wiring: Install according to Division 26 Section "Low-Voltage Electrical Power Conductors and Cables" unless otherwise indicated.
- B. 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.

3.7 CONNECTIONS

- A. Comply with requirements in Division 28 Section "Perimeter Security Systems" for connecting, terminating, and identifying wires and cables.
- B. Comply with requirements in Division 28 Section "Intrusion Detection" for connecting, terminating, and identifying wires and cables.
- C. Comply with requirements in Division 28 Section "Access Control" for connecting, terminating, and identifying wires and cables.
- D. Comply with requirements in Division 28 Section "Video Surveillance" for connecting, terminating, and identifying wires and cables.
- E. Comply with requirements in Division 28 Section "Digital Addressable Fire-Alarm System" for connecting, terminating, and identifying wires and cables.

3.8 FIRESTOPPING

- A. Comply with requirements in Division 07.
- B. Comply with TIA-569-B, "Firestopping" Annex A.
- C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.9 GROUNDING

- A. For low-voltage wiring and cabling, comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems."

3.10 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."

3.11 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. Test cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors.
- 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. Cabling will be considered defective if it does not pass tests and inspections.
- E. Prepare test and inspection reports.

END OF SECTION 280513

SECTION 283111-DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

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. Fire-alarm control unit.
 - 2. Manual fire-alarm boxes.
 - 3. System smoke detectors.
 - 4. Heat detectors.
 - 5. Notification appliances.
 - 6. Magnetic door holders.
 - 7. Remote annunciator.
 - 8. Addressable interface device.
 - 9. Digital alarm communicator transmitter.

1.3 DEFINITIONS

- A. LED: Light-emitting diode.
- B. NICET: National Institute for Certification in Engineering Technologies.

1.4 SYSTEM DESCRIPTION

- A. Noncoded addressable system, with automatic sensitivity control of certain smoke detectors and multiplexed signal transmission, dedicated to fire-alarm service only.

1.5 PERFORMANCE REQUIREMENTS

- A. Seismic Performance: Fire-alarm control unit and raceways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.
 - 1. The term "withstand" means "the unit will remain in place without separation of any parts from the device when subjected to the seismic forces specified and the unit will be fully operational after the seismic event."

1.6 ACTION SUBMITTALS

- A. Product Data: For each type of product indicated.
- B. Shop Drawings: For fire-alarm system. 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 notification appliance circuits.
 3. Include battery-size calculations.
 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. Locate detectors according to manufacturer's written recommendations.
 6. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits.
- C. 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. NICET-certified fire-alarm technician.
 - c. Licensed or certified by authorities having jurisdiction.
- D. Seismic Qualification Certificates: For fire-alarm control unit, 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. 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 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.

F. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.7 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 single manufacturer.
- 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. NFPA Certification: Obtain certification according to NFPA 72 by a UL-listed alarm company.

1.8 PROJECT CONDITIONS

- A. Coordinate all device programming and addressing with the Owner.

1.9 SOFTWARE SERVICE AGREEMENT

- A. Comply with UL 864.
- B. Technical Support: Beginning with Substantial Completion, provide software support for two years.
- C. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion.

Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.10 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. Lamps for Remote Indicating Lamp Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than 1 unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than 1 unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than 1 unit of each type.
5. Keys and Tools: One extra set for access to locked and tamperproofed components.
6. Audible and Visual Notification Appliances: One of each type installed.
7. Fuses: Two of each type installed in the system.

PART 2 - PRODUCTS

2.1 MANUFACTURERS

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

1. Notifier.
2. GAMEWELL; a Honeywell company.
3. Siemens.

2.2 SYSTEMS OPERATIONAL DESCRIPTION

A. Fire-alarm signal initiation shall be by one or more of the following devices and systems:

1. Manual stations.
2. Heat detectors.
3. Smoke detectors.
4. Duct smoke detectors.
5. Verified automatic alarm operation of smoke detectors.
6. Automatic sprinkler system water flow.
7. Heat detectors in elevator shaft and pit.
8. Fire-extinguishing system operation.
9. Fire standpipe system.

- B. Fire-alarm signal shall initiate the following actions:
1. Continuously operate alarm notification appliances.
 2. Identify alarm at fire-alarm control unit and remote annunciators.
 3. Transmit an alarm signal to the remote alarm receiving station.
 4. Release fire and smoke doors held open by magnetic door holders.
 5. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
 6. Close smoke dampers in air ducts of designated air-conditioning duct systems.
 7. Recall elevators to primary or alternate recall floors.
 8. Activate emergency shutoffs for gas and fuel supplies.
 9. Record events in the system memory.
- C. Supervisory signal initiation shall be by one or more of the following devices and actions:
1. Valve supervisory switch.
 2. Low-air-pressure switch of a dry-pipe sprinkler system.
 3. Elevator shunt-trip supervision.
- D. System trouble signal initiation shall be by one or more of the following devices and actions:
1. Open circuits, shorts, and grounds in designated circuits.
 2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
 3. Loss of primary power at fire-alarm control unit.
 4. Ground or a single break in fire-alarm control unit internal circuits.
 5. Abnormal ac voltage at fire-alarm control unit.
 6. Break in standby battery circuitry.
 7. Failure of battery charging.
 8. Abnormal position of any switch at fire-alarm control unit or annunciator.
 9. Fire-pump power failure, including a dead-phase or phase-reversal condition.
 10. Low-air-pressure switch operation on a dry-pipe or preaction sprinkler system.
- E. System Trouble and Supervisory Signal Actions: Initiate notification appliance and annunciate at fire-alarm control unit and remote annunciators. Transmit a trouble or supervisory signal to the remote alarm receiving station.

2.3 FIRE-ALARM CONTROL UNIT

- A. General Requirements for Fire-Alarm Control Unit:
1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864 and listed and labeled by an NRTL.
 - a. System software and programs shall be held in flash electrically erasable programmable read-only memory (EEPROM), retaining the information through failure of primary and secondary power supplies.
 - b. Include a real-time clock for time annotation of events on the event recorder.

2. Addressable initiation devices that communicate device identity and status.
 - a. Smoke sensors shall additionally communicate sensitivity setting and allow for adjustment of sensitivity at fire-alarm control unit.
 - b. Temperature sensors shall additionally test for and communicate the sensitivity range of the device.
 3. Addressable control circuits for operation of mechanical equipment.
- B. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.
1. Annunciator and Display: Liquid-crystal type, 2 line(s) of 40 characters, minimum.
 2. Keypad: Arranged to permit entry and execution of programming, display, and control commands and to indicate control commands to be entered into the system for control of smoke-detector sensitivity and other parameters.
- C. Circuits:
1. Initiating Device, Notification Appliance, and Signaling Line Circuits: NFPA 72, Class A.
 - a. Notification Appliance Circuits: Style Z.
 - b. Signaling Line Circuits: Style 6.
 - c. Install no more than 50 addressable devices on each signaling line circuit.
 2. Serial Interfaces: Two RS-232 ports for printers.
- D. Smoke-Alarm Verification:
1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
 2. Activate an NRTL-listed and -approved "alarm-verification" sequence at fire-alarm control unit and detector.
 3. Sound general alarm if the alarm is verified.
 4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.
- E. Elevator Recall:
1. Smoke detectors at the following locations shall initiate automatic elevator recall.
 - a. Elevator lobby detectors except the lobby detector on the designated floor.
 - b. Smoke detector in elevator machine room.
 - c. Smoke detectors in elevator hoistway.
 2. Elevator lobby detectors located on the designated recall floors shall be programmed to move the cars to the alternate recall floor.
 3. Water-flow alarm connected to sprinkler in an elevator shaft and elevator machine room shall shut down elevators associated with the location without time delay.

- a. Water-flow switch associated with the sprinkler in the elevator pit may have a delay to allow elevators to move to the designated floor.
- F. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke barrier walls shall be connected to fire-alarm system.
- G. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory, and print out the final adjusted values on system printer.
- H. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.
- I. Primary Power: 24-V dc obtained from 120-V ac service and a power-supply module. Initiating devices, notification appliances, signaling lines, trouble signals, supervisory and digital alarm communicator transmitters shall be powered by 24-V dc source.
 1. Alarm current draw of entire fire-alarm system shall not exceed 80 percent of the power-supply module rating.
- J. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.
 1. Batteries: Sealed lead calcium.
- K. Instructions: Computer printout or typewritten instruction card mounted behind a plastic or glass cover in a stainless-steel or aluminum frame. Include interpretation and describe appropriate response for displays and signals. Briefly describe the functional operation of the system under normal, alarm, and trouble conditions.

2.4 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. Single-action mechanism, type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
 2. Station Reset: Key- or wrench-operated switch.
 3. Indoor Protective Shield: Factory-fabricated clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.

2.5 SYSTEM SMOKE DETECTORS

A. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be two-wire type.
3. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
4. 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.
5. Self-Restoring: Detectors do not require resetting or readjustment after actuation to restore them to normal operation.
6. Integral Visual-Indicating Light: LED type indicating detector has operated and power-on status.
7. Remote Control: Unless otherwise indicated, detectors shall be analog-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.
 - a. 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. Fixed-temperature sensing shall be independent of rate-of-rise sensing and shall be settable at fire-alarm control unit to operate at **135 or 155 deg F (57 or 68 deg C)**.
 - c. Provide multiple levels of detection sensitivity for each sensor.

B. Photoelectric Smoke Detectors:

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.
 - d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).

C. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:
 - a. Primary status.
 - b. Device type.
 - c. Present average value.

- d. Present sensitivity selected.
 - e. Sensor range (normal, dirty, etc.).
3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector.
 4. Each sensor shall have multiple levels of detection sensitivity.
 5. Sampling Tubes: Design and dimensions as recommended by manufacturer for specific duct size, air velocity, and installation conditions where applied.
 6. Relay Fan Shutdown: Rated to interrupt fan motor-control circuit.

2.6 HEAT DETECTORS

- A. General Requirements for Heat Detectors: Comply with UL 521.
- B. Heat Detector, Combination Type: Actuated by either a fixed temperature of **135 deg F (57 deg C)** or a rate of rise that exceeds **15 deg F (8 deg C)** per minute unless otherwise indicated.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.
- C. Heat Detector, Fixed-Temperature Type: Actuated by temperature that exceeds a fixed temperature of **190 deg F (88 deg C)**.
 1. Mounting: Twist-lock base interchangeable with smoke-detector bases.
 2. Integral Addressable Module: Arranged to communicate detector status (normal, alarm, or trouble) to fire-alarm control unit.

2.7 NOTIFICATION APPLIANCES

- A. General Requirements for Notification Appliances: Connected to notification appliance signal circuits, zoned as indicated, equipped for mounting as indicated and with screw terminals for system connections.
 1. Combination Devices: Factory-integrated audible and visible devices in a single-mounting assembly, equipped for mounting as indicated and with screw terminals for system connections.
- B. Horns: Electric-vibrating-polarized type, 24-V dc; with provision for housing the operating mechanism behind a grille. Comply with UL 464. Horns shall produce a sound-pressure level of 90 dBA, measured **10 feet (3 m)** from the horn, using the coded signal prescribed in UL 464 test protocol.
- C. 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.

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.
6. Mounting Faceplate: Factory finished, [red] [white].

2.8 MAGNETIC DOOR HOLDERS

- A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.
 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.
 4. Rating: 120-V ac.
- B. Material and Finish: Match door hardware.

2.9 REMOTE ANNUNCIATOR

- A. Description: Annunciator functions shall match those of fire-alarm control unit for alarm, supervisory, and trouble indications. Manual switching functions shall match those of fire-alarm control unit, including acknowledging, silencing, resetting, and testing.
 1. Mounting: Flush cabinet, NEMA 250, Type 1.
- B. Display Type and Functional Performance: Alphanumeric display and LED indicating lights shall match those of fire-alarm control unit. Provide controls to acknowledge, silence, reset, and test functions for alarm, supervisory, and trouble signals.

2.10 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.
- B. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall to circuit-breaker shunt trip for power shutdown.

2.11 DIGITAL ALARM COMMUNICATOR TRANSMITTER

- A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632 and be listed and labeled by an NRTL.

- B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture two telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.
- C. Local functions and display at the digital alarm communicator transmitter shall include the following:
 - 1. Verification that both telephone lines are available.
 - 2. Programming device.
 - 3. LED display.
 - 4. Manual test report function and manual transmission clear indication.
 - 5. Communications failure with the central station or fire-alarm control unit.
- D. Digital data transmission shall include the following:
 - 1. Address of the alarm-initiating device.
 - 2. Address of the supervisory signal.
 - 3. Address of the trouble-initiating device.
 - 4. Loss of ac supply or loss of power.
 - 5. Low battery.
 - 6. Abnormal test signal.
 - 7. Communication bus failure.
- E. Secondary Power: Integral rechargeable battery and automatic charger.
- F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.12 DEVICE GUARDS

- A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.
 - 1. Factory fabricated and furnished by manufacturer of device.
 - 2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.1 EQUIPMENT INSTALLATION

- A. Comply with NFPA 72 for installation of fire-alarm equipment.

- B. Install wall-mounted equipment, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
 - 1. Comply with requirements for seismic-restraint devices specified in Section 260548 "Vibration and Seismic Controls for Electrical Systems."
- C. 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 or Appendix B 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.
- D. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct.
- E. Heat Detectors in Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location.
- F. 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.
- G. 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.
- H. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least **6 inches (150 mm)** below the ceiling.
- I. Device Location-Indicating Lights: Locate in public space near the device they monitor.
- J. Fire-Alarm Control Unit: Surface mounted, with tops of cabinets not more than **72 inches (1830 mm)** above the finished floor.
- K. Annunciator: Install with top of panel not more than **72 inches (1830 mm)** above the finished floor.

3.2 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 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.
 5. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
 6. Supervisory connections at valve supervisory switches.
 7. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
 8. Supervisory connections at elevator shunt trip breaker.
 9. Supervisory connections at fire-pump power failure including a dead-phase or phase-reversal condition.
 10. Supervisory connections at fire-pump engine control panel.

3.3 IDENTIFICATION

- A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 260553 "Identification for Electrical Systems."
- B. Install framed instructions in a location visible from fire-alarm control unit.

3.4 GROUNDING

- A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

3.5 FIELD QUALITY CONTROL

- A. Field tests shall be witnessed by Owner's representative.
- 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. 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 visible appliances for the public operating mode according to manufacturer's written instructions.
 5. 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.
- D. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.
- E. Fire-alarm system will be considered defective if it does not pass tests and inspections.
- F. Prepare test and inspection reports.

3.6 DEMONSTRATION

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

END OF SECTION 283111

SECTION 312000 EARTH MOVING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Work included under this Section includes, but is not limited to, providing all labor, materials, equipment, and incidentals to conduct and complete the Work related to the planned building, parking, structures, lawn areas, utilities and site improvements as specified herein and shown on the Drawings.
1. Excavate all materials, including soil, boulders, abandoned utilities, existing and previous building foundations, pavements, curbs, granite blocks, and all other materials as necessary to construct the building improvements shown on the Drawings, and as specified in the Geotechnical Report.
 2. The CONTRACTOR shall be solely responsible for impacts and damage to structures due to his/her work, and for corrective action or repairs needed to restore the structure(s) to its original condition at no additional cost to the OWNER. Where structures are adversely affected by construction operations, they shall be repaired, restored and replaced in accordance with the requirements outlined herein.
 3. The CONTRACTOR shall note that over-excavation, site preparation and placement of fill is required. Contractor shall conduct work per recommendations of the geotechnical report.
 4. Handle, process, re-handle, segregate, and stockpile materials during the course of the Work. Existing on-site materials may require processing prior to reuse. Processing may include crushing, blending, screening, and other measures to meet the requirements herein and as directed by the ENGINEER. Only those soils and other materials approved by the ENGINEER shall be reused on-site.
 5. Prepare, grade, shape, compact and protect all subgrades, backfills, and ground surfaces shown on the Drawings.
 6. Dewater as necessary to enable construction of site improvements, including backfilling, in-the-dry. The CONTRACTOR shall be responsible for control, pumping, and legal disposal of groundwater, precipitation, or other water which enters or accumulates in excavations to maintain stable subgrades and allow all below-grade construction to be conducted in-the-dry.
 7. Provide, place, moisture condition, compact, and grade fill, backfill and other materials to the horizontal and vertical limits to construct the proposed site improvements and achieve the lines and grades as shown on the Drawings.
 8. Place plastic separators, vapor barriers, mudmats, and geotextiles as necessary and as specified in Geotechnical Report.

9. Install foundation drainage system elements at the locations shown on the Drawings.
10. Preserve and protect existing structures and utilities and new site improvements during the course of the Work.
11. Manage and legally dispose off-site all excess excavated materials, including, but not limited to, soil, rock, boulders, water, demolition waste, and debris that cannot be reused on-site. Contractor shall note the presence of debris and ash detected in boring logs. Contractor shall provide testing of soils as necessary for disposal per local, state, and federal regulations.
12. Obtain, maintain and pay for all required permits, licenses, and approvals prior to commencing the Work of this and other related Sections.
13. Provide and install erosion control during the Work as indicated on the Drawings, as required in the Specifications, and in accordance with applicable regulations and permits.
14. The CONTRACTOR shall be solely responsible for impacts and damage to any existing structures due to their Work, and for corrective action or repairs needed to restore the structure(s) to original condition at no additional cost to the OWNER.
15. Complete required compaction tests and provide minimum thicknesses of gravel under pavement and slabs, and reach minimum required compaction values.
16. Furnish and place all additional fill as required to complete work for contract.
17. Removal of all unsuitable material from site.
18. Removal of all abandoned utility lines incidental to work.

1.2 RELATED REFERENCES

- A. Specification Sections:
 1. Selective Site Demolition: Section 024113
 2. Dewatering: Section 312319
 3. Erosion and Sedimentation Control: Section 312513
- B. State of Maine Department of Transportation "Standard Specifications", most recent revision
- C. State of Maine Department of Transportation "Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications", most recent revision
- D. Manual of Accident Prevention in Construction - Associated General Contractors of America, Inc.

- E. 29 CFR 1926/1910 - OSHA Safety and Health Standards for Construction Industry
- F. Standard Specifications for Highways and Bridges - Maine Department of Transportation, current edition
- G. Maine Construction General Permit (MCGP), Effective July 21, 2006.
- H. Geotechnical Investigation., see attachment.

1.3 PROTECTION

- A. Paved Surfaces: Do not operate equipment that will cause damage on paved surfaces. Any damage to existing roads or other paved surfaces caused by construction equipment shall be repaired at no additional cost to OWNER.
- B. Maintain excavations with approved barricades, lights, and signs to protect life and property until excavation is filled and graded to a condition acceptable to the PROJECT ARCHITECT and ENGINEER.
- C. Protect structures, utilities, property monuments, and other facilities from damage caused by settlement, lateral movement, undermining, washout, and other hazards created by earthwork operations. The CONTRACTOR shall be responsible for actual cost of repair or replacement of any items damaged as a result of construction activities, including any professional services required for inspection of repairs and replacement.

1.4 QUALITY ASSURANCE

- A. Testing and Inspection: CONTRACTOR shall be responsible for all testing, unless otherwise noted. The cost for retesting due to failed tests shall be the responsibility of the CONTRACTOR.
- B. The ENGINEER will observe the CONTRACTOR'S earthwork activities, including excavation, dewatering, subgrade preparation, backfilling and on-site reuse of excavated materials. The Contractor shall provide sufficient notice to the ENGINEER to allow the ENGINEER to be present to observe the Work.
- C. The ENGINEER will conduct field and laboratory density testing of placed and compacted soils to confirm compliance with the requirements of this Section. Field and laboratory density testing will be conducted in general conformance with ASTM or other applicable reference standards. The CONTRACTOR shall cooperate with the ENGINEER in all respects to facilitate any testing or observations.
- D. The CONTRACTOR shall not place or compact any fill, prepare subgrades or place concrete on bearing surfaces unless the ENGINEER is present to observe the Work. Materials placed and/or compacted which do not conform to project specifications for the area, shall be removed and replaced with appropriate, suitable material when directed by the OWNER or the ENGINEER at no additional cost to the OWNER. Costs related to testing or replacement of nonconforming Work or materials, and/or delays caused by nonconforming Work or materials, shall be paid for by the CONTRACTOR at no additional cost to the OWNER.

- E. The presence of the ENGINEER shall not relieve the CONTRACTOR of its responsibility to perform the Work in accordance with the Contract Documents, nor shall it be construed to relieve the CONTRACTOR from full responsibility for the means and methods of construction, protection of site improvements against damage, and for safety on the construction site. The CONTRACTOR shall comply with all applicable laws, rules, ordinances and regulations of the Federal Government, the State of Maine, and the City of Portland, governing the transportation, storage, handling and use of explosives. All labor, materials, equipment and services necessary to make the blasting operations comply with such requirements shall be provided without additional cost to the Owner.
- F. The CONTRACTOR shall adhere to the applicable requirements of the specifications, OSHA Standards and to all other applicable ordinances, codes, statutory rules, and regulations of federal, state, and local authorities having jurisdiction over the Work of this Section.
- G. The CONTRACTOR may conduct additional field and laboratory testing or screening tests for its own information at no additional cost to the OWNER.
- H. In case of conflict between regulations or between regulations and Specifications, the CONTRACTOR shall comply with the strictest applicable codes, regulations, or Specifications.

1.5 JOB AND SUBSURFACE CONDITIONS

- A. Site Information: A geotechnical investigation was completed for this project. A copy of the report and associated borings is attached to these specifications.

The CONTRACTOR may make his own borings, hand probes, explorations, and observations to determine soil, water levels, and other subsurface conditions at no additional cost to OWNER. Coordinate with OWNER prior to start of additional investigative work.

- B. Existing Utilities: Locate existing underground utilities in areas of excavation work. If utilities are indicated to remain in place, provide adequate means of support and protection during earthwork operations. Coordinate with utility companies for actual locations and shut-off services. If utilities are encountered that are not shown or that are shown incorrectly on the Drawings, notify PROJECT ARCHITECT immediately. Repair damaged utilities to satisfaction of PROJECT ARCHITECT and utility.

1.6 SUBMITTALS

- A. Excavation and Backfilling
 - 1. A narrative and drawings (plans and elevations at 1 in.= 40 ft scale) describing the schedule, construction sequence and procedures for excavation, subgrade preparations, foundation construction, cold weather subgrade protection, backfilling, dewatering, soil handling, stockpiling and other related activities.
 - 2. Details of proposed backfill materials and equipment.

3. Proposed types and sources of all off-site fill materials, including topsoil. For each type of soil to be utilized as fill or backfill, the CONTRACTOR shall deliver on 50-lb. bag sample from each borrow source or supplier to the ENGINEER'S laboratory for review and laboratory testing. Do not import any material to the site unless accepted by the ENGINEER. With each sample provide the following documentation:
 - a. Location of the borrow source site.
 - b. Present and past usage of the source site material.
 - c. All previously existing report(s) associated with an assessment of the source site as related to the presence of oil or hazardous materials.
 - d. If materials are suspected of containing oil and/or hazardous materials based on the ENGINEER'S review of the submitted data described above, the CONTRACTOR shall submit the following chemical test data on the material. The cost of any required testing shall be borne entirely by the CONTRACTOR. The ENGINEER will review the data and determine its acceptability for use on site.
4. For use of filter fabrics and foundation drain piping, submit manufacturer's literature for approval by the ENGINEER.
5. Details regarding proposed dewatering procedures including general approach to dewatering; equipment; pumping locations; discharge locations; means for preventing the pumping of fines from subgrade soils; means for controlling suspended solids in effluent.
6. Copies of Contractor's erosion & sediment control inspections and Notice of Termination demonstrating compliance with the requirements of the Construction General Permit.

1.7 LINES, GRADES AND TOLERANCES

- A. The CONTRACTOR shall be responsible for establishing all lines, grades and other survey control to complete the Work as shown on the Drawings.
- B. Maintain the moisture content of backfill materials as necessary to allow for the material to be readily placed to the degree of compaction specified herein.
- C. Construct finished soil and backfill surfaces to the elevations indicated on the Drawings.
- D. Compact backfill materials to the specified degree of compaction.

PART 2 MATERIALS

2.1 MATERIALS

- A. General: All materials utilized for this Project shall be obtained from a source that has been licensed or permitted for such use by local and state authorities. The CONTRACTOR shall be required to submit evidence of such if so requested.
1. Suitable materials: Suitable soil materials are defined as those complying with ASTM D2487 soil classification groups GW, SM, SW, and SP, or as required by Geotechnical Report.
 2. Unsuitable materials: Materials containing excessive amounts of water, blue clay, vegetation, organic matter, debris, pavement, stones or boulders over 6-inches in greatest dimension, frozen material, and material which, in the opinion of the ENGINEER, will not provide a suitable foundation or subgrade.
 3. On-Site Material: Any suitable material from on-site excavation.
 4. Material for embankments and general site fills may contain pieces of excavated ledge having a greatest dimension of up to 6-inches, unless otherwise approved by ENGINEER.
 5. Inspection: The ENGINEER may inspect off-site sources of materials and order tests of these materials to verify compliance with these Specifications.
 6. Sieve Analysis: Submit sieve analysis in accordance with ASTM D422 for all materials prior to start of construction.
- B. Gravel/Aggregate Base: Hard, durable gravel equal to MDOT 703.06 Type A or Type B material as specified on the drawings. Sieve analyses by weight:

Type A Aggregate Base

<u>Sieve Size</u>	<u>% Passing by Weight</u>
2"	100
1/2"	45 - 70
1/4"	30 - 55
No. 40	0 - 20
No. 200	0 - 5

Type B Aggregate Base

<u>Sieve Size</u>	<u>% Passing by Weight</u>
4"	100
1/2"	35 - 75
1/4"	25 - 60
No. 40	0 - 25
No. 200	0 - 5

- C. Aggregate Subbase: Sand or gravel of hard, durable particles; equal to MDOT 703.06 Type D material. Aggregate subbase shall not contain particles that will not pass the 6-inch sieve. The part that passes the 3-inch sieve shall meet the following gradation requirements:

<u>Sieve Size</u>	<u>% Passing by Weight</u>
1/4"	25 – 70
No. 40	0 – 30
No. 200	0 – 7

- D. Granular Borrow: a sand, silty sand, or sand and gravel meeting the requirements of MDOT Specification 703.19 ‘Granular Borrow.’ Granular borrow shall be used in locations as identified in the Construction Documents, and as referenced in Geotechnical Report.

- E. Structural Fill: Clean, non-frost susceptible, sand and gravel, free of organics and other deleterious materials, meeting the following gradation:

<u>Sieve Size</u>	<u>% Passing by Weight</u>
4 inch	100
3 inch	90 to 100
¼ inch	25 to 90
No. 40	0 to 30
No. 200	0 to 5

Structural Fill shall be used for backfill for exterior side of perimeter foundations; slab base material; backfill within frost transition zone for entrance walks to buildings; backfill for repair of soft or yielding areas; and in other locations as identified in the Construction Documents and Geotechnical Report.

- F. 3/4" Crushed Stone: Durable, clean angular rock fragments obtained by breaking and crushing rock material. Gradation shall be:

<u>Sieve Size</u>	<u>% Passing by Weight</u>
1"	100
3/4"	90 – 100
3/8"	20 – 55
No. 4	0 – 10
No. 200	0 – 1.5

Crushed stone shall be used for backfill for installation of utility pipes; roof drip edges where specified; and in other locations as identified in the Construction Documents.

- G. Sand: Sand shall be well-graded coarse sand without excessive fines and free from loam, clay, and organic matter. Beach sand shall not be used. The grading requirements are as follows:

<u>Sieve Size</u>	<u>% Passing by Weight</u>
3/8"	100
No. 4	95 – 100
No. 16	50 – 85
No. 50	10 – 30
No. 100	2 – 10

- H. River Rock: Use rounded stone sized D50 equal to 6 inches. Stone shall be approved by ENGINEER prior to installation. River rock shall be used for roof drip edges and in other locations as identified in the Construction Documents.
- I. Refill Material: Use 3/4" crushed stone for refilling excavation below normal grade, rock excavation or refilling excavations of unsuitable material, unless otherwise directed by ENGINEER.
- J. Fabric Protection Layer: As specified on the Contract Plans.

PART 3 EXECUTION

3.1 GENERAL

- A. CONTRACTOR shall coordinate all activities with the City of Portland and the OWNER. If sidewalk closures or parking restrictions are necessary to complete the work, CONTRACTOR shall be responsible for obtaining approval and permits from City of Portland as well as paying any associated fees.
- B. CONTRACTOR shall provide and maintain erosion & sedimentation controls in compliance with the Construction General Permit. Contractor shall provide inspections per requirements of the Construction General Permit and complete the Notice of Termination upon completion of earth disturbing activities.

3.2 EXCAVATION

- A. General: Excavation shall include the removal of all encountered materials, including but not limited to, soil, boulders, asphalt pavement, concrete (reinforced and unreinforced), miscellaneous debris, buried and abandoned foundations and utilities, site improvements, incidental structures and all other materials encountered to the limits shown on the Drawings, or designated in the Specifications. Where excavations are required to be made into the Zone of Influence (ZOI) below an existing or new foundation, utility or other structure, CONTRACTOR shall be responsible for having excavation and bracing system, underpinning, or other system designed by Professional Engineer licensed in the State of Maine to: 1) provide support to protect the soil within the ZOI from loosening and becoming disturbed, and 2) protect the structure from movement. The ZOI beneath a structure or utility is defined by imaginary lines extending outward 2 ft laterally beyond the bottom edge of a footing or from the springline of a utility and down on a one horizontal to one vertical (1H:1V) slope to the top of the natural inorganic bearing soils. Soils located within the zone of influence provide foundation support. Excavation and backfilling shall be performed in the day.
- B. Call Dig Safe prior to beginning any excavation.

- C. Rock Excavation includes removal and disposal of materials and obstructions encountered that cannot be excavated with modern, track-mounted, heavy-duty excavating equipment without drilling, blasting, or ripping; includes boulders larger than 2 cubic yards each.

Do not perform rock excavation or excavation of unsuitable materials until material to be excavated has been cross-sectioned and classified by ENGINEER.

- D. Earth Excavation: Remove and dispose of obstructions visible on ground surface, underground structures, utilities, and items indicated to be demolished and removed, and other materials encountered that are not classified as rock excavation or unauthorized excavation.
- E. Excavation in Paved Areas: Cut pavement prior to excavation to provide a clean, uniform edge. Minimize disturbance of remaining pavement. Cut and remove the minimum amount of pavement required to do the Work. Use shoring and bracing where sides of excavation will not stand without undermining pavement.
- F. Excavation for Structures: Over-excavate, handle, process, segregate, and stockpile soils per recommendations of Geotechnical Report. Conform to elevations and dimensions shown within a tolerance of plus or minus 0.10 foot, and extending a sufficient distance from foundations to permit placing and removal of concrete formwork, installation of services, other construction, and for inspection.

Use shoring and bracing as required by OSHA standards.

- G. Excavation for Utility Trenches: Excavate to widths shown on the Drawings and depths indicated or required to establish indicated slope and invert elevations. Produce an evenly graded, flat trench bottom at the subgrade elevation required for installation of pipe and bedding material. Place backfill material directly into trench or excavation. Do not stockpile material to be used as backfill along edges of trenches. Load excavated material directly into trucks, unless otherwise permitted by the ENGINEER.
- H. Unauthorized Excavation: Removal of materials beyond indicated subgrade elevations or dimensions without specific direction of PROJECT ARCHITECT. Unauthorized excavation, as well as remedial work directed by PROJECT ARCHITECT, including refilling, shall be at CONTRACTOR's expense.
- I. Refilling Unauthorized Excavation: For trenches, use 3/4-inch crushed stone. Elsewhere, backfill and compact unauthorized excavations as specified for authorized excavations of same classification, unless otherwise directed by PROJECT ARCHITECT.
- J. Excavation of Unsuitable Materials: When excavation has reached required subgrade elevations, notify PROJECT ARCHITECT and ENGINEER who will make an inspection of conditions. If unsuitable bearing materials are encountered at required subgrade elevations, carry excavations deeper only at the direction of the PROJECT ARCHITECT and ENGINEER and replace excavated material as specified.
- K. Material Storage: Stockpile and maintain suitable surplus excavated materials for re-use as backfill within the Project limits, as directed by PROJECT ARCHITECT and ENGINEER. Place, grade, and shape stockpiles for proper drainage. Locate and retain soil materials away from edge of excavations.

3.3 BLASTING

- A. General: CONTRACTOR shall obtain approval of OWNER, PROJECT ARCHITECT, and City of Portland before blasting.
- B. Pre-blast Survey shall be the responsibility of the CONTRACTOR. Provide pre-blast survey prior to any blasting or blasting related operations. A written report of the preblast survey will be provided to the OWNER and PROJECT ARCHITECT by the CONTRACTOR and will be available for review by the City of Portland. A copy of the blasting plan will be submitted to the City of Portland, OWNER and PROJECT ARCHITECT for review and approval prior to the initiation of the site preparation work.
- C. All owners of dwellings or residences located within 500-feet of the blasting location shall be notified, in writing, by the CONTRACTOR a minimum of 30 days prior to the scheduled blasting date about the proposed blasting and how to request a pre-blast survey. Upon request, the CONTRACTOR shall determine the pre-blasting condition of any structure located within this area and prepare a written report. The pre-blast survey shall be limited to the surface conditions of the structures but shall comply in all respects with 30 CFR, Chapter VII, Section 816.62.
 1. Pre-blast Survey shall include, but not be limited to:
 - a. Video tape of each structure within 500-feet of the blasting location to show pre-blast conditions. Highlight existing defects in structures and pavements. Provide some means of establishing scale of existing defects (i.e., include tape measure or folding ruler at defect during video taping).
 - b. Video taping shall be done with commercial grade equipment to allow equipment still viewing without distortion of the viewed area.
 - c. Still photos and videotapes shall be retained by the pre-blast surveyor and shall be available for viewing by the OWNER and PROJECT ARCHITECT within 24 hours upon request.
 2. A blasting plan shall be prepared which addresses:
 - a. Airblast Limits
 - b. Ground Vibrations
 - c. Maximum Peak Particle Velocity
 3. The blasting plan shall meet criteria established in Chapter 3 (Control of Adverse Effects) in the Blasting Guidance Manual of the United States Department of the Interior Office of Surface Mining Reclamation and Enforcement.
 4. Provisions and measures to monitor and assure compliance with the blasting plan.
 5. The blasting plan and preblast survey shall conform to all recommendations of the project geotechnical report and supplemental geotechnical evaluations included in these Specifications.

- D. Particle Velocities: Maximum allowable peak particle velocity shall be limited to 1.25 inches per second within 300 feet of the blast site. Monitor at location designated by OWNER.
- E. Documentation: Submit an accurate record of the blasting operation to the PROJECT ARCHITECT. A copy should be retained by the blasting firm for at least 3 years. This record shall consist of the following information as listed in 30 CFR, Chapter VII, Section 816.68.
1. Name of the firm conducting the blast.
 2. Location, date, and time of the blast.
 3. Name, signature, and certification number of the blaster conducting the blast.
 4. Identification, direction, and distance, in feet, from the nearest blast hole to the nearest dwelling, public building, school, church, community or institutional building outside the project area.
 5. Weather conditions, including those that may cause possible adverse blasting effects.
 6. Type of material blasted.
 7. Sketches of the blast pattern including number of holes, burden, spacing, decks, and delay pattern.
 8. Diameter and depth of holes.
 9. Types and total weight of explosives used.
 10. Mats or other protections used.
 11. Seismographic and airblast records, which shall include: type of instrument, sensitivity, and calibration signal or certification of annual calibration; exact location of instrument and the date, time, and distance from the blast; and the vibration and/or airblast level recorded.
- F. All blasting shall be performed in accordance with all pertinent provisions of the “Manual of Accident Prevention in Construction”, issued by the Associated General Contractors of America, Inc., of the “Construction Safety Rules and Regulations”, as adopted by the State Board of Construction Safety, Augusta, Maine, and the Maine Department of Transportation “Standard Specifications” Section 105.2.6, Use of Explosives. Blasting through the overburden will not be allowed.
- G. Drilling Equipment will be equipped with suitable dust control apparatus that must be kept in repair and used during all drilling operations.
- H. Open Blasting shall pertain to all blasting required for the placement of foundations and other project elements not specifically identified in paragraph H, Utility Trench Blasting.

Blasting for placement of underdrain piping and associated appurtenances depicted along building footings will be considered Open Blasting.

- I. Utility Trench Blasting shall pertain to all blasting required for the placement of any pipe, utility structure, or associated appurtenances. Utilities associated with the site shall include water distribution and service, sanitary sewer collection and service, storm sewer collection, underground electrical service, telecommunications, data, and geothermal related elements, as indicated on the drawings.

3.4 STABILITY OF EXCAVATIONS

- A. General: Slope sides of excavations shall comply with OSHA Regulations and Local Codes. Shore and brace where sloping is not possible due to space restrictions or stability of material excavated. Maintain sides and slopes of excavations in safe condition until completion of backfilling. Shoring and bracing shall be designed by a Professional Engineer licensed in the State of Maine.

3.5 DEWATERING

- A. General: Perform all Work in the dry. Prevent surface water and subsurface or groundwater from flowing into excavations and from flooding project site and surrounding area.
- B. Do not allow water to accumulate in excavations. Provide and maintain pumps, sumps, suction and discharge lines, and other dewatering system components necessary to convey water away from excavations.
- C. Establish and maintain temporary drainage ditches and other diversions outside excavation limits to convey water removed from excavations and rainwater to collecting or run-off areas. Do not use trench excavations as temporary drainage ditches.
- D. CONTRACTOR shall obtain necessary licenses from the City of Portland Public Works prior to directing dewatering into the City's combined sewer infrastructure.

3.6 SUBGRADE PREPARATION

- A. General
 - 1. Care shall be taken to avoid disturbance to subgrades.
 - 2. Provide a firm, smooth, stable, undisturbed subgrade as judged by the ENGINEER. Loose, disturbed soil shall be removed by hand shovel.
 - 3. Subgrades consisting of cohesive soils shall not be "backbladed" or compacted to prepare a smooth surface.
 - 4. Subgrades shall be prepared as recommended in the attached geotechnical report prepared by S.W. Cole.
 - 5. Movement of construction equipment directly over exposed final subgrades, except for compaction equipment, shall not be permitted.

6. The exposed subgrade will be examined in the field by the ENGINEER to observe the strength and bearing capacity of the soils. Disturbed or soft or unstable soils, as judged by the ENGINEER, shall be excavated and replaced with lean concrete, granular fill, or other acceptable materials at no additional cost to the Owner.
 7. Prevent soil subgrades from freezing and frost. Soil subgrades that freeze prior to concrete or backfill placement shall be thawed and recompact, or removed and replaced with non-frozen backfill, lean concrete or other acceptable material as directed by the PROJECT ARCHITECT.
 8. Excavations shall not undermine existing foundations, streets, sidewalks, or structures.
- B. Contaminated material shall be identified and disposed of per local, state, and federal regulations.

3.7 BACKFILL AND FILL

- A. General: Place suitable soil material in layers to required elevations as shown on the Drawings. Fill, backfill, and compact to produce minimum subsequent settlement of the material and provide adequate support for the surface treatment or structure to be placed on the material. Place material in approximately horizontal layers of beginning at lowest area to be filled. Do not impair drainage.
- B. Placement: Place backfill and fill materials in layers not more than 12-inches in loose depth for material compacted by heavy compaction equipment, and not more than 9-inches in loose depth for material compacted by hand-operated tampers. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

Place backfill and fill materials evenly adjacent to structures to required elevations. Take care to prevent wedging action of backfill against structures or displacement of piping or conduit by carrying material uniformly around structure, piping, or conduit to approximately same elevation in each lift.

Do not allow heavy machinery within 5 feet of structure during backfilling and compacting.

- C. Backfill excavations as promptly as work permits, but not until completion of the following:
1. Acceptance of construction below finish grade including dampproofing, and/or waterproofing.
 2. Inspection, approval and recording locations of underground utilities.
 3. Removal of concrete formwork.
 4. Removal of shoring and bracing, and backfilling of voids with suitable materials.
 5. Removal of trash and debris from excavation.

6. Permanent or temporary horizontal bracing is in place on horizontally supported walls.
7. Backfill cast-in-place concrete structures when the concrete has developed adequate strength.
8. Use care in backfilling to avoid damage or displacement of underground structures and pipe.

D. Backfilling Trenches: See Trench Detail on the Drawings.

Bed pipe in 3/4-inch crushed stone, unless otherwise indicated. Limits of bedding and requirements for remaining trench backfill shown on Drawings.

E. Replacement of Unsuitable Materials:

Below normal grade: See paragraph 3.2 J.

Above normal grade: Replace unsuitable material with suitable material from on-site. All excess suitable material must be used before additional material from off-site is used.

3.8 COMPACTION

A. Methods: Use methods which produce the required degree of compaction throughout the entire depth of material placed without damage to new or existing facilities and which are approved by the ENGINEER. Adjust moisture content of soil as required. Remove and replace material that is too wet to compact to required density. Compact each horizontal layer of fill and slope as Work progresses.

B. Degree of Compaction: Compact to the following minimum densities:

<u>FILL AND BACKFILL LOCATION</u>	<u>DENSITY</u>
Under structure foundations and slab on grade	95% of max.
Top 3 feet under pavement	95%
Below top 3 feet under pavement	92%
Structural fills	95%
Pipe Bedding	95%

Maximum density: ASTM D1557.

Field density tests: ASTM D1556 (sand cone) or ASTM D2167 (rubber balloon), or ASTM D2922 (nuclear methods).

C. Testing: In-place densities using field tests will be determined by the ENGINEER. Perform additional work to obtain proper compaction if in-place densities do not meet specified densities at no additional cost to the OWNER.

D. Protection of Fill

1. The CONTRACTOR shall take the necessary steps to avoid disturbance of subgrade and underlying soils during excavation and backfilling operations. Procedures for excavating and backfilling shall be revised as necessary to avoid disturbance of subgrade and underlying soils, including restricting the use of certain types of construction equipment and their movement over sensitive or unstable materials, dewatering, and other acceptable control measures. Disturbance shall include the deterioration of backfill (after placement and satisfactory compaction) due to the Contractor's operations, such as moving equipment, hauling trucks, etc. All excavated or backfilled areas or subgrades that become disturbed during construction shall be removed and replaced with acceptable materials.
2. Prevent materials below constructed foundations from freezing. Materials that become frozen shall be removed and replaced, including foundations, at no additional cost to the OWNER.
3. At the completion of Work, all ground surfaces shall be left in a firm, stable, unyielding, reasonably uniform condition, free of ruts and surface irregularities, in accordance with grading requirements shown on the Drawings.

3.9 GRADING

- A. Grading: Uniformly grade areas within limits of grading under this section, including adjacent transition areas. Smooth finish surface within specified tolerances and compact with uniform levels or slopes between points where elevations are shown, or between such points and existing grades.
- B. Grading Outside Structure Lines: Grade areas adjacent to structure to drain away from structures and to prevent ponding.
- C. Finish surfaces free from irregular surface changes and as follows:

Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10' above or below required subgrade elevations.

Pavements: Shape surface of areas under pavement to line, grade and cross-section, with finish surface not more than 1/2 inch above or below required subgrade elevation.

Fill Under Slabs: Grade smooth and even, free of voids, compacted as specified, and to required elevation. Provide final grades within a tolerance of 1/2-inch when tested with a 10-foot straightedge.
- D. Compaction: After grading, compact subgrade surfaces as required.

3.10 EROSION CONTROL

- A. Provide erosion control measures as specified in Section 31 25 13 and as shown on Drawings.

3.11 MAINTENANCE

- A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris. Repair and re-establish grades in settled, eroded, and rutted areas to specified tolerances.
- B. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, scarify surface, re-shape, and compact to required density prior to further construction.
- C. Settling: Where settling is measurable or observable at excavated areas during warranty period; remove surface, add backfill material, compact, and replace surface. Restore appearance, quality, and condition of surface to match adjacent work, and eliminate evidence of restoration work to greatest extent possible.

3.12 DISPOSAL OF EXCESS MATERIALS

- A. Remove excess excavated material and dispose of it off-site in a lawful manner, unless otherwise directed by ENGINEER.

END OF SECTION 312000

SECTION 312319 - DEWATERING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide, install, and maintain all necessary material and equipment used to keep excavation free of standing or flowing water and to transport water to a suitable discharge point.
- B. Provide measures to dispose of water in accordance with all local, state and federal regulations, including the City's Industrial Pretreatment Program. Notify the City of Portland Public Works Department prior to conducting dewatering operations.

1.2 REFERENCES

- A. Specification Sections:
 - 1. Selective Site Demolition: Section 024113
 - 2. Earth Moving: Section 312000
 - 3. Erosion and Sedimentation Control: Section 312513
 - 4. Utilities: Division 33

1.3 SUBMITTALS

- A. At least 2 weeks prior to the start of construction in any areas of anticipated dewatering, submit to the PROJECT ARCHITECT and City of Portland Public Works Department, a written plan for removal, storage, treatment, and disposal of groundwater from excavations. Do not proceed with construction in any of these areas until the plan has been reviewed and approved by the PROJECT ARCHITECT and City of Public Works Department.

PART 2 PRODUCTS (not applicable)

PART 3 EXECUTION

3.1 DEWATERING EXCAVATIONS

- A. Perform all work in the dry. Prevent surface water or groundwater from flowing into excavations and from flooding project site and surrounding area. Do not allow water to accumulate in excavations.
- B. Provide and maintain pumps, well points, sumps, hoses, filters, and all other dewatering system components necessary to convey water away from excavations.
- C. Minimize the suspended solids content in the water by lining the excavation collection area with crushed stone and placing the pump intake in a perforated bucket.

- D. Convey water removed from excavations to a frac tank. Do not use trench excavations as temporary drainage ditches. Do not allow silt laden water to discharge to gutters or storm drainage system. Do not discharge water directly to the storm, sanitary or combined sewer.
- E. Any damages to existing facilities or new work resulting from the failure of the CONTRACTOR to maintain the work areas in a dry condition shall be repaired by the CONTRACTOR, as directed by the ENGINEER, at no additional expense to the OWNER. Pumping shall be continuous where specified or directed or as necessary to protect the work and to maintain satisfactory progress.
- F. Onsite recharge of dewatering effluent shall not be allowed unless otherwise approved by the City of Portland and ENGINEER.

3.2 STORAGE/TREATMENT/DISCHARGE PROCESS

- A. Water removed from excavations shall be stored in a frac tank to allow settling of solids and testing prior to discharge. The dewatering pump line shall be placed at the opposite end from the tank outlet.
- B. Limit circulating tank contents to prevent freezing. Do not discharge from the tank while the circulation pump is operating to allow adequate settling time before discharge.
- C. If needed for additional storage and treatment volume, provide a second tank to be placed in series for secondary settlement. Transfer the water from the first tank to the second tank by suspending the intake line immediately below the water level to minimize disturbance of sediment at the bottom of the tank.
- D. Prior to discharge of the initial tank load, the CONTRACTOR must collect a water sample for laboratory analysis of the parameters identified with an "X" in the lists appended within this specification using the methods identified within the list. The CONTRACTOR must provide the test results to the PROJECT ARCHITECT and City of Portland Environmental Engineering Department. The City will use these test results to develop a baseline for testing of future frac tank loads. All future frac tank loads shall be required to be tested in accordance to the baseline developed by these initial analyses.

Both the City and the PROJECT ARCHITECT must provide approval prior to discharge.

The CONTRACTOR must provide access to the tanks for the City of Portland Public Works Department to take independent water samples. Do not add water or other materials to the frac tank after collecting the water sample.

- E. Managing and treating water determined to have contaminant levels exceeding the City's Industrial Pretreatment Program limits shall be in accordance with local, state, and federal regulations.

The CONTRACTOR shall work with the City of Portland to identify any other contaminants exceeding the Industrial Pretreatment Program discharge limits. The City of Portland may provide recommended treatment methods for water found to exceed the City of Portland's Industrial Pretreatment Program discharge limitations.

- F. Follow direction provided by the City of Portland Public Works Department on further testing and disposal requirements.
- G. Obtain all local, state, and federal approvals necessary for the discharge of the water. If water is discharged to the combined or sanitary sewer, bag filters must be installed on the discharge piping and water must meet the City of Portland's Industrial Pretreatment Program discharge limitations.
- H. The City of Portland and/or the Portland Water District reserve the right to stop the CONTRACTOR from discharging flow to the combined sewer system during periods of time when the Combined Sewer Overflow (CSO) is or has the potential to be active.
- I. Cease discharge immediately upon discovery, through testing or other means that discharge is not in compliance with the requirements of local, state or federal regulations or permits. Additional costs from delays in work due to non-conformance with the requirements shall be borne by the CONTRACTOR at no additional cost to the OWNER.

3.3 DIVERSION OF WATER

- A. The CONTRACTOR shall be responsible for providing and maintaining all ditching, grading, sheeting, and bracing, pumping and appurtenant work for the protection from flooding as necessary to permit construction of work in the dry.
- B. Upon completion of the contract work, the CONTRACTOR shall remove all temporary construction and shall do all necessary earthwork and grading to restore the areas disturbed to their original condition or to such other conditions as indicated or directed by the OWNER.
- C. Water shall not be permitted to flow into or through excavations in which work is under way or has been partially completed. The CONTRACTOR shall not restrict or close off the natural flow of water in such a way that ponding or flooding will occur, and shall at all times prevent flooding of public and private property. All damages resulting from flooding or restriction of flows shall be the sole responsibility of the CONTRACTOR, at no additional expense to the OWNER.

City of Portland and Portland Water District Industrial Waste Report

Location:						Sample Date:			
Sample Type					Sample Condition				
Composite	<input checked="" type="checkbox"/>	Grab	<input type="checkbox"/>	Discrete	<input type="checkbox"/>	Refrigerated			
• Methods 40 CFR Part 136 •									
	ID No	Parameter	Preservative	Method	Report Value	Duplicate % Recovery	Analysis Date	Analyst	
<input checked="" type="checkbox"/>	23	<i>pH (Composite)</i>	Analysis (ASAP)	150.1					
<input checked="" type="checkbox"/>	1	<i>Caustic Alk.</i>	Refrigerate	310.1					
<input checked="" type="checkbox"/>	30	<i>TSS</i>	Refrigerate	160.2					
<input checked="" type="checkbox"/>	14	<i>Cadmium</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	14	<i>Copper</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	14	<i>Chromium</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	14	<i>Lead</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	14	<i>Nickel</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	14	<i>Zinc</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	32	<i>Silver</i>	HNO3 to pH <2	200.7					
<input checked="" type="checkbox"/>	54	<i>Mercury</i>	HNO3 to pH <2	245.1					
<input checked="" type="checkbox"/>	62	<i>Arsenic</i>	HNO3 to pH <2	206.2/200.7					
Person(s) Sampling:			Community:			Location:			
Type Of System:			<input type="checkbox"/> Industrial	<input type="checkbox"/> Combined	<input type="checkbox"/> Sanitary	<input type="checkbox"/> Storm	<input type="checkbox"/> Surface		
Automatic Sampler Information:									
Date/Time Set:		Start Time:			Time Period:				
Time Interval:		Samples per Bottle:			No. of Bottles:				
Date/Time Pulled:		Comments:							
Grab Sample Information (including bottle size & type)									
Date/Time Pulled:		No. of Samples:							
1000 ml HDPE Amber		1000 ml Glass		950 ml Plastic					
Other Bottle Type:									
Relinquished by:			Received by:			Date / Time:			
Reviewed for release by:			Date:						

Notes: Copy Portland Water District and City of Portland Public Works Industrial Pretreatment Program

City of Portland and Portland Water District Industrial Waste Report

Location:						Sample Date:			
Sample Type					Sample Condition				
Composite		Grab		Discrete					
• Methods 40 CFR Part 136 •									
	ID No	Parameter	Preservative	Method	Report Value	Duplicate % Recovery	Analysis Date	Analyst	
X	56	<i>Tot. Cyanide (Grab)</i>	NaOH to pH >12, Refrigerate	335.2					
Person(s) Sampling:					Community:		Location		
Type Of System:		Industrial		Combined		Sanitary		Storm	
		Surface							
Automatic Sampler Information:									
Date/Time Set:					Start Time:				
Time Interval:					Samples per Bottle:				
Date/Time Pulled:					Comments:				
Grab Sample Information (including bottle size & type)									
Date/Time Pulled:						No. of Samples:			
1000 ml HDPE Amber		1000 ml Glass				950 ml Plastic			
Other Bottle Type:									
Relinquished by:			Received by:			Date / Time:			
Reviewed for release by:						Date			

Notes: Copy Portland Water District and City of Portland Public Works Industrial Pretreatment Program

City of Portland and Portland Water District Industrial Waste Report

Location:						Sample Date:			
Sample Type					Sample Condition				
Composite		Grab		Discrete					
• Methods 40 CFR Part 136 •									
	ID No	Parameter	Preservative	Method	Report Value	Duplicate % Recovery	Analysis Date	Analyst	
X	1	<i>pH</i>	Analyze (ASAP)	150.1					
		<i>Caustic Alk.</i>	Refrigerate	310.1					
Person(s) Sampling:			Community			Location:			
Type Of System:			Industrial	Combined	Sanitary	Storm	Surface		
Automatic Sampler Information:									
Date/Time Set:					Start Time:				Time Period:
Time Interval:					Samples per Bottle:				No. of Bottles:
Date/Time Pulled:					Comments:				
Grab Sample Information (including bottle size & type)									
Date/Time Pulled:						No. of Samples:			
1000 ml HDPE Amber		1000 ml Glass				950 ml Plastic			
Other Bottle Type:									
Relinquished by:			Received by:			Date / Time:			
Reviewed for release by:						Date:			

Notes: Copy Portland Water District and City of Portland Public Works Industrial Pretreatment Program

City of Portland and Portland Water District Industrial Waste Report

Location:						Sample Date:			
Sample Type						Sample Condition			
Composite			Grab	X	Discrete				
• Methods 40 CFR Part 136 •									
	ID No	Parameter	Preservative	Method	Report Value	Duplicate % Recovery	Analysis Date	Analyst	
X		FLASHPOINT (Closed Cup)	None						
Person(s) Sampling:					Community:		Portland		Location
Type Of System:		X							
		Industrial	Combined		Sanitary		Storm		Surface
Automatic Sampler Information:									
Date/Time Set:					Start Time:				Time Period:
Time Interval:					Samples per Bottle:				No. of Bottles:
Date/Time Pulled:					Comments:				
Grab Sample Information (including bottle size & type)									
Date/Time Pulled:						No. of Samples			
1000 ml HDPE Amber		1000 ml Glass				950 ml Plastic			
Other Bottle Type:									
Relinquished by:			Received by:			Date / Time:			
Reviewed for release by:							Date		

Notes: Copy Portland Water District and City of Portland Public Works Industrial Pretreatment Program

City of Portland and Portland Water District Industrial Waste Report

Location:						Sample Date:			
Sample Type					Sample Condition				
Composite		Grab		Discrete					
• Methods 40 CFR Part 136 •									
	ID No	Parameter	Preservative	Method	Report Value	Duplicate % Recovery	Analysis Date	Analyst	
		<i>PCB's and Pesticides</i>		EPA 608					
		<i>(GRO) Gasoline Range Organics</i>		Me HETL 4.2.17					
		<i>(DRO) Diesel Range Organics</i>		Me HETL 4.1.25					
X		<i>Hydrocarbon (PAH Range)</i>		EPA 8015					
Person(s) Sampling:					Community:			Location:	
Type Of System:		Industrial	Combined	Sanitary	Storm	Surface			
Automatic Sampler Information:									
Date/Time Set:					Start Time:			Time Period:	
Time Interval:					Samples per Bottle:			No. of Bottles:	
Date/Time Pulled:					Comments:				
Grab Sample Information (including bottle size & type)									
Date/Time Pulled:						No. of Samples:			
1000 ml HDPE Amber		1000 ml Glass		950 ml Plastic					
Other Bottle Type:									
Relinquished by:			Received by:			Date / Time:			
Reviewed for release by:							Date:		

Notes: Copy Portland Water District and City of Portland Public Works Industrial Pretreatment Program

End of Section 312319

SECTION 312513 - EROSION AND SEDIMENTATION CONTROLS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide, inspect, and maintain devices to control erosion, siltation, sedimentation, and dust that occur during construction operations. Undertake every reasonable precaution and do whatever is necessary to avoid erosion of soil.
- B. Furnish and install stabilized construction entrances, catch basin inlet sediment filters, and siltation fences as required.
- C. Provide measures to control dust caused whether on or off the Project site.
- D. Deficiencies in erosion control measures indicated by failures or erosion shall be immediately corrected by providing additional measures or different techniques to correct the situation and prevent subsequent erosion.
- E. Exposure of soils on embankments, excavations, and graded areas shall be kept as short as possible. Initiate seeding and other erosion control practices as soon as reasonably possible.

1.2 QUALITY ASSURANCE

- A. Conform to all requirements of applicable federal, state and local permits, and Contract Documents, and conform to the recommendations of the Standards (see Part D below) whether the measures are specifically noted herein, or not.

1.3 REFERENCES:

- A. "Maine Erosion and Sedimentation Control BMPs" prepared by the Maine Department of Environmental Protection, most recent updated version.

PART 2 PRODUCTS

2.1 MATERIALS

- A. General: Use the following materials in construction of sediment traps, erosion control devices, and slope protection as specified on the DRAWINGS. Other materials require approval of the ENGINEER.
- B. Siltation Fence: MIRAFI Silt Fence, Geotex Silt Fence, or approved equal.
- C. Catch Basin Inlet Sediment Barrier: ACF Environmental, Inc. High Flow Siltsack® or approved equal.

PART 3 EXECUTION

3.1 TEMPORARY EROSION DEVICES

- A. General: Provide the following devices to control erosion. Other devices require approval of the ENGINEER.
- B. Silt Fence:
 - 1. Install silt fence prior to any earthwork including grubbing.
 - 2. Place where shown on Drawings or as directed by the ENGINEER. Install parallel to contours where possible, prior to site clearing and grading activities.
 - 3. Bury lower edge of fabric at least 8 inches below ground surface to prevent underflow.
 - 4. Curve ends of fence uphill to prevent flow around ends.
 - 5. Inspect frequently; repair or replace any damaged sections.
 - 6. Remove fence only when adequate grass catch has been established as determined by the ENGINEER.
- C. Catch Basin Inlet Sediment Barrier: Install, check, and clean or replace per manufacturer's recommendations.

3.2 REMOVAL OF TEMPORARY EROSION CONTROL

- A. Remove temporary materials and devices when permanent soil stabilization has been achieved. Re-use materials in good condition if approved by the ENGINEER.
- B. Remove unsuitable materials from site and dispose of in a legal manner.

3.3 SUBGRADE PREPARATION

- A. Grade and compact, where possible, areas to receive protection to a uniform slope. Allow for depth of protection stone layer.

3.4 MAINTENANCE

- A. Inspect erosion control practices immediately after each rainfall and at least daily during prolonged rainfall or snowmelt for damage. Provide maintenance and make appropriate repairs or replacement at no additional cost to the OWNER, until Project acceptance or as required to comply with maintenance requirements if longer.
- B. Remove silt from silt fence when it has reached one foot above grade or prior to expected heavy runoff or siltation.

END OF SECTION 312513

SECTION 321200 - FLEXIBLE PAVING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Provide and install hot mix asphalt (HMA) pavement as specified and as directed by the PROJECT ARCHITECT. This work includes:
 - 1. HMA pavement including driveway aprons, roadways, and trench patches
 - 2. Painting and pavement markings

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000
- B. "Standard Specifications: Highways and Bridges", current revision, Maine Department of Transportation.
- C. State of Maine Department of Transportation "Standard Specifications – Revision of December 2002"
- D. State of Maine Department of Transportation "Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications", most recent revision.
- E. AASHTO M320-Standard Specification for PGAB.

1.3 SUBMITTALS

- A. Material Certificates: Certificates signed by material producer and CONTRACTOR stating that each material complies with specified requirements.
- B. Design Mix: Provide design mix for each grade of pavement to be used at least 20 days prior to start of paving.
- C. Certified Weigh Slips: If required by the OWNER, provide for each truck load of bituminous material.

1.4 QUALITY ASSURANCE

- A. Comply with any road opening permits issued for the Work.

1.5 JOB CONDITIONS

- A. Weather and Seasonal Limitations: Follow MDOT "Standard Specification" Section 401.07.
- B. Tack Coat Limitations:
 - 1. Apply bituminous prime and tack coats only when the ambient temperature in the shade is at least 50°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.

PART 2 PRODUCTS

2.1 AGGREGATE BASE AND SUBBASE

- A. Refer to Section 312000.

2.2 ASPHALT CEMENT

- A. General: Comply with materials requirements, MDOT "Standard Specification", Section 702.

2.3 BITUMINOUS PAVEMENTS

- A. Comply with materials requirements, MDOT "Standard Specification", current revision, Section 401, Superpave Mixes, used as indicated on the Drawings.
 - 1. HMA 19mm
 - 2. HMA 12.5mm
 - 3. HMA 9.5mmShims: Hot Mix Asphalt, Shim

2.4 BITUMINOUS TACK COAT

- A. General: MDOT "Standard Specifications" Section 702.04.

2.5 MARKING PAINT

- A. General: Alkyd-resin type, ready-mixed complying with AASHTO M 248, Type I.
- B. Color: White for shoulder striping, bicycle lane demarcation, and directional arrows; blue for handicapped parking symbols; yellow for other lane demarcation striping.

PART 3 EXECUTION

3.1 BASE AND SUBBASE

- A. General: Do not begin paving operations until base and subbase have been accepted.

3.2 BITUMINOUS PAVEMENTS

- A. General: MDOT Standard Specifications.
- B. Base Course: Section 401.
- C. Surface Course: Section 403.
- D. Saw cuts and butt joints shall be used in existing pavement as indicated on the Drawings to facilitate the installation of new pavement.

3.3 BITUMINOUS TACK COAT

- A. General: Apply tack coat immediately prior to placing pavement adjacent to curbing, gutters, manholes, pavement, etc. for adequate bond. Generally a tack coat will not be required for pavement placed immediately following the rolling of the underlying course.
- B. MDOT Standard Specification Section 409.
- C. Rate of Application: 0.05 to 0.15 gallons per square yard.

3.4 TRENCH PATCHING

- A. General: Do not leave more than 1000 linear feet of backfilled trench unpaved at any one time. Place aggregate base and subbase as shown on the Drawings.
- B. Permanent Patching:
 - 1. Remove all existing pavement and regrade base material and compact as required.
 - 2. Provide base and surface courses to the depths shown on the Drawings.

3.5 TRAFFIC AND PARKING LOT MARKINGS

- A. Cleaning: Sweep and clean surface to eliminate loose material and dust.
- B. Striping: Use chlorinated-rubber base traffic lane-marking paint, factory-mixed, quick-drying, and non-bleeding.
- C. Apply paint with mechanical equipment to produce uniform straight edges. Apply at manufacturer's recommended rates to provide minimum 12 to 15 mils dry thickness.

END OF SECTION 321200

SECTION 321600 - CURBS

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Remove, stockpile, dispose/deliver existing curbing as directed. Provide all new Type 1 granite curbing and tipdowns as shown on the Drawings.

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000.
 - 2. Flexible Paving: Section 321200.
 - 3. Sidewalks: Section 322000.
- B. State of Maine Department of Transportation "Standard Specifications: Highways and Bridges", most recent revision.
- C. State of Maine Department of Transportation "Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications", most recent revision.
- D. American Society for Testing and Materials (ASTM): C 615-68 (1972), Structural Granite

1.3 SUBMITTALS

- A. Shop Drawings:
 - 1. Dimensions of cut curbing.
 - 2. Manufacturers construction data for granite curbs.
 - 3. Manufacturers printed data on recommended installation procedures for granite curb.
- B. Certificates: Manufacturer's certification that products meet specification requirements.

PART 2 PRODUCTS

2.1 GRANITE CURB

- A. Vertical face curb, Type 1, straight sections.
- B. Vertical face curb, Type 1, circular sections.
- C. Tip-down curb, Type 1.

- D. MDOT Specification, Paragraph 712.04.

2.2 JOINT PAD

- A. Bituminous Fiber Joint Filler: Preformed strips of composition below, complying with ASTM D1751: Asphalt saturated fiber board.
- B. MDOT Specification, Paragraph 609.03

PART 3 EXECUTION

3.1 INSPECTION:

- A. Verify that earthwork is completed to correct line and grade.
- B. Check that subgrade is smooth, compacted, and free of frost or excessive moisture.
- C. Do not commence work until conditions are satisfactory.

3.2 INSTALLATION

- A. For installation of granite Type 1 curbing, comply with appropriate Paragraphs of MDOT Specification, 609.

3.3 CLEANING

- A. Clean completed work with appropriate agent and rinse thoroughly.

END OF SECTION 321600

SECTION 322000 – SIDEWALKS

PART 1 GENERAL

1.1 SUMMARY

- A. This work shall consist of providing and installing brick sidewalks on bituminous concrete base in accordance with these specifications and in reasonably close conformity with the lines and grades as shown on the plans.
- B. This work shall include the construction of sidewalk ramps at locations as shown on the plans and shall be in accordance with the sidewalk pedestrian ramp typical details and with the current Americans with Disabilities Act requirements.

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000.
 - 2. Flexible Paving: Section 321200.
 - 3. Curbs and Gutters: Section 321600.
- B. State of Maine Department of Transportation “Standard Specifications: Highways and Bridges”, most recent revision.
- C. State of Maine Department of Transportation “Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications”, most recent revision
- D. City of Portland Technical Manual, most recent revision

PART 2 PRODUCTS

2.1 BRICK

- A. New Brick: Shall conform to the City of Portland technical standards for brick sidewalks. Brick shall conform to requirements of ASTM Standard Specifications for Building Brick (made of clay or shale) Designation C62-66 for Grade SW with the following modifications:
 - 1. The absorption limits shall be from 8 to 12 percent for the average of 5 bricks.
 - 2. The compressive strength shall not be less than 8000 pounds per square inch (psi).
 - 3. The modulus of rupture shall not be less than 1000 pounds per square inch (psi).
 - 4. Bricks shall be Pine Hall Pathway Paver Brick, manufactured by Pine Hall Brick Co., Madison, North Carolina, distributed by Lachance as Item # 193623. Bricks shall be of standard size (2-1/4" deep x 3-3/4" wide x 8" long) with permissible variations not to exceed 1/16" in depth, 1/8" in width or 1/4" in length.

- B. All base courses and joints shall conform to the applicable subsections of Division 700 of the Maine Department of Transportation Standard Specifications.

2.2 SAND-CEMENT BASE

- A. MATERIALS: Six (6) parts of washed mortar sand to one (1) part Portland Cement.

2.3 BITUMINOUS CONCRETE

- A. MATERIALS: Material for bituminous concrete base courses and surface courses for sidewalks shall be as identified on the Plans and shall conform to the requirements Specification 32 12 00.

PART 3 EXECUTION

3.1 BRICK

- A. Subgrade: The subgrade for the sidewalks shall be shaped parallel to the proposed surface of the walks and shall be thoroughly compacted. All depressions occurring shall be filled with a suitable material and again compacted until the surface is smooth and hard.
- B. Foundation: After the subgrade has been prepared, a foundation of crushed gravel shall be placed upon it. After being thoroughly compacted, the foundation shall have a thickness as shown on the plans and typical details and shall be parallel to the proposed surface of the work.
- C. Bituminous Base: A layer of hot bituminous pavement shall be spread upon the properly prepared crushed gravel, as shown in the typical detail.
- D. Sand-Cement Base: A layer of sand-cement base course material one (1") inch in thickness shall be spread upon the properly prepared bituminous base course. The course shall be thoroughly compacted and present a hard smooth surface parallel to the proposed finished slope and grade of the walks.
- E. Brick Placement: After the sand base course has been properly prepared, the brick shall be placed in the pattern shown on the plans and typical details. The brick shall be placed as closely together as possible and the sand joints between the brick shall be no wider than that allowed by the natural texture of the brick itself. **NO OPEN JOINTS WILL BE ALLOWED.** Brick shall be saw cut to fit spaces requiring less than a whole brick. No cut brick shall be less than two (2") inches in length. A journeyman brick mason shall supervise all brick placement.
- F. After the bricks are carefully set upon the properly prepared sand-cement base, a plank or heavy sheet of plywood covering several course of brick shall be placed upon the bricks and carefully rammed with a heavy hammer until the bricks reach a firm, unyielding bed and present a surface of the proper slope and grade. Any divergence from line and grade shall be corrected by taking up and relaying the bricks. After the ramming of the bricks, a sufficient amount of sand-cement shall be spread over the surface and thoroughly swept or raked so as to fill the joints. All surplus sand-cement remaining on the sidewalk after the joints have been properly filled, shall be carefully removed by sweeping. Care shall be taken to avoid raking out the joints during removal of excess sand-cement. A final

application of sand only shall be spread on the sidewalk. The application of sand shall then be removed by sweeping while the aforementioned precautions are being exercised.

3.2 BITUMINOUS CONCRETE

- A. Excavation: Excavation shall be made to the required depth and width. The foundation shall be shaped and compacted to a firm even surface conforming to the section shown on the plans and typical details. All soft and yielding material shall be removed and replaced with acceptable material.
- B. Construction: As per Drawings and specification 321200 – Flexible Pavement.

END OF SECTION 322000

SECTION 323200 - SEGMENTAL RETAINING WALLS

PART 1 – GENERAL

1.1 SUMMARY

- A. This Section includes furnishing and installing concrete segmental retaining wall units to the lines and grades designated on the construction drawings and as specified herein.

1.2 SUBMITTALS

- A. Submit the following:
 - 1. Product Data: Manufacturer's product data and manufacturer's recommended installation instructions and details.
 - 2. Shop Drawings: Complete shop drawings with installation details to include, but not limited to, excavation limits, wall layout and elevations, leveling pad and backfill material.
 - 3. Calculations: Structural analysis data and design signed and sealed by a State of Maine licensed professional engineer.
 - 4. Color: Manufacturer's standard color and texture samples.

1.3 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000.

1.4 DELIVERY, HANDLING, AND STORAGE

- A. Contractor shall check the materials upon delivery to assure proper material has been received.
- B. Contractor shall prevent excessive mud, wet cement and like materials from coming in contact with the retaining wall units.
- C. Contractor shall protect the materials from damage. Damage material shall not be incorporated in then project.

1.5 QUALITY ASSURANCE

- A. All segmental retaining wall units and accessories shall be provided by a single manufacturer.

PART 2 – PRODUCTS

2.1 APPROVED MANUFACTURER

- A. Provide segmental retaining wall units from one of the following manufacturers:
 - 1. Redi-Scapes, 05481 South US-31, Charlevoix, MI 49720, 1866-222-8400,
 - 2. Approved Equal.

2.2 WALL UNITS

- A. Segmental wall units shall be equal to Redi-Scape 115 Retaining Series Wall System.
- B. Wall units shall be made with ready-mixed concrete in accordance with ASTM C 94, and per the following:
 - 1. Air Content: 4.5 to 7.5%
 - 2. 28 Day Compressive Strength: 4,000 psi
 - 3. Slump: 5" ± 1.5"
- C. Provide cap, corner and end units as required to complete the approved wall layout.
- D. Exterior block dimensions shall be uniform and consistent. Maximum dimensional deviations shall be 1/8" excluding the architectural textured surface.
- E. Exposed face shall have a finish equal to McKinley Texture. Other surfaces shall be smooth form type.
- F. Color to be selected by Owner.

2.3 LEVELING PAD AND FREE DRAINAGE BACKFILL

- A. Leveling Pad shall be crushed stone as specified in Section 31 20 00 Earth Moving.
- B. Free Draining Backfill material shall be crushed stone as specified in Section 31 20 00 Earth Moving.
- C. Backfill material shall be structural fill material as specified in Section 31 20 00 Earth Moving.

- D. Non-woven geotextile fabric type and placement shall be as specified by wall unit manufacturer.
- E. Geogrid soil reinforcement type and placement shall be as specified by wall unit manufacturer.

2.4 DRAINAGE

- A. Internal and external drainage shall be evaluated by the principal Engineer responsible for the final wall design.

PART 3 – EXECUTION

3.1 EXCAVATION

- A. Contractor shall excavate to the lines and grades shown on the construction drawings and approved shop drawings and as specified in Section 31 20 00 Earth Moving.

3.2 FOUNDATION SOIL PREPARATION

- A. Native foundation soil shall be compacted to 95% of standard proctor prior to placement of the Leveling Pad material.

3.3 LEVELING PAD PLACEMENT

- A. Leveling Pad shall be placed as shown on the approved shop drawings.
- B. Leveling Pad shall be placed on undisturbed native soils or suitable replacement fills.
- C. Leveling Pad shall be compacted to 95% of standard proctor to ensure a level, hard surface on which to place the first course blocks. Pad shall be constructed to proper elevation to ensure the final elevation shown on the plans.
- D. Leveling Pad shall have a 6 inch minimum depth for walls under 8 feet in height and a 12 inch minimum depth for walls 8 feet and taller. Pad dimensions shall extend beyond the blocks in all directions to a distance at least equal to the depth of the pad or as designed by principle Engineer responsible for the final wall design.

3.4 WALL UNIT INSTALLATION

- A. The first course of wall units shall be placed on the prepared Leveling Pad with the aesthetic surface facing out and the front edges tight together. All units shall be checked for level and alignment as they are placed.

- B. Ensure that units are in full contact with Leveling Pad. Proper care shall be taken to develop straight lines and smooth curves on base course as per approved wall layout.
- C. The backfill in front and back of entire base row shall be placed and compacted to firmly lock them in place. Check all units again for level and alignment. All excess material shall be swept from top of units.
- D. Fill block cores with crushed stone consolidated by hand tamping.
- E. Install next course of wall units on top of base row.
 - 1. Position blocks to be offset from seams of blocks below.
 - 2. Blocks shall be placed fully forward so knob and groove are engaged.
 - 3. Check each block for proper alignment and level.
 - 4. Backfill a 12 inch width behind block with Free Draining Backfill.
 - 5. Spread backfill in uniform lifts not exceeding 9 inches.
 - 6. Employ methods using lightweight compaction equipment that will not disrupt the stability or batter of the wall. Hand-operated plate compaction equipment shall be used around the block and within 3 feet of the wall to achieve consolidation.
 - 7. Compact backfill to 95% of standard proctor (ASTM D 698, AASHTO T-99) density within 2% of its optimum moisture content.
 - 8. Fill block cores with crushed stone consolidated by hand tamping
- F. Install each subsequent course in like manner. Repeat procedure to the extent of wall height.
- G. Free Draining Backfill shall extend from Leveling Pad to 4-inches below top of wall.
- H. Allowable construction tolerance at the wall face is 2 degrees vertically and 1 inch and 10 feet horizontally.
- I. All walls shall be installed in accordance with local building codes and requirements.

3.5 GEORGRID INSTALLATION

- A. If geogrid is required by the principle Engineer for soil reinforcement, install in accordance with the approved manufacturer's shop drawings.

END OF SECTION 323200

SECTION 329200 - TURF AND GRASSES

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. Seeding.
 - 2. Hydroseeding.

1.3 DEFINITIONS

- A. Duff Layer: The surface layer of native topsoil that is composed of mostly decayed leaves, twigs, and detritus.
- B. Finish Grade: Elevation of finished surface of planting soil.
- C. Manufactured Topsoil: Soil produced off-site by homogeneously blending mineral soils or sand with stabilized organic soil amendments to produce topsoil or planting soil.
- D. Planting Soil (Topsoil): Standardized topsoil; existing, native surface topsoil; existing, in-place surface soil; imported topsoil; or manufactured topsoil that is modified with soil amendments and perhaps fertilizers to produce a soil mixture best for plant growth.
- E. Subgrade: Surface or elevation of subsoil remaining after excavation is complete, or top surface of a fill or backfill before planting soil is placed.
- F. Subsoil: All soil beneath the topsoil layer of the soil profile, and typified by the lack of organic matter and soil organisms.
- G. Surface Soil: Soil that is present at the top layer of the existing soil profile at the Project site. In undisturbed areas, the surface soil is typically topsoil, but in disturbed areas such as urban environments, the surface soil can be subsoil.

1.4 SUBMITTALS

- A. Certification of Grass Seed: From seed vendor for each grass-seed monostand or mixture stating the botanical and common name, percentage by weight of each species and variety, and percentage of purity, germination, and weed seed. Include the year of production and date of packaging.

1. Certification of each seed mixture for turfgrass sod. Include identification of source and name and telephone number of supplier.
2. For topsoil, submit topsoil analysis done by a plant and oilt testing agency such as the Maine Soil Testing and Analytical Lab (207-581-2934) for review by the Owner's Representative. State recommended quantities for amendments necessary to produce satisfactory topsoil as stated in the specifications herein.
3. Submit product information with mix ratios and amounts for hydromulching to be used during hydroseeding for Owner's Representative's approval.
4. Submit fertilizer, herbicide and fungicide products for application as required for Owner's Representative's approval.

B. Product Certificates: For soil, soil amendments and fertilizers, from manufacturer.

1.5 QUALITY ASSURANCE

A. Soil-Testing Laboratory Qualifications: An independent laboratory with the experience and capability to conduct the testing indicated and that specializes in types of tests to be performed.

B. Soil Analysis: For each unamended soil type, furnish soil analysis and a written report by a qualified soil-testing laboratory stating percentages of organic matter; gradation of sand, silt, and clay content; cation exchange capacity; deleterious material; pH; and mineral and plant-nutrient content of the soil.

1. Testing methods and written recommendations shall comply with USDA's Handbook No. 60.
2. The soil-testing laboratory shall oversee soil sampling, with depth, location, and number of samples to be taken per instructions from Owner's Representative. A minimum of three representative samples shall be taken from varied locations for each soil to be used or amended for planting purposes.
3. Report suitability of tested soil for turf growth.
 - a. Based on the test results, state recommendations for soil treatments and soil amendments to be incorporated. State recommendations in weight per 1000 sq. ft. or volume per cu. yd. for nitrogen, phosphorus, and potash nutrients and soil amendments to be added to produce satisfactory planting soil suitable for healthy, viable plants.
 - b. Report presence of problem salts, minerals, or heavy metals, including aluminum, arsenic, barium, cadmium, chromium, cobalt, lead, lithium, and vanadium. If such problem materials are present, provide additional recommendations for corrective action.

1.6 DELIVERY, STORAGE, AND HANDLING

A. Seed and Other Packaged Materials: Deliver packaged materials in original, unopened containers showing weight, certified analysis, name and address of manufacturer, and indication of conformance with state and federal laws, as applicable.

B. Bulk Materials:

1. Do not dump or store bulk materials near structures, utilities, walkways and pavements, or on existing turf areas or plants.
 2. Provide erosion-control measures to prevent erosion or displacement of bulk materials, discharge of soil-bearing water runoff, and airborne dust reaching adjacent properties, water conveyance systems, or walkways.
 3. Accompany each delivery of bulk fertilizers, lime, and soil amendments with appropriate certificates.
- C. Use all means necessary to protect seed from moisture and other contaminants which may adversely effect proper germination.
- D. Use all means necessary to protect fertilizers, amendments and other materials from moisture and other contaminants which may adversely effect their efficacy.

1.7 PROJECT CONDITIONS

- A. Planting Restrictions: Plant during one of the following periods. Coordinate planting periods with initial maintenance periods to provide required maintenance from date of planting completion.
1. Spring Planting: April 15 to June 1.
 2. Fall Planting: September 1 to October 15.
 3. The Contractor may seed at times other than those specified, only upon authorization of the Architect.
- B. Weather Limitations: Proceed with planting only when existing and forecasted weather conditions permit planting to be performed when beneficial and optimum results may be obtained. Apply products during favorable weather conditions according to manufacturer's written instructions.

1.8 MAINTENANCE SERVICE

- A. Initial Turf Maintenance Service: Provide full maintenance by skilled employees of landscape Installer. Maintain as required in Part 3. Begin maintenance immediately after each area is planted and continue until acceptable turf is established but for not less than the following periods:
1. Seeded Turf: 60 days from date of planting completion.
 - a. When initial maintenance period has not elapsed before end of planting season, or if turf is not fully established, continue maintenance during next planting season.

PART 2 - PRODUCTS

2.1 TOPSOIL

- A. Refer to Section 329300 "Plantings."

2.2 SEED

- A. Grass Seed: Fresh, clean, dry, new-crop seed complying with AOSA's "Journal of Seed Technology; Rules for Testing Seeds" for purity and germination tolerances.
- B. Seed Species: Seed of grass species as follows, with not less than 95 percent germination, not less than 85 percent pure seed, and not more than 0.5 percent weed seed:
 - 1. Lawn Mixture: Proportioned by weight as follows:
 - a. 50 percent Creeping Red Fescue.
 - b. 30 percent Kentucky Bluegrass.
 - c. 20 percent Annual Ryegrass.
 - d. 10 percent White Clover.

2.3 INORGANIC SOIL AMENDMENTS

- A. Lime: ASTM C 602, agricultural liming material containing a minimum of 80 percent calcium carbonate equivalent and as follows:
 - 1. Class: O, with a minimum of 98 percent passing through No. 20 sieve and a minimum of 55 percent passing through No. 60 sieve.
 - 2. Provide lime in form of ground dolomitic limestone.

2.4 ORGANIC SOIL AMENDMENTS

- A. Compost: Well-composted, stable, and weed-free organic matter, pH range of 6.1 to 7.8; moisture content 40 to 60 percent by weight; 100 percent passing through 1/2-inch sieve; soluble salt content of less than 2mmho/cm in final topsoil mix; not exceeding 0.5 percent inert contaminants and free of substances toxic to plantings; and as follows:
 - 1. Organic Matter Content: 30 to 60 percent of dry weight.
 - 2. Nutrients: Provide NPK level information.
 - 3. Feedstock: Agricultural, food, or industrial residuals; biosolids; yard trimmings; or source-separated or compostable mixed solid waste.
- B. Sphagnum Peat: Partially decomposed sphagnum peat moss, finely divided or of granular texture, with a pH range of 3.4 to 4.8 and an ash content not exceeding 15 percent as determined by ASTM D2974.

2.5 FERTILIZERS

- A. Slow-Release Fertilizer: Granular or pelleted fertilizer consisting of 50 percent water-insoluble nitrogen, phosphorus, and potassium in the following composition:
 - 1. Composition: 15 percent nitrogen, 15 percent phosphorous, and 15 percent potassium, by weight or as otherwise recommended by the soil analysis.

2. Registration: Fertilizer must be registered with the Maine State Department of Agriculture and shall meet their standard requirements.

2.6 MULCHES

- A. Hay or Straw Mulch: Provide air-dry, clean, mildew- and seed-free, salt hay or threshed straw of wheat, rye, oats, or barley. No material shall be used which is too wet, decayed or compacted as to inhibit even uniform spreading.
- B. Fiber Mulch: Biodegradable, green dyed wood, cellulose-fiber mulch; nontoxic and free of plant-growth or germination inhibitors; with a maximum moisture content of 15 percent and a pH range of 4.5 to 6.5. Provide in moisture resistant sealed bags marked with the manufacturer's name, the air dry weight and composition of the contents.
- C. Hydromulch: Shall be Terra-Sorb GB, or an approved equal. Add Terra-Sorb to the hydroseed tank at the amount of 60 pounds per acre.
- D. Mulch Binder: Asphalt emulsion; ASTM D 977, Grade SS-1; nontoxic and free of plant-growth or germination inhibitors.

2.7 EROSION-CONTROL MATERIALS

- A. Erosion-Control Blankets: Biodegradable wood excelsior, straw, or coconut-fiber mat enclosed in a photodegradable plastic mesh. Include manufacturer's recommended steel wire staples, 6 inches long.
- B. Erosion-Control Fiber Mesh: Biodegradable burlap or spun-coir mesh, a minimum of 0.92 lb/sq. yd., with 50 to 65 percent open area. Include manufacturer's recommended steel wire staples, 6 inches long.

PART 3 - EXECUTION

3.1 EXAMINATION

- A. Examine areas to be planted for compliance with requirements and other conditions affecting performance.
 1. Verify that no foreign or deleterious material or liquid such as paint, paint washout, concrete slurry, concrete layers or chunks, cement, plaster, oils, gasoline, diesel fuel, paint thinner, turpentine, tar, roofing compound, or acid has been deposited in soil within a planting area.
 2. Do not mix or place soils and soil amendments in frozen, wet, or muddy conditions.
 3. Suspend soil spreading, grading, and tilling operations during periods of excessive soil moisture until the moisture content reaches acceptable levels to attain the required results.
 4. Uniformly moisten excessively dry soil that is not workable and which is too dusty.
- B. Proceed with installation only after unsatisfactory conditions have been corrected.

- C. If contamination by foreign or deleterious material or liquid is present in soil within a planting area, remove the soil and contamination as directed by Architect and replace with new planting soil.

3.2 PREPARATION

- A. Protect structures, utilities, sidewalks, pavements, and other facilities, trees, shrubs, and plantings from damage caused by planting operations.
 - 1. Protect adjacent and adjoining areas from hydroseeding and hydromulching overspray.
 - 2. Protect grade stakes set by others until directed to remove them.

3.3 TURF AREA PREPARATION

- A. Limit turf subgrade preparation to areas to be planted.
- B. Newly Graded Subgrades: Loosen subgrade to a minimum depth of 4 inches. Remove stones larger than 1 inch in any dimension and sticks, roots, rubbish, and other extraneous matter and legally dispose of them off Owner's property.
 - 1. Spread topsoil, apply soil amendments and fertilizer on surface, and thoroughly blend planting soil.
 - a. Delay mixing fertilizer with planting soil if planting will not proceed within a few days.
 - b. Mix lime with dry soil before mixing fertilizer.
 - 2. Spread planting soil to a depth of 6 inches unless noted otherwise, but not less than required to meet finish grades after light rolling and natural settlement. Do not spread if planting soil or subgrade is frozen, muddy, or excessively wet.
- C. Unchanged Subgrades: If turf is to be planted in areas unaltered or undisturbed by excavating, grading, or surface-soil stripping operations, prepare surface soil as follows:
 - 1. Remove existing grass, vegetation, and turf. Do not mix into surface soil.
 - 2. Loosen surface soil to a depth of at least 6 inches. Apply soil amendments and fertilizers according to planting soil mix proportions and mix thoroughly into top 4 inches of soil. Till soil to a homogeneous mixture of fine texture.
 - 3. Remove stones larger than 1 inch in any dimension and sticks, roots, trash, and other extraneous matter.
 - 4. Legally dispose of waste material, including grass, vegetation, and turf, off Owner's property.
- D. Finish Grading: Grade planting areas to a smooth, uniform surface plane with loose, uniformly fine texture. Grade to within plus or minus 1/2 inch of finish elevation. Roll and rake, remove ridges, and fill depressions to meet finish grades. Limit finish grading to areas that can be planted in the immediate future.

- E. Moisten prepared area before planting if soil is dry. Water thoroughly and allow surface to dry before planting. Do not create muddy soil.
- F. Before planting, obtain Architect's acceptance of finish grading; restore planting areas if eroded or otherwise disturbed after finish grading.
- G. Provide fertilizer and lime application if recommended by the soil testing lab. Apply with broadcast spreader and incorporate into the top 4 inches of topsoil.

3.4 SEEDING

- A. Method of seeding may be varied at discretion of Contractor. It is his or her responsibility to establish a smooth, uniform turf composed of approved grasses.
- B. Sow seed with spreader or seeding machine. Do not broadcast or drop seed when wind velocity exceeds 5 mph. Evenly distribute seed by sowing equal quantities in two directions at right angles to each other.
 - 1. Do not use wet seed or seed that is moldy or otherwise damaged.
 - 2. Do not seed against existing trees. Limit extent of seed to outside edge of planting saucer.
- C. Sow seed at rate recommended by the supplier.
- D. Rake seed lightly into top 1/8 inch of soil, roll lightly, and water with fine spray.
- E. Protect seeded areas with slopes exceeding 1:4 with erosion-control blankets and 1:6 with erosion-control fiber mesh installed and stapled according to manufacturer's written instructions.
- F. Mulch seeded areas with straw mulch, 1-1/2 to 2 tons per acre. Secure mulch at Contractor's discretion as to method or need.

3.5 HYDROSEEDING

- A. Method of seeding may be varied at discretion of Contractor. It is his or her responsibility to establish a smooth, uniform turf composed of approved grasses.
- B. Hydroseeding: Mix specified seed, fertilizer, and fiber mulch in water, using equipment specifically designed for hydroseed application. Continue mixing until uniformly blended into homogeneous slurry suitable for hydraulic application.
 - 1. Mix slurry with asphalt-emulsion tackifier.
 - 2. Apply slurry uniformly to all areas to be seeded in a two-step process. Apply first slurry coat at a rate so that mulch component is deposited at not less than 500-lb/acre dry weight, and seed component is deposited at not less than the specified seed-sowing rate. Apply slurry cover coat of fiber mulch (hydromulching) at a rate of 1400 lb/acre.

3.6 TURF MAINTENANCE

- A. Maintain and establish turf by watering, fertilizing, weeding, mowing, trimming, replanting, and performing other operations as required to establish healthy, viable turf. Roll, regrade, and replant bare or eroded areas and mulch to produce a uniformly smooth turf. Provide materials and installation the same as those used in the original installation.
 - 1. Fill in as necessary soil subsidence that may occur because of settling or other processes. Replace materials and turf damaged or lost in areas of subsidence.
 - 2. In areas where mulch has been disturbed by wind or maintenance operations, add new mulch and anchor as required to prevent displacement.
 - 3. Apply treatments as required to keep turf and soil free of pests and pathogens or disease. Use integrated pest management practices whenever possible to minimize the use of pesticides and reduce hazards.
 - 4. Schedule watering to prevent wilting, puddling, erosion, and displacement of seed or mulch. Lay out temporary watering system to avoid walking over muddy or newly planted areas.
 - 5. Water turf with fine spray at a minimum rate of 1 inch per week unless rainfall precipitation is adequate.
- B. Mow turf as soon as top growth is tall enough to cut. Repeat mowing to maintain specified height without cutting more than 1/3 of grass height. Remove no more than 1/3 of grass-leaf growth in initial or subsequent mowings. Do not delay mowing until grass blades bend over and become matted. Do not mow when grass is wet. Schedule initial and subsequent mowings to maintain a grass height of 2-1/2 to 3 inches.

3.7 INSPECTION AND ACCEPTANCE

- A. Turf installations shall meet the following criteria as determined by Owner's Representative. The Owner's Representative will inspect lawns upon written request by the Contractor. The request shall be received at least ten (10) days before the anticipated date of inspection.
 - 1. Satisfactory Seeded Turf: At end of maintenance period, a healthy, uniform, close stand of grass has been established, free of weeds and surface irregularities, with coverage exceeding 90 percent over any 10 sq. ft. and bare spots not exceeding 5 by 5 inches.
 - 2. Satisfactory Sodded Turf: At end of maintenance period, a healthy, well-rooted, even-colored, viable turf has been established, free of weeds, open joints, bare areas, and surface irregularities.
- B. Use specified materials to reestablish turf that does not comply with requirements and continue maintenance until turf is satisfactory.
- C. If the grass is in satisfactory condition, the Contractor's care and maintenance responsibilities will end. If the grass stand is unsatisfactory, the Contractor's maintenance responsibility shall continue, including a normal program of mowing, trimming, reseeding, fertilization and repair until an acceptable stand of grass is achieved.

3.8 CLEANUP AND PROTECTION

- A. Promptly remove soil and debris created by turf work from paved areas. Clean wheels of vehicles before leaving site to avoid tracking soil onto roads, walks, or other paved areas.
- B. Erect temporary fencing or barricades and warning signs as required to protect newly planted areas from traffic. Maintain fencing and barricades throughout initial maintenance period and remove after plantings are established.
- C. Remove nondegradable erosion-control measures after grass establishment period.

END OF SECTION 329200

SECTION 329300 - PLANTINGS

PART 1 – GENERAL

1.01 RELATED DOCUMENTS:

- A. Drawings and general provisions of Contract, including General and Supplementary Conditions apply to this Section.

1.02 DESCRIPTION OF WORK:

- A. Extent of Landscape Work is indicated on Drawings and in schedules.
- B. Provide and furnish all labor, materials and equipment required or inferred from Drawings and Specifications to complete the Work of this Section.
- C. The work to be done under this section shall require the Contractor to provide all labor, material, equipment and transportation necessary for the furnishing and planting of trees, shrubs and herbaceous materials and loam and seed on the Contract Drawings and as specified herein.

1.03 QUALITY ASSURANCE:

- A. Industry Reference Standards: Refer to Division 1 Reference Standards Section.
 - 1. USDA, NRCS 1999. The PLANTS database (<http://plants.usda.gov/plants>).
 - 2. American National Standards Institute, Inc. (ANSI):
ANSI Z60.1-96 American Standard for Nursery stock by the American Association of Nurserymen.
- B. Qualifications
 - 1. Installer Qualifications: All work under this Section shall be performed by experienced firm specializing in landscape installation. All workers shall be familiar with planting procedures and under full time supervision. Submit written documentation of successful completion of projects of similar size, scope and complexity to work specified for this Project.
 - a. Firm Experience Period: Seven years of experience.
 - b. Field Foreman Experience: Five years of experience with installing firm.

1.04 SUBMITTALS:

- A. Approval: Obtain approval from Landscape Architect for all submittals prior to the beginning of Work, unless otherwise approved.
- B. Plant Material Orders from Approved Nurseries:
- C. Topsoil Test Report: Submit results of laboratory soil tests, for information only, of topsoil proposed for use in planting soil mixes. Report shall include content of deleterious materials, organic matter, sand, silt, and clay, as determined by test methods included in Part 2 - Products; pH level, major nutrient levels and micro nutrient levels.

- D. Planting Soil Mix Test Report: Submit results of laboratory soil tests, for information only, of each planting soil mix as specified. Report shall included pH level, major nutrient levels, micro nutrient levels, and recommendations for fertilizer and lime amendments.
- E. Fertilizer Analysis: Submit, for information only, label or technical data for fertilizer bearing the trade name, manufacturer's name, weight and analysis for fertilizers used in planting soil mixes and on sodded lawn areas.
- F. Maintenance Instructions: Upon completion of the installation, submit typewritten recommendations for maintenance of any portion of the landscape which, in the opinion of the Contractor, requires special attention.

1.05 MATERIAL QUANTITIES:

- A. It is the Contractor's responsibility to total and confirm all material quantities. Items quantified by an area (i.e., square feet - sf., square yard - sq. yd.) or volume (cubic feet - cu. ft., cubic yard - cu. yd.) shall be calculated and confirmed by the Contractor. The quantities listed on the plant list are estimated. In the event of a discrepancy between the totals listed on the plant list and the numerical call-outs on the Drawings, the Drawings shall govern. The actual total quantities shall be determined by the Contractor.

1.06 DELIVERY, STORAGE AND HANDLING:

- A. Packaged Materials: Deliver packaged materials in containers showing weight, analysis and name of manufacturer. Protect materials from deterioration during delivery and while stored on site.
- B. Trees, Shrubs and Ground Cover: Provide freshly dug trees and shrubs. Do not prune prior to delivery. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Provide protective covering during shipment.
 - 1. In preparing plants for moving, all precautions customary in good trade practice shall be taken. Balled and burlapped plants shall have a solid ball of earth of minimum specified size (as recommended by ANSI z60.1) held in place securely. Oversize or exceptionally heavy plants are acceptable if the size of the ball or spread of the roots is proportionately increased to the satisfaction of the Landscape Architect. Broken, loose balls may be rejected.
 - 2. All plants shall be packed, transported and handled with utmost care to insure adequate protection against injury and drying. Any inspection certificates required by law shall accompany each shipment invoice or order of stock and, on arrival, the certificates shall be filed with the Architect.
 - 3. Provide container grown or freshly dug plant materials. Plant materials which have been in cold storage or heeled-in may be rejected. Do not bend or bind-tie trees or shrubs in such manner as to damage bark, break branches or destroy natural shape. Provide protective covering during delivery.
 - 4. Deliver plant material after preparation for planting has been completed and plant immediately. If planting is delayed more than 6 hours after delivery, protect from weather and mechanical damage, and keep roots moist.
 - 5. Do not remove container grown stock from containers until planting time.
 - 6. Label all plant materials of each variety with a securely attached waterproof tag bearing legible designation of botanical and common name (in the case of large

mass plantings of greater than 100 of the named variety a representative sample shall be tagged as above).

7. Do not remove labels attached to plant material by the Architect until directed to do so.

1.07 PROJECT CONDITIONS:

- A. Insurance on plant material and other materials stored or installed is the responsibility of the Contractor. Such insurance shall cover fire, theft and vandalism. Should the Contractor elect not to provide such insurance, he will in no way hold the Owner responsible for any losses incurred by the aforementioned acts. The Contractor is responsible for all costs incurred in replacing damaged or stolen materials prior to Date of Substantial Completion of the Work.
- B. Proceed with and complete landscape work as rapidly as portions of Site become available, working within seasonal limitations for each kind of landscape work required.
- C. Existing Grades: Existing grades will be within .2 feet of grades shown on the Civil Engineering Drawings when landscape work is to begin. Determine condition of existing grades prior to beginning the Work. When irregular or incomplete grading conditions are encountered, notify the Contract Manager in writing before beginning the Work. Determine location of existing drainage patterns and maintain patterns in completed Work. Perform Work in a manner which will avoid damage to finished grading and drainage patterns. All damage to finished grading and drainage resulting from Work covered in these Contract Documents shall be repaired at the Contractor's expense.
- D. Existing Utilities: Determine location of underground utilities. Perform Work in a manner which will avoid possible damage. Excavate as required. Maintain grade stakes set by others unless removal is mutually agreed upon by parties concerned. All damage to utilities resulting from Work covered in these Contract Documents shall be repaired at the Contractor's expense.
- E. Existing Conditions: Perform landscape Work in the Tree Protection Zones and in existing or previously completed landscape areas to avoid damage and disturbance to these areas. Limit work in these areas to only that necessary to perform work specified herein and shown on the Drawings. Return and repair any areas damaged or disturbed while performing the Work to the existing conditions encountered prior to the Work.
- F. Excavation: When conditions detrimental to plant growth are encountered, such as rubble fill, adverse drainage conditions, or obstructions, notify Landscape Architect in writing before planting.
- G. Planting Time: Plant or install materials during suitable weather conditions.
- H. Planting Schedule: Prepare a proposed planting schedule. Schedule dates for each type of landscape work during contract period. Coordinate schedule with General Contractor and Irrigation Contractor.

PART 2 – PRODUCTS

2.01 SOURCE QUALITY CONTROL:

- A. Only plant material grown in a recognized nursery in accordance with good horticultural practice will be accepted. Provide healthy, vigorous stock free of disease, insects, eggs, larvae, and defects such as knots, sun-scald, injuries, abrasions or disfigurement.
- B. Inspection of Plant Material Prior to Digging:
 - 1. Contractor must locate all plant material to be supplied for the Project and inform the Landscape Architect in writing of location within thirty (30) days of the date of the Contract or notice to proceed, whichever is first.
 - 2. In the event plant material is found to be unacceptable, the Contractor will pursue other sources until acceptable plant material is found, at no additional cost to the Owner.
 - 3. Approval at the plant source does not impair the right of the Landscape Architect to inspect and reject material at the time of shipping or during installation of the Work.
- C. Shipping:
 - 1. Ship landscape materials with certificates of inspection required by governing authorities. Inspection by Federal and/or State Governments at Grower does not preclude rejection of plants at the site by the Landscape Architects. Comply with regulations applicable to landscape materials. Prepare plants for shipment to prevent damage to the plants.
 - 2. If temperature is over 75 degrees Fahrenheit, ship plant material to be transported over 100 miles at night only. Make arrangements to have plant material watered during shipment as necessary to avoid excessive stress. Plant material may be rejected if not properly shipped.
 - 3. Do not ship plant material in temperatures below 20 degrees Fahrenheit.
- D. Do Not Make Substitutions: If specified landscape material is not obtainable, submit to Landscape Architect proof of non-availability and request for use of equivalent material. For proof of non-availability submit a written statement from a minimum of 3 reliable nursery sources (American Nurserymen's Association Members) that the plant in question is not obtainable in the Eastern United States.
- E. Approval and Selection of Materials and Work: The selection of all materials and the execution of all operations required under the Drawings and Specifications is subject to the approval of the Landscape Architect. The Landscape Architect has the right to reject any and all materials and any and all Work which, in his opinion, does not meet the requirements of the Contract Documents at any stage of the operations. The Contractor shall remove rejected work and/or materials from Project site and replace promptly.

2.02 TOPSOIL:

- A. Loam or approved topsoil removed within the confines of the project area shall be stock-piled on site and reused in accordance with the remainder of this section. The Contractor shall provide additional topsoil from approved sources off the site as required to complete work.

1. Topsoil shall be fertile, friable natural loam of the following types: sandy loam, clay loam, loam, silt loam, sandy clay loam, or other soil approved by the Landscape Architect. It shall not have a mixture of subsoil and contain no slag, cinders, stones, sticks, roots, trash or other extraneous material larger than 1.5" in diameter or length. Topsoil must also be free of noxious weeds. All topsoil shall be tested by a recognized laboratory for pH and soluble salts. A pH of 4.5 to 7.5 is required. Topsoil shall not contain soluble salts higher than 500 parts per million and shall not contain more than 20 percent organic matter or less than 3 percent organic matter. Phosphorus, nitrogen and potassium shall be in the medium to medium high range according to standard soil test results.
 2. The Contractor shall make any and all additions to or amendments of topsoil as required to remedy any deficiency shown in tests as required in soil analysis.
- B. Obtain topsoil from local sources or from areas having similar soil characteristics to that found at Project Site. Obtain topsoil only from naturally, well-drained sites where topsoil occurs in a depth of not less than 4 inches; do not obtain from bogs or marshes, unless specified.
- C. Topsoil ASTM D 5268 shall comply with the following composition as determined by the indicated test methods:
1. Deleterious Materials: 2 percent max. by mass; ASTM D 2487. (Rock, gravel, slag, cinder, stone).
 2. Organic Material: 10 percent min. by mass; ASTM D 2974.
 3. Sand Content: 20 to 30 percent by mass; ASTM D 1140.
 4. Silt and Clay Content: 40 to 60 percent by mass; ASTM D 1140.
 5. pH Range: 5 to 7; ASTM D 4972.

2.03 SOIL AMENDMENTS:

- A. Humus: Air dried, finely shredded, and pH range suitable for intended horticultural use. Humus shall be completely decomposed forest type including composted leaves, bark and organic wastes.
- B. Peat: Air dried, finely shredded or granular texture, completely decomposed and free of fibers with pH range suitable for intended horticultural use. Peat shall be naturally occurring, highly organic and derived primarily from plant materials.
- C. Organic Pre-Mixed Soil Amendment: Composted and screened 100 percent organic manufactured soil amendment.
- D. Perma Till: Rotary kiln expanded slate lightweight aggregate, processed with non-hazardous fuels and containing no clay lumps or any organic impurities.
- E. Shredded Pine Bark: Shredded bark pieces between 1/2 inch and 2 inches in length with partially decomposed bark matter.
- F. Lime: ASTM C 602, Class T, agricultural limestone containing a minimum of 80 percent calcium carbonate equivalent, with a minimum 99 percent passing a No. 8 sieve and a minimum 75 percent passing a No. 60 sieve.

- G. Bonemeal: Commercial, raw, finely ground; minimum of 4 percent nitrogen and 20 percent phosphoric acid.
- H. Dolomitic Lime: agricultural grade ground limestone containing total carbonates of 85% with a minimum of 30% magnesium carbonates.
- I. Trace elements: commercially available slow release materials contain zinc (Zn), molybdenum (Mo), iron (Fe), copper (Cu), boron (B), chlorine (Cl) and magnesium (Mn).
- J. Superphosphate: Commercial phosphate mixture, soluble, minimum of 20 percent available phosphoric acid.
- K. Commercial Fertilizer shall be as follows:
 - 1. Fertilizer shall be granular, packet or pellet with 35% to 80% in a slowly available form (water insoluble nitrogen urea form).
 - 2. Fertilizer shall be a complete fertilizer with a minimum analysis of 10% N, 6% P, and 4% K.
 - 3. Where superphosphate is used the analysis shall be 0-20-0.
 - 4. Manure shall be well rotted horse or cow manure or a combination of both. It shall be free from any chemicals used to hasten decomposition artificially, or any other injurious substance. Manure shall be at least nine months old, free from sawdust, hay, tanbark or wood shavings, or refuse of any kind. Manure shall consist of not more than 25% straw or other acceptable materials.
 - 5. Dehydrated manure may be used but must meet the same criteria as K4 above.

2.04 PLANTING SOIL:

- A. Planting Soil Mix For On-Grade Plantings: Provide soil mix amended as per laboratory recommendations. Basic planting soil mix consists of:
 - 1. 60% topsoil (as specified)
 - 2. 40% prepared additives (by volume as follows)
 - a. 2 parts humus and/or peat
 - b. 1 part shredded pine bark (bark pieces between 1/2 inch and 2 inches in length)
 - c. 1 part sterilized composted cow manure
 - 3. Commercial fertilizer as recommended in soil report
 - 4. Lime as recommended in soil report
- B. Humus shall be omitted from planting soil mixes if topsoil used has an organic content of 40 percent or greater as determined by the topsoil test report.

2.05 PLANT MATERIALS:

- A. General:
 - 1. All plants shall be nursery grown unless otherwise stated.
 - 2. Provide plants true to species and variety, complying with recommendations of ANSI Z60.1 "American Standard for Nursery Stock". Nomenclature to comply with "USDA, NRCS 1999. The PLANTS database (<http://plants.usda.gov/plants>)."
 - 3. All plants shall be legibly tagged with proper botanical names.

4. Specific requirements concerning plant material and the manner in which it is to be supplied are shown on the Drawings and plant list.
5. Acclimatization: All woody plant material other than that grown vegetatively shall have been growing within one plant hardiness zone (as defined by Arnold Arboretum) of the location of this project for at least two years prior to award date of this contract.
6. All plants shall be subject to approval at their source prior to shipment. All plants shall be clearly labeled. The Contractor shall notify the Landscape Architect at least one week prior to shipping the plants to the job site.
7. Plant materials shall be substantially free of damage as a result of handling and transportation.
8. All parts of the plant shall be moist and shall show active green cambium when cut.

B. Quality and Size:

1. All plants shall be typical of their species and variety. Plants shall have normal, well-developed branches and vigorous root systems typical of the species. They shall be healthy, vigorous plants free from defects, decay, disfiguring roots, sunscald injuries, abrasions of the bark, plant diseases, insect pests, eggs, borers, and all forms of infestations or objectionable disfigurements. Furnish nursery grown plants, freshly dug, normally shaped and well branched, fully foliated when in leaf and with healthy well developed root systems.
2. Furnish plants to match as closely as possible whenever symmetry is called for.
3. Provide trees and shrubs of sizes shown or specified. A plant shall be dimensioned as it stands in its natural position. Large plants which have been cut back to the specified size will not be accepted. Plants that meet the measurements specified, but do not possess a normal balance between height and spread, will not be accepted. Plants shall not be pruned prior to delivery.
4. Trees and shrubs of larger size may be used if acceptable to the Landscape Architect, and if sizes of roots or rootballs are increased proportionately. The increased size will not result in additional cost to the Owner.
5. Stock Specified in a Size Range: Within each size range not less than 50% of the plants must be of the maximum size specified.
6. Balled and Burlapped Plants: Plants designated "B&B" are to have firm, natural balls of soil corresponding to sizes specified in ANSI Z60.1 "American Standard for Nursery Stock". Balls to be firmly wrapped in biodegradable burlap and securely tied with biodegradable heavy twine, rope and/or wire baskets. Plants with loose, broken or manufactured rootballs will be rejected. Rootballs shall be lifted from the bottom only, not by stems or trunks.
7. Container grown plants in cans or plastic containers will be acceptable in lieu of balled and burlapped plants provided that they are of specified quality. Container-grown stock shall have been grown in a container long enough for the root system to have developed sufficiently to hold its soil together, firm and whole. No plants shall be loose in the container. The container must be removed prior to planting, with care being exercised as to not injure the plant.

C. Trees:

1. Provide trees of height and caliper listed or shown and with branching configuration recommended by ANSI Z60.1 for type and species required. Provide single stem trees except where special forms are specified in the Contract Documents.

2. Provide self supporting trees with straight trunks and leaders intact. Where required in the Contract Documents, provide trees with character as described.
 3. Determining dimensions for trees are caliper, height and spread: Caliper shall be measured 6 inches above ground for trees up to and including 4 inch caliper. Trees over 4 inch caliper shall be measured 12 inches above ground. Specified height and spread dimensions refer to the main body of the plant and not branch tip to tip. Take measurements with branches in natural position.
- D. Tree Forms: Do not limb up tree forms more than 2 feet before planting. Prune to desired shape as directed by Landscape Architect.
- E. Herbaceous Groundcovers and Perennials: Provide established and well rooted plants in removable containers, integral peat pots, or flats. Containers shall be free of any extraneous or noxious weeds.
- F. Grass Materials:
1. Conservation Seed Mix: New England Conservation Wildlife Mix
 - a. Source: New England Wetland Plants, inc (413) 548-8000
 - b. Mixture: To be determined by landscape architect if applicable.
 - c. Rate: 25lbs/ acre

2.06 MISCELLANEOUS LANDSCAPE MATERIALS:

- A. Burlap for wrapping earthball shall be biodegradable jute mesh not less than 7.2 oz. per square yard. Wrapping materials made from man made fibers are unacceptable.
- B. Burlap for slope stabilization shall be biodegradable jute mesh not less than 7.2 oz. per square yard. Attach with wire landscape staples, typical.
- C. Stakes and Deadmen: Grade No. 2 or better, uniform grade pressure treated pine LP-22, or sound new hardwood or redwood free of knotholes and other defects. Deadmen shall be 2'-4' long by 4"-8" wide timbers, or other approved material capable of supporting the tree specified for its use.
- D. Anchors: #4 rebars or comparable size steel stakes, 36 inches in length.
- E. Guys and Wire Ties: 2-strand, twisted, pliable galvanized steel wire not lighter than #12 gauge.
- F. Hose: 1/2 inch diameter black reinforced rubber or plastic garden hose. Cut to required lengths to protect tree trunks from damage by wires. Used hose is acceptable.
- G. Plastic chain: "Adjust-i-tie" or approved equal.
- H. Clamps: Galvanized or zinc and large enough to hold wire or cable used.
- I. Turnbuckles: Galvanized steel or zinc coated.
- J. Filter Fabric (soil separator): A fiber soil separator approved by the Landscape Architect shall be used to prevent infiltration of soil into drainage aggregate or gravel and to allow

free passage of water. Manufacturer's standard nonwoven pervious geotextile fabric of polypropylene, nylon or polyester fibers, or a combination.

1. Provide filter fabrics that meet or exceed the listed minimum physical properties determined according to ASTM D 4759 and the referenced standard test method:
 - a. Grab Tensile Strength (ASTM D 4632): 100 lb.
 - b. Apparent Opening Size (ASTM D 4751): #100 U.S. Standard Sieve.
 - c. Permeability (ASTM D 4491): 150 gallons per minute per sq. ft.

- K. Water: Shall be furnished by the Contractor unless stipulated otherwise and will be suitable for irrigation and free from ingredients harmful to plant life. Hose and other watering equipment required for the work shall be furnished by the Contractor until Substantial Completion of the project.

- L. Mulch:
 1. Shredded bark: shall consist of bark fibers shredded from either softwood trees or hardwood trees that shall be free of chunks of wood or other debris and whose fibers shall not exceed 4" in length and shall be of a consistent texture and color.

- M. Hay or straw: shall consist of long fibered hay or straw, reasonably free from noxious weeds or other undesirable material. No material shall be used which is so wet decayed, or compacted as to inhibit even and uniform spreading. No chopped hay, grass clippings or other short fibered material shall be used unless directed.

- N. Anti-Desiccant: Emulsion type, film-forming agent designed to permit transpiration but retard excessive loss of moisture from plants. Deliver in manufacturer's fully identified containers and mix in accordance with manufacturer's instructions.

PART 3 – EXECUTION

3.01 PREPARATION:

- A. General:
 1. Contractor shall examine conditions under which planting is to be installed, review applicable architectural and engineering Drawings, and be familiar with alignment of underground utilities before digging.
 2. Planting Time: Planting operations are to be performed at such times of the year as the job may require, with the stipulation that the Contractor guarantees the plant material as specified. Plant only during periods when weather conditions are suitable.
 3. Verify layout information shown on the Drawings, in relation to property survey and existing benchmarks before proceeding to layout the work. Locate and protect existing benchmarks and control points. Calculate and measure required dimensions. Do not scale Drawings to determine dimensions.
 4. Layout individual tree and shrub locations and areas for multiple plantings. Stake locations and outline areas and secure Landscape Architect's acceptance before start of excavation for planting work. Make adjustments as requested.
 5. Notify Landscape Architect of adverse sub-surface drainage or soil conditions. State conditions and submit a recommendation for correction including costs. Obtain approval for method of correction prior to continuing work in the affected area.

In the event that alternate locations are selected, the Contractor shall prepare such areas at no additional expense to the Owner.

- B. Excavation for Trees and Specimen Shrubs:
 - 1. Excavate pits, beds and trenches with vertical sides, as specified and as shown on the Drawings.
 - 2. Loosen hardpan and moisture barrier until hardpan has been broken and moisture is allowed to drain freely.
 - 3. For balled and burlapped (B&B trees and shrubs), make excavations at least 4 feet wider than the ball diameter for the top 12 inches of the pit. For the remaining depth of the pit, excavate at least 2 feet wider than the full diameter and equal to the ball depth, plus an allowance for setting of ball on a layer of compacted backfill. Allow for 6 inch minimum setting layer of excavated soil.
 - 4. For container grown stock, excavate as specified for balled and burlapped stock, adjusted to size of container width and depth.

- C. Test Drainage:
 - 1. Tree and Specimen Shrub Pits: Fill each pit with water. If percolation is less than 100 percent within a period of 12 hours, drill a 10 inch diameter auger hole to a depth up to five (5) feet below the bottom of the pit. Fill auger hole with drainage gravel and cover with filter fabric. Retest pit. In case drainage is still unsatisfactory, notify Landscape Architect, in writing, of the condition before planting trees in the questionable areas. Contractor is fully responsible for warranty of the plant material.

- D. Subsoil Removal:
 - 1. Dispose of subsoil removed from landscape excavations at an off-site location. Do not mix with planting soil. Do not use as backfill.

3.02 FIELD QUALITY CONTROL:

- A. Testing: Contractor shall employ testing agency to perform soil permeability test in accordance with ASTM 2434 on planting soil mix to be used in structured planters prior to procuring and installing drainage matting. Test results shall be used to determine weight of integral non-woven filter fabric.

3.03 PREPARATION OF PLANTING SOIL:

- A. Before mixing, clean topsoil (or existing surface soil if using a soil conditioner) of roots, plants, clods, stones, clay lumps, and other extraneous materials harmful or toxic to plant growth.
- B. Mix specified soil amendments and fertilizers with topsoil, or soil conditioner with existing surface soil at rates specified. Delay mixing of fertilizer if planting will not follow placing of planting soil within a few days.
- C. For pit and trench type backfill, mix planting soil prior to backfilling and keep covered until used.

- D. For planting soil prepared with a manufactured soil conditioner, mix planting soil in large batches before backfilling, stockpile for use at site and keep covered until used. Do not mix soil conditioner at individual planting sites.
- E. For perennial and shrub beds, mix planting soil either prior to planting or apply on a surface layer over prepared bed area and mix both thoroughly in the bed before planting.
 - 1. Mix lime, if required, with dry soil prior to mixing of fertilizer.
 - 2. Prevent lime from contacting roots of acid-loving plants.
 - 3. Apply phosphoric acid fertilizer (in addition to that constituting a portion of complete fertilizers) directly to subgrade before applying planting soil and tilling.

3.04 PREPARATION OF SHRUB AND PERENNIAL PLANTING BEDS:

- A. Lay out planting beds on the ground to the lines shown on the Drawings. Have layout approved by Landscape Architect prior to constructing the bed.
- B. Outline bed with a trench edge as shown on the Drawings. Place soil for trench edge within bed area.
- C. Loosen existing soil to a minimum depth of 12 inches using a roto tiller or similar equipment. Remove all sticks, stones, rubbish and other material detrimental to plant growth.
- D. Spread 4 inch min. layer of planting soil mixture over entire bed area. (Additional soil mix may be necessary to build up shrub beds to grade as shown on the Drawings.) Work planting soil into top of loosened soil with roto tiller.
- E. Smooth planting areas to conform to specified grades after settlement has occurred. Slope surface of shrub beds to drain toward the trench edge.
- F. Mass preparation of beds is not applicable for areas exceeding 4:1 slope.

3.05 PLANTING TREES AND SPECIMEN SHRUBS:

- A. Set balled and burlapped (B&B) stock on layer of compacted planting soil mixture, plumb and in center of pit or trench with top of ball 2-3 inches above the finish grade and also 2-3 inches above the grade they bore to natural grade before transplanting. Remove all straps and ropes made of man-made fibers completely from rootball. Loosen and remove burlap and biodegradable ropes from top half of rootball. Cut and remove the top half of all wire baskets before backfilling. Use planting soil mixture to backfill plant pits. When plants are set, place additional backfill around base and sides of ball, and work each layer to settle backfill and eliminate voids and air pockets. When excavation is approximately 2/3 full, water thoroughly before placing remainder of backfill. Repeat watering until no more is absorbed. Water again after placing final layer of backfill.
- B. Remove all man made or impervious materials from the rootball and trunk before final installation of trees and specimen shrubs.
- C. Set container grown stock as specified for balled and burlapped stock, except remove containers, without damaging rootballs, prior to backfilling.

- D. Apply anti-desiccant using power spray to provide an adequate film over trunks, branches, stems, twigs and foliage. If deciduous trees or shrubs are moved in full leaf, spray with anti-desiccant at nursery before moving and again after planting as per manufacturer's recommendations.
- E. Mulching: Immediately after planting work has been completed, mulch pits, trenches and planting beds. Provide a minimum depth of 3 inches of bark mulch. Finish edges according to the Drawings.
- F. Water: Soak all plants immediately after planting, continue watering thereafter as necessary until Date of Substantial Completion.
- G. Smooth planting areas to conform to specified grades after full settlement has occurred and mulch has been applied.

3.06 STAKING, GUYING AND PRUNING:

- A. Stake and guy trees immediately after planting. Plants shall be plumb after staking or guying. Maintain stakes, wires and guys until Final Acceptance of the Work.
- B. Staking trees of 1 inch caliper and under, or less than 4 feet height: Use single stake with rubber hose and wire loop around trunk. Use only wooden stakes as specified.
- C. Staking trees of 1 to 2-3/4 inch caliper: Drive stakes securely into ground and fasten to tree with wire and tie. Use hose around wire so wire is not in contact with plant, or use Cinch-tie of appropriate size. Adhere to staking details unless alternate detail has been approved by Landscape Architect prior to beginning of planting operation.
- D. Guying trees of 3 inch caliper and larger: Guy trees according to detail. Position guys around trunk at approximately two-fifths the height of the tree. Anchor guys in ground either to notched stakes or steel rods driven securely into ground with top end 3 inches below finish grade.
- E. Pruning: Unless otherwise directed by the Landscape Architect do not cut tree leaders. Remove only injured or dead branches from trees, if any. Prune shrubs at the direction of the Landscape Architect.
- F. Remove and replace promptly any plants pruned or mis-formed resulting from improper pruning.
- G. Inspect tree trunks for injury, improper pruning and insect infestation and take corrective measures.

3.07 PLANTING SHRUB

- A. Excavate large enough area in loosened soil to install specified container grown plants.
- B. Remove containers without damaging the rootball and set in excavated hole.
- C. Place container grown plant in excavated hole with top of rootball even with final shrub bed elevation.

- D. Backfill rootball with soil from the bed and lightly compact soil around plant to eliminate voids and air pockets.
- E. Mulching: Immediately after planting, mulch planting beds with a minimum depth of 3 inches of bark mulch. Finish edges according to the Drawings. Remove all mulch from foliage of plants.
- F. Watering: Soak entire area immediately after planting. Continue watering thereafter as necessary until Date of Substantial Completion.

3.08 MAINTENANCE:

- A. Begin maintenance immediately after planting.
- B. Maintain trees, shrubs, lawns and other plants until Date of Substantial Completion of the Work.
- C. Maintain trees, shrubs, lawns and other plants by watering, pruning, cultivating, weeding, and re-mulching as required for healthy growth. Restore planting saucers. Tighten and repair stake and guy supports and reset trees and shrubs to proper grades or vertical position as required. Restore or replace damaged wrappings. Spray as required to keep trees and shrubs free of insects and disease.

3.09 CLEAN UP AND PROTECTION:

- A. During Landscape Work, keep pavements clean and work area in an orderly condition.
 - 1. Protect site, landscape work, and materials from damage due to landscape operations, operations by other Contractors and trades and trespassers. Maintain protection during installation and maintenance periods.
 - 2. All labeling and other non-organic substances such as flagging, grade ribbons, etc. must be removed from the project prior to provisional acceptance.
- B. Upon completion of Work, clear grounds of debris, superfluous materials and all equipment. Remove from site to satisfaction of Landscape Architect and Owner.
- C. Protect landscape 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 or replace damaged landscape Work as directed, at no additional cost to the Owner.
- D. Restoration: All pavements, sodded and planted areas, structures and substructures not specifically provided for in the contract disturbed by the Contractor during the execution of the work shall be restored by the Contractor, in a manner satisfactory to the Landscape Architect, to their original condition at no cost to the Owner.

3.10 OBSERVATION AND ACCEPTANCE:

- A. Periodic site visits will be made by the Landscape Architect to review the quality and progress of the Work. Work found to be unacceptable must be corrected within five calendar days. Remove rejected plants and materials promptly from the Project.

- B. Upon completion of Work, the Contractor shall notify the Landscape Architect and the Owner at least ten (10) days prior to requested date of site visit for Substantial Completion of all or portions of the Work. Landscape Architect will issue a punch list for work to be corrected. All work in the punch list must be completed within five (5) working days from date of site visit. Where Work does not comply with requirements, replace rejected Work and continue specified maintenance until by Landscape Architect finds work to be acceptable.
- C. If a site visit to verify Substantial Completion has been scheduled and the Landscape Architect arrives at the site and determines that the Landscape Development is not substantially complete, the Contractor shall be responsible for all costs incurred by the Landscape Architect to re-visit the site. Reimbursable expenses include but are not limited to the following: mileage, airfare, consultant's time, parking fee, meals, rental car, etc. All incurred expenses will be deducted from the final contract amount.
- D. Certificate of Substantial Completion will be issued for acceptable Work. If punch list items are issued with the Certificate, they must be corrected within five (5) working days.

PART 4 – GUARANTEES AND FINAL ACCEPTANCE

4.01 WARRANTY:

- A. One Year Warranty commences on the date of issuance of the Certificate of Substantial Completion.
 - 1. Warranty for a period of one year, following the Date of Substantial Completion, all trees, shrubs, groundcovers, plants and grass against any defects including death and unsatisfactory growth, as determined by the Landscape Architect. Warranty shall include the complete cost to supply and install all replacement plant materials according to the requirements herein. Defects resulting from neglect by the Owner, abuse or damage by others, or unusual phenomenon or incidents beyond the Contractor's control are excepted. Should questions arise concerning the responsibility of replacement, the Landscape Architect will be available for arbitration provided the Owner and Contractor mutually desire.
 - 2. Remove and replace all trees, shrubs, groundcovers and lawn, or other plants found to be more than 25 percent dead or in unhealthy condition during warranty period as determined by Landscape Architect or Owner. Make replacements immediately unless required to plant in the succeeding planting season.
 - 3. Replacements: Match adjacent specimens of same species. Replacements are subject to all requirements stated in the Contract Documents and are subject to inspection by the Landscape Architect prior to digging.
 - 4. Repair grades, lawn areas, paving and any other damage resulting from replacement planting operations, at no additional cost to the Owner.
 - 5. The contractor shall make periodic inspections, at no extra cost, during the guarantee period to determine what changes, if any, should be made in the maintenance program. If changes are recommended, they shall be submitted in writing to the landscape architect. Claims by the contractor that the owner's maintenance practices or lack of maintenance resulted in dead or dying plants will not be considered if such claims have not been documented by the contractor during the guarantee period.

6. Replacements made during the Warranty Period or following inspection for Final Acceptance will carry on additional one year warranty beginning at the time of replacement.

4.02 FINAL ACCEPTANCE:

- A. At the end of the guarantee period, one year after Date of Substantial Completion of the Work in total, the Landscape Architect and/or the Owner will visit the site to determine Final Acceptance. Upon satisfactory completion of repairs and/or replacements the Landscape Architect and/or the Owner will certify, in writing, the Final Acceptance of the Work. The Final Acceptance letter will serve as evidence that the Contractor's one-year warranty obligations have been met.
- B. Contractor shall remove all staking and guying at the end of one year, with the exception of replaced plants. Contractor shall remove all staking and guying from replaced plants one year after the date of replacement.

END OF SECTION

SECTION 331100 - WATER UTILITY DISTRIBUTION PIPING

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Water distribution piping includes:
1. Furnishing and installing all distribution piping as noted on the Drawings.
 2. Verifying location of existing utilities prior to construction.
 3. Coordinating with the Portland Water District for connection to the existing utilities.
 4. Supply and installation of all valving, and accessories.
 5. Flushing, testing and disinfection of all water distribution piping.
 6. Repair of water piping damaged during construction.

1.2 REFERENCES:

- A. Specification Sections:
1. Earth Moving: Section 31 20 00.
 2. Erosion and Sedimentation Controls: Section 31 25 13.
- B. Portland Water District Specifications and Procedures, www.pwd.org

1.3 QUALITY ASSURANCE

- A. Code Compliance: Comply with State Plumbing Code and local plumbing codes where more stringent. Comply with Maine Department of Human Services, Division of Health Engineering rules.
- B. AWWA Standards: Comply with requirements of Section 4 of AWWA C601, "Preventive Measures During Construction" for cleanliness.
- C. Other Standards: Comply with requirements of the Portland Water District specifications.
- D. Testing: CONTRACTOR shall pay for all flushing, pressure and leakage testing, disinfection, and fire flow testing.

1.4 SUBMITTALS

- A. Submit manufacturer's product data and installation instructions for each product specified for water service piping.

PART 2 PRODUCTS

2.1 General

- A. All products shall be in conformance with the Portland Water District's standard specifications.

2.2 PRESSURE PIPE

- A. General: Provide fittings and other required piping accessories of same type and class of material as conduit, or of material having equal or superior physical and chemical properties.
- B. Copper Tube: Type K conforming to ASTM B88, with compression fittings.
- C. Ductile Iron Pipe: Push-on joints unless indicated otherwise, centrifugally cast bituminous-coated, cement-lined (AWWA C104), seal-coated and manufactured in accordance with the latest revision of AWWA Standards C150 and C151. Interior shall be seal-coated twice with asphalt to a minimum of 2 mils dry film thickness. Pipe shall be Class 52 unless indicated otherwise. Weight, class, manufacturer's mark, year of production, and "DI" or "Ductile" shall be cast or stamped on the pipe.

2.3 VALVES, FITTING, CLAMPS, ETC.

- A. General: All products used in the construction that come in contact with drinking water shall meet the National Sanitation Foundation Standard 61 for Drinking Water System Components - Health Effects. The products and/or materials covered include, but are not limited to, protective materials (coatings, linings, liners, etc.), joining and sealing materials (solvent cements, welding materials, gaskets, etc.), and mechanical devices used in transmission/distribution systems, (valves, etc.).
- B. All valves, joints, corporations stops, clamps, repair sleeves, valve boxes, accessories, and fittings shall be installed per Portland Water District Standards.

PART 3 EXECUTION

3.1 INSTALLATION

- A. General: Install products in compliance with the Portland Water District's standard specifications and procedures and the manufacturer's instructions. Prevent introduction of any groundwater or foreign materials into pipe during construction. Provide watertight plug in ends of pipe at all times when construction is not in progress. Coordinate all work with the Portland Water District.
- B. Excavation: Where location of distribution pipe is known, excavate within 2 feet of pipe by hand.
- C. Bedding of Pipe: Bed in sand or crushed stone. Refer to trench detail on Drawings.
- D. Cleaning: Clear interior of pipe of dirt and other superfluous material as work progresses. Place plugs in end of uncompleted pipe whenever work stops.

- E. Coordinate connections to existing water mains with the Portland Water District. Provide 48 hours notice prior to such work. The CONTRACTOR is responsible for the cost and all work associated with water service taps and connection to existing mains.
- F. Water Service Piping: Extend water service piping of size indicated to existing water service. Provide new shutoffs as indicated and shown. Bed pipe in sand or crushed stone. See trench detail on Drawings.
- G. Backfill under all existing utility pipes crossed by new utility pipes or work with ¾" crushed stone. The crushed stone backfill shall extend continuously from the bedding of the new pipe to the utility pipe crossed, including a 6" thick envelope of crushed stone all around the existing utility pipe(s). The ¾" crushed stone backfill shall stand at its own angle of repose. No "haunching" or "forming" with common fill will be allowed.

3.2 INSULATION

- A. Install as shown on Drawings.

3.3 FLUSHING AND TESTING

- A. General: The CONTRACTOR shall not operate any existing Portland Water District valves for filling, flushing or testing the new main. The District will provide the necessary personnel upon request.
- B. Flushing: The CONTRACTOR shall flush the new main at a minimum velocity of 2.5 feet per second to remove any particulate matter. Provide the following minimum flow in gallons per minute: 4" dia. - 100 GPM; 6" dia. - 220 GPM; 8" dia. - 390 GPM; 12" dia. - 880 GPM, or as directed by Portland Water District. The CONTRACTOR shall be responsible for disposal of all flushing water and providing any necessary hoses or equipment for flushing.
- C. Perform pressure and leakage testing of completed lines. CONTRACTOR shall coordinate all testing with the Portland Water District. Pressurize test pipe to 150 psi and allow to stabilize (+/- 2.5 psi) for a minimum of 15 minutes, or as directed by Portland Water District. Pressure and leakage test shall be conducted at pressure of 150 psi for minimum of two hours. Maximum allowable leakage per 1000 feet of pipeline shall be 0.37 gph for 4-inch diameter pipe and 0.55 gph for 6-inch diameter pipe.
- D. Perform operational testing of valves by opening and closing under water pressure to insure proper operation.

3.4 DISINFECTION

- A. General: Upon satisfactory completion of the pressure and leak test, all new water mains shall be disinfected before they are placed into service in accordance with AWWA Standard C651, latest revision, procedures specified herein, and as specified by Portland Water District. Fittings required for final connection to existing water main shall be disinfected by swabbing with a sodium hypochlorite solution immediately prior to final connection.

- B. Disinfection:
1. The CONTRACTOR shall chlorinate the new water main in accordance with the continuous feed method specified in Section 5.2 of AWWA Standard C651, latest revision, using 5 percent to 15 percent sodium hypochlorite solution.
 2. The CONTRACTOR may use calcium hypochlorite granules or tablets placed in the new water mains during installation in accordance with Section 5.1 of AWWA Standard C651, latest revision, in addition to the continuous feed method, not as a substitute.
- C. Chlorine Requirement: The new water main shall be chlorinated so that a chlorine residual of not less than 25 parts per million remains in the water after standing 24 hours in the pipe. Chlorine residual at start of the test shall be a minimum of 50 parts per million.
- D. Point of Application: Chlorinating solution point of application shall be within 10 feet of the connection to the existing main through a corporation stop inserted in the water main. Alternate points of application may be used when accepted or directed by the Portland Water District.
- E. Rate of Application: Water from the distribution system, or other source of supply as accepted by the Portland Water District, shall be controlled to flow very slowly into the new water main during application of the chlorine. The rate of chlorine solution flow shall be in such proportion to the rate of water entering the new water main that the dosage applied to the water will be sufficient for a minimum of 50 parts per million unless directed by the Portland Water District.
- F. Retention Period: Treated water shall be retained in the new water main for a minimum of 24 hours. CONTRACTOR shall provide sampling taps at 500 ft. intervals, at all deadends, and at end of all new water mains. Take one sample at each location. Treated water shall contain no less than 25 parts per million of available chlorine.
- G. Flushing and Draining:
1. At the end of the retention period, the chlorination water shall be flushed from the main until all heavily chlorinated water has been removed. CONTRACTOR shall arrange for all testing of water. CONTRACTOR shall provide testing at no cost to OWNER.
 2. CONTRACTOR shall coordinate with the Portland Water District to obtain all water required for flushing and draining. CONTRACTOR to provide temporary blow-offs as necessary for flushing and draining.
 3. Chlorine residual of water being disposed shall be neutralized by treating with one of the chemicals listed in the table below:

Amount Of Chemicals Required To Neutralize Various
Residual Chlorine Concentrations In 100,000 Gallons Of Water*

<u>Residual Chlorine Concentration (mg/l)</u>	<u>Sulfur Dioxide</u>	<u>Sodium Bisulfate</u>	<u>Sodium Sulfite</u>	<u>Sodium Thiosulfate</u>
1	0.8	1.2	1.4	1.2
2	1.7	2.5	2.9	2.4
10	8.3	12.5	14.6	12.0
50	41.7	62.6	73.0	60.0

*Except for residual chlorine concentration, all amounts are in pounds

- H. Bacteriological Testing: Following disinfection and final flushing, bacteriological testing shall be done as specified in Section 5 of AWWA C651 as follows:
1. After final flushing and before the new water main is connected to the distribution system, two consecutive sets of acceptable samples, taken at least 24 hours apart, shall be collected from the new main. At least one set of samples shall be collected from every 1,200 feet of the new water main, plus one set from the end of the line at least one set from each branch.
 2. All samples shall be tested for bacteriological quality in accordance with Standard Methods for the Examination of Water and Wastewater, and shall show the absence of coliform organisms.
 3. If the initial disinfection fails to produce satisfactory bacteriological results, the new main shall be reflushed and resampled. If check samples also fail to produce acceptable results, the main shall be rechlorinated by the continuous-feed or slug methods until satisfactory results are obtained.
- I. Equipment: Provide water pumps with adequate metering devices. Provide chlorination injection pumps which allow accurate measurement of the disinfection solution being introduced to new water main.
- J. Personnel: Submit names of personnel or firm to perform disinfection work.

END OF SECTION 331100

SECTION 333000 - SANITARY SEWERAGE UTILITIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish and install sanitary sewer system as shown on the Drawings. This includes:
 - 1. Sanitary sewer service pipe
 - 2. Repairs to existing pipe damaged during construction
 - 3. Precast manholes and precast concrete structures and their appurtenances
 - 4. Sanitary sewer cleanouts
 - 5. Insulation and/or concrete encasement as necessary for utility crossings
 - 6. Back flow preventers
 - 7. Connection to existing systems

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Refer to Section 312000
 - 2. Erosion and Sedimentation Controls: Refer to Section 312513
 - 3. State of Maine Department of Transportation "Standard Specifications: Highways and Bridges", most recent revision.
- B. State of Maine Department of Transportation "Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications", most recent revision.
- C. City of Portland Technical Manual, most recent revision.

1.3 SUBMITTALS

- A. Manufacturer's product data and installation instructions.
- B. Anti-floatation calculations for all precast concrete structures, stamped by Professional Engineer licensed in the State of Maine.
- C. Certified copies of tests on pipe units.
- D. Construction Records:
 - 1. Record depth and location of the following:

- a. Sanitary sewer pipe and service locations, cleanouts, bends in services, connection points to sewer main.
 - b. Repairs to existing pipes.
2. Record neatly in a permanently bound notebook and submit at Substantial Completion. Provide access to records for PROJECT ARCHITECT at all times. Submit copies to PROJECT ARCHITECT on a weekly basis.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

- A. General: Provide fittings of same type and class of materials as pipe. Provide commercially manufactured wyes or tee/wyes for service connections. Fitting must have single piece gasket.
- B. PVC Non-Pressure Pipe and Services (Sewer): 4- through 15-inch Diameter: ASTM D3034 or ASTM D3033, 18- through 27-inch Diameter: ASTM F-679, strength requirement SDR 35; push-on joints, ASTM D3212; gaskets, ASTM F477.

2.2 PRECAST CONCRETE STRUCTURES

- A. Base Sections: Precast monolithic construction with steps.
- B. Barrel Sections: Precast with steps.
- C. Top Sections: Precast eccentric cone with steps.
- D. Steps: Polypropylene reinforced with steel rod. Meet OSHA requirements, minimum width 16-inches. Cast into concrete.
- E. Pipe to Structure Connections: Connections shall be watertight, expandable pipe sleeve with adjustable expansion ring equal to Press-Boot by Press-Seal Gasket Corp., Fort Wayne, Indiana.
- F. Joints Between Precast Sections: Watertight, shiplap-type seal with two rings of one-inch diameter butyl rubber sealant.

2.3 FRAMES, COVERS, AND GRATES

- A. Material: Cast iron, ASTM A48 Class 30
- B. Provide frames, covers and grates as identified on the plans

2.4 MISCELLANEOUS

- A. Flexible Couplings: Use and location shall be approved by PROJECT ARCHITECT or ENGINEER.
 1. Type A: Dresser Style 253 as manufactured by Dresser, or approved equal.

2. Type B: Neoprene sleeve with stainless steel bands by Fernco, or approved equal.
- B. Pipe Supports: Saddle type, steel, painted, adjustable, by ITT Grinnell, or approved equal.
- C. Marking Tape: Lineguard III by Tri-Sales, Inc., 2-inch wide, green; detectable with magnetic locators, or approved equal.
- D. Frost Barrier: U.V. resistant, high grade polyethylene, minimum thickness six (6) mils.
- E. Joint Sealants:
1. Butyl Rubber Sealant: One (1) inch diameter strips manufactured by Kent Seal, or approved equal.
 2. Butyl Rubber Caulking: Conform to AASHTO M-198, Type B.
 3. Sewer Manhole Inverts: Provide inverts as shown on the Drawings. Configuration to be as required by connecting pipes and as shown on Drawings.

PART 3 EXECUTION

3.1 INSTALLATION OF GRAVITY PIPE AND FITTINGS

- A. Methods: Install in accordance with manufacturer's recommendations. Use a laser beam for line and grade unless otherwise permitted by the ENGINEER. Secure each length of pipe with bedding before placing next length. Plug open ends when work is suspended. Bed pipe as shown on Drawings. A 30-inch minimum cover over the top of PVC pipe and DI pipe should be provided before the trench is wheel-loaded.
1. Backfill under all existing utility pipes crossed by new utility pipes or work with $\frac{3}{4}$ " crushed stone. The crushed stone backfill shall extend continuously from the bedding of the new pipe to the utility pipe crossed, including a 6" thick envelope of crushed stone all around the existing utility pipe(s). The $\frac{3}{4}$ " crushed stone backfill shall stand at its own angle of repose. No "haunching" or "forming" with common fill will be allowed.
- B. Grade and Line:
1. Lay pipe to line and grade shown on the Drawings. If grade is not shown, determine elevations of start and finish points for each run of pipe. Lay pipe to a uniform grade between these points.
 2. Line and grade may be adjusted by the PROJECT ARCHITECT as required by field conditions.
- C. Conditions: Lay pipe in the dry. Do not use installed pipe to remove water from work area.
- D. Flush and clean all pipe and remove all debris and materials. Flushing and cleaning methods approved by ENGINEER. Gravity flushing is not acceptable.

- E. Connections to Manholes and Catch basins: Provide short length of pipe so that joints are located within 3 feet of inside surface of manholes and catch basins for all pipe.
- F. Sanitary Sewer Service Fittings and Leads:
 - 1. Size of service leads 6-inch unless otherwise indicated.
 - 2. Depth and location of service to be determined by PROJECT ARCHITECT in field.
 - 3. Provide tee/wye or wye fittings on main line pipe.
 - 4. Provide clean outs as shown and detailed on Drawings.

3.2 INSTALLATION OF MANHOLES

- A. Placement: Place precast bases and structures on compacted bedding material so bottom of structure is plumb and pipe inverts are at proper elevations. Place manhole barrel and top sections in the appropriate height combinations. Plug all lifting holes inside and out with non-shrink grout. Construct manhole inverts in accordance with the Drawings.
- B. Joints: Follow manufacturer's instructions for sealing joints between precast sections. Provide two rings of 1 inch diameter butyl rubber sealant. Point joints inside and out with butyl caulk.
- C. Frame and Covers:
 - 1. Set to final grade as shown on the Drawings and as specified. Provide adequate temporary covers to prevent accidental entry until final placement of frame and cover is made.
 - 2. Use two rings of 1 inch diameter butyl rubber sealant between frame and rubber riser. Provide downward force to frame so as to compress the joint, provide a watertight seal, and prevent future settlement. Point compressed joint with butyl rubber caulk sealant.
 - 3. Set manhole frames and covers to final grade only after pavement base course has been applied, or after final grading of gravel roads.
- D. Inverts: As specified in paragraph 2.04G of this section
- E. Steps: Replace any steps that are out of plumb and proper horizontal placement.
- F. Frost Barriers: Wrap each manhole to the maximum excavation depth or not less than 6 feet below grade, with a minimum of four layers of 6 mils each of the polyethylene.
 - 1. Clean manhole exterior of all dirt and remove any protrusions.
 - 2. Apply a 6-inch wide vertical strip of bituminous waterproofing adhesive from the top of manhole to the greatest excavation depth, but not in excess of 6 feet.

3. Start poly wrap at adhesive strip and proceed around manhole continuously, overlapping adhesive strip a minimum of 24 inches on the final layer.
4. Tuck and pleat poly at top in a continuous manner, minimizing size of folds. Extend poly past top of manhole frame and temporarily tuck remainder inside frame, until final backfill and paving.
5. Paved areas: Cut poly flush with manhole rim after pavement is in place.
6. Unpaved areas: Pull loose ends of poly together, remove excess air and tie off end with galvanized wire. Bury with manhole below grade.

3.3 UTILITIES TO BE ABANDONED

- A. Close open ends of abandoned underground utilities which are not indicated to be removed. Provide sufficiently strong closures, such as caps or brick and mortar, acceptable to ENGINEER to withstand hydrostatic or earth pressure which may result after ends of abandoned utilities have been closed.
- B. All abandoned laterals shall be done in accordance with Section 2.6.11 of the City of Portland's Technical Manual.

3.4 TESTING OF SANITARY SEWERS

- A. General: Test all sanitary sewer pipes after backfilling. Install service leads on main line before testing. Perform tests in presence of ENGINEER. A maximum of 1000 feet of pipe may be installed but not tested at any time.
- B. Gravity Sewer Leakage Tests: Use low pressure air test as follows:
 1. Plug ends of section to be tested.
 2. Supply air slowly to the pipe to be tested until the air pressure inside the pipe is 4.0 psi greater than the average back pressure of any groundwater submerging the pipe.
 3. Disconnect air supply and allow a minimum of two minutes for stabilization of pressure.
 4. Following stabilization period measure drop in pressure over the test period within the following times:

<u>Nominal Pipe Size (in.)</u>	<u>Test Period (min.)</u>
4	4
6	4
8	6
10	6
12	7
15	8
18	9

21	11
24	13

- 5. Acceptable drop: No more than 1.0 psi.
- C. Deflection Test for PVC Gravity Sewer Pipe: Test 100% of pipe with "GO-NO-GO" gauge allowing maximum deflection per ASTM D3034.
- D. TV Inspection: All sewers may be inspected by the OWNER using TV pipe inspection. Defects in materials and/or workmanship found during the inspection shall be corrected by the CONTRACTOR.
- E. Repair all pipes not passing tests, using materials and methods approved by the ENGINEER, and retest.

END OF SECTION 333000

SECTION 334000 - STORM DRAINAGE UTILITIES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Furnish and install storm sewer system as shown on the Drawings. This includes:
 - 1. Storm drain piping
 - 2. Repairs to existing pipe damaged during construction
 - 3. Precast manholes, catch basins and precast concrete structures and their appurtenances as called out on the plans
 - 4. Concrete encasement as necessary for utility crossings
 - 5. Foundation drain
 - 6. Connection to existing systems

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Refer to Section 312000
 - 2. Erosion and Sedimentation Controls: Refer to Section 312513
- B. State of Maine Department of Transportation "Standard Specifications: Highways and Bridges", most recent revision.
- C. State of Maine Department of Transportation "Supplemental Specifications – Corrections, Additions & Revisions to Standard Specifications", most recent revision.
- D. City of Portland Technical Manual, most recent revision

1.3 SUBMITTALS

- A. Manufacturer's product data and installation instructions.
- B. Anti-floatation calculations for all precast concrete structures, stamped by a Professional Engineer licensed in the State of Maine.
- C. Certified copies of tests on pipe units.
- D. Construction Records: Record depth and location of the following:
 - 1. Storm drain pipe and structure locations and elevations
 - 2. Repairs to existing pipes.

3. Connection points to storm drainage system, and elevations.

PART 2 PRODUCTS

2.1 PIPE AND FITTINGS

- A. General: Provide fittings of same type and class of materials as pipe. Fitting must have single piece gasket.
- B. PVC Non-Pressure Pipe and Services (Storm Drain): 4- through 15-inch Diameter: ASTM D3034 or ASTM D3033, 18- through 27-inch Diameter: ASTM F-679, strength requirement SDR 35; push-on joints, ASTM D3212; gaskets, ASTM F477.
- C. Foundation Drain Pipe: Foundation drain pipe shall be perforated 4-inch diameter PVC pipe, conforming to the material requirements for PVC storm drain pipe.
- D. Reinforced Concrete Pipe: ASTM C76; Class IV, O-ring gasket joints with rubber gaskets, meeting MDOT specifications.
- E. Ductile Iron Pipe: AWWA C151; thickness Class 52 AWWA C150; double cement lined, AWWA C104; push-on joints or mechanical joints with rubber gaskets, AWWA C111; fittings, AWWA C110.
- F. Corrugated Polyethylene Drainage Pipe (For Uses Outside of the Public Right of Way Only): ADS N-12 or equal.

2.2 Stormwater Chamber System:

1. Chambers shall be injection molded of Polypropylene resin. Chambers shall conform to the requirements of ASTM F2418, "Standard Specification for Polypropylene (PP) Corrugated Wall Stormwater Collection Chambers."
2. Chambers shall be open bottomed with a continuously curved section profile and nominal dimensions as shown on drawings.
3. Chambers shall have forty-eight orifices penetrating the sidewalls for lateral conveyance of water with two orifices near the top to allow for air pressure equalization.
4. Each chamber shall incorporate an overlapping corrugation joint system to allow chamber rows of required length to be created. Total required chamber row length is shown on the Drawings.
5. Isolator Row: Isolator Row consists of a non-woven geotextile wrapped stormwater collection chamber installed within a crushed stone bed. Use stormwater collection chamber by StormTech (www.stormtech.com).
6. Nonwoven geotextiles shall be Mirafi 180 N or equal.
7. Woven geotextiles shall be Mirafi 600x or equal. Fabric must have a minimum width of 5 feet as no seams will be allowed.

8. Crushed stone bedding shall be MDOT 703.31.
9. Impermeable liners (if required) shall be 30 mil PVC or equal.
10. Underdrain pipe shall be MDOT Type B.

2.3 PRECAST CONCRETE STRUCTURES

- A. Base Sections: Precast monolithic construction with steps.
- B. Barrel Sections: Precast with steps.
- C. Top Sections: Precast eccentric cone with steps.
- D. Steps: Polypropylene reinforced with steel rod. Meet OSHA requirements, minimum width 16-inches. Cast into concrete.
- E. Pipe to Structure Connections: Connections shall be watertight, expandable pipe sleeve with adjustable expansion ring equal to Press-Boot by Press-Seal Gasket Corp., Fort Wayne, Indiana.
- F. Joints Between Precast Sections: Watertight, shiplap-type seal with two rings of one-inch diameter butyl rubber sealant.
- G. Inverts: Provide inverts as shown on the Drawings. Configuration to be as required by connecting pipes and as shown on Drawings.

2.4 FRAMES, COVERS, AND GRATES

- A. Material: Cast iron, ASTM A48 Class 30
- B. Provide frames, covers and grates as identified on the plans

2.5 MISCELLANEOUS

- A. Flexible Couplings: Use and location shall be approved by ENGINEER.
- B. Pipe Supports: Saddle type, steel, painted, adjustable, by ITT Grinnell, or approved equal.
- C. Marking Tape: Lineguard III by Tri-Sales, Inc., 2-inch wide, green; detectable with magnetic locators, or approved equal.
- D. Rigid Insulation: Extruded closed-cell rigid foamed polystyrene, 2-inch thickness, width of trench, Styrofoam HI-60, by Dow Chemical, or approved equal.
- E. Frost Barrier: U.V. resistant, high grade polyethylene, minimum thickness six (6) mils.
- F. Joint Sealants:
 1. Butyl Rubber Sealant: One (1) inch diameter strips manufactured by Kent Seal, or approved equal.

2. Butyl Rubber Caulking: Conform to AASHTO M-198, Type B.

PART 3 EXECUTION

3.1 INSTALLATION OF GRAVITY PIPE AND FITTINGS

- A. Methods: Install in accordance with manufacturer's recommendations. Use a laser beam for line and grade unless otherwise permitted by the ENGINEER. Secure each length of pipe with bedding before placing next length. Plug open ends when work is suspended. Bed pipe as shown on Drawings. A 30-inch minimum cover over the top of PVC pipe and DI pipe should be provided before the trench is wheel-loaded.
- B. Grade and Line:
 1. Lay pipe to line and grade shown on the Drawings. If grade is not shown, determine elevations of start and finish points for each run of pipe. Lay pipe to a uniform grade between these points.
 2. Line and grade may be adjusted by the ENGINEER as required by field conditions.
- C. Conditions: Lay pipe in the dry. Do not use installed pipe to remove water from work area.
- D. Flush and clean all pipe and remove all debris and materials. Flushing and cleaning methods approved by ENGINEER. Gravity flushing is not acceptable.
- E. Connections to Manholes and Catch basins: Provide short length of pipe so that joints are located within 3 feet of inside surface of manholes and catch basins for all pipe.
- F. Foundation Drain: Provide 4-inch diameter, perforated PVC pipe around perimeter of proposed building, as indicated on the Drawings. Wrap drain in minimum of 6 inches of crushed stone bedding and nonwoven filter fabric.

3.2 INSTALLATION OF STORMWATER CHAMBER SYSTEM

- A. Stormwater Chamber System shall be constructed as detailed on the plans. Stormwater chamber shall be installed per the manufacturer's instructions.

3.3 INSTALLATION OF MANHOLES/CATCH BASINS

- A. Placement: Place precast bases and structures on compacted bedding material so bottom of structure is plumb and pipe inverts are at proper elevations. Place manhole barrel and top sections in the appropriate height combinations. Plug all lifting holes inside and out with non-shrink grout. Construct manhole inverts in accordance with Drawings.
- B. Joints: Follow manufacturer's instructions for sealing joints between precast sections. Provide two rings of 1 inch diameter butyl rubber sealant. Point joints inside and out with butyl caulk.
- C. Frame and Covers:

1. Set to final grade as shown on the Drawings and as specified. Provide adequate temporary covers to prevent accidental entry until final placement of frame and cover is made.
 2. Use two rings of 1 inch diameter butyl rubber sealant between frame and rubber riser. Provide downward force to frame so as to compress the joint, provide a watertight seal, and prevent future settlement. Point compressed joint with butyl rubber caulk sealant.
 3. Set manhole frames and covers to final grade only after pavement base course has been applied, or after final grading of gravel roads.
- D. Inverts: As specified in paragraph 2.02G of this section.
- E. Steps: Replace any steps that are out of plumb and proper horizontal placement.
- F. Frost Barriers: Wrap each manhole to the maximum excavation depth or not less than 6 feet below grade, with a minimum of four layers of 6 mils each of the polyethylene.
1. Clean manhole exterior of all dirt and remove any protrusions.
 2. Apply a 6-inch wide vertical strip of bituminous waterproofing adhesive from the top of manhole to the greatest excavation depth, but not in excess of 6 feet.
 3. Start poly wrap at adhesive strip and proceed around manhole continuously, overlapping adhesive strip a minimum of 24 inches on the final layer.
 4. Tuck and pleat poly at top in a continuous manner, minimizing size of folds. Extend poly past top of manhole frame and temporarily tuck remainder inside frame, until final backfill and paving.
 5. Paved areas: Cut poly flush with manhole rim after pavement is in place.
 6. Unpaved areas: Pull loose ends of poly together, remove excess air and tie off end with galvanized wire. Bury with manhole below grade.

3.4 UTILITIES TO BE ABANDONED

- A. Close open ends of abandoned underground utilities which are not indicated to be removed. Provide sufficiently strong closures, such as caps or brick and mortar, acceptable to City of Portland to withstand hydrostatic or earth pressure which may result after ends of abandoned utilities have been closed.
- B. All abandoned laterals shall be done in accordance with Section 2.6.11 of the City of Portland's Technical Manual.

3.5 TESTING OF STORM DRAINS

- A. General: Inspect all storm drain pipes after backfilling. Notify ENGINEER a minimum of 24 hours prior to inspection. A maximum of 1000 feet of pipe may be installed but not tested at any time.

- B. TV Inspection: All storm drains may be inspected by the OWNER using TV pipe inspection. Defects in materials and/or workmanship found during the inspection shall be corrected by the CONTRACTOR.
- C. Repair all pipes not passing inspection, using materials and methods approved by the ENGINEER, and retest.

END OF SECTION 334000

SECTION 335100 - NATURAL GAS DISTRIBUTION

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Confirm location of existing natural gas lines prior to work.
- B. Provide new natural gas service as shown on the plans
- C. Relocate existing natural gas service as necessary to complete the work
- D. Coordinate all natural gas work with Unitil Corp.

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000
- B. Unitil Corp. standard technical specifications

PART 2 PRODUCTS

2.1 MATERIALS

- A. Piping, valves, and fittings shall be provided by Unitil.
- B. Bedding, backfill, and surface material shall be as shown on the Drawings.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall coordinate all work with Unitil.
- B. Contractor shall field verify the location of the gas line prior to work and notify ENGINEER of potential conflicts.
- C. Contractor shall perform excavation and provide bedding, backfill, and surface restoration.

END OF SECTION 335100

SECTION 337119 - ELECTRICAL AND COMMUNICATIONS UNDERGROUND DUCTS AND
MANHOLES

PART 1 GENERAL

1.1 DESCRIPTION OF WORK

- A. Confirm location of existing electrical utilities prior to work.
- B. Provide underground electrical duct banks
- C. Modify existing electrical manholes
- D. Protect existing utility poles
- E. Provide new electrical transformers and generator
- F. Coordinate all electrical utility work with Central Maine Power and applicable Communication Utilities

1.2 REFERENCES

- A. Specification Sections:
 - 1. Earth Moving: Section 312000
- B. Central Maine Power standard technical specifications
- C. Communication Utility's technical specifications

PART 2 PRODUCTS

2.1 MATERIALS

- A. For sizes and materials, see Electrical Plans.

PART 3 EXECUTION

3.1 GENERAL

- A. Contractor shall coordinate all work with Central Maine Power and applicable communication utilities.
- B. Contractor shall field verify the location of existing electrical utilities prior to work and notify Engineer of potential conflicts.
- C. For installation requirements, see Electrical Site Plans.

END OF SECTION 337100

