Specification Manual For:

MID-COAST SCHOOL OF TECHNOLOGY – REGION 8
ROCKLAND, MAINE

Bid Specifications – VOLUME 2

Project 14-019-00
19 June 2017

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Geotechnical Report: “Mid-Coast School of Technology, 1 Main Street, Rockland, Maine”, Dated February 10, 2017.

Geothermal Test Well Report

SECTION 21 10 00

FIRE-SUPPRESSION SPRINKLER SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. The fire protection system shall be an automatic sprinkler system arranged to properly protect the building and shall meet NFPA 13, local, and State requirements.

B. This Section includes fire-suppression sprinklers, piping, and equipment.

C. The Sprinkler Contractor shall place the sprinkler system in service and hand over the sprinkler system to the General Contractor for care and maintenance.

D. Performance and Design Criteria: Provide products and systems complying with specific performance and design criteria indicated.

1.03 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. Provide freeze protection for sprinklers in unheated areas with a dry pipe system.

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

G. 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.

H. Contractor shall obtain and pay for required permits.

1.04 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. 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.

C. Sprinkler Occupancy Hazard Classifications:

1. Light Hazard:

   a. Office and Public Areas
   b. Corridors

2. Ordinary Hazard, Group 1:

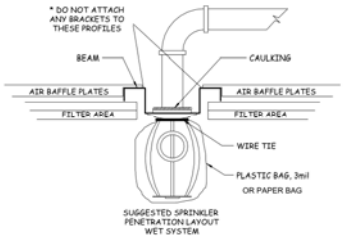
   a. General Storage Areas
   b. Mechanical Equipment Rooms
   c. Building Service Areas.
   d. Electrical Equipment Rooms
   e. Art Rooms

3. Ordinary Hazard, Group 2

   a. Industrial Arts Shops
   b. Kitchens
   c. Receiving Area

4. Extra Hazard, Group 2:

   a. Paint spray booth and mixing room.
      1) Provide per NFPA 33.
      2) Provide a listed indicating valve and flow switch to serve the spray booth and mixing room.
      3) Paint Spray Booth (located in Auto Collision) – Minimum 286°F or higher for actuation temperature (booth is capable of constant 190°F temperature in bake cycle). “Dry Pipe” heads shall be provided. Note, cold air will infiltrate through ducting and cabin. All heads in spray booth cabin must be caulked. Provide a 3 mil plastic bag over the sprinklers. Provide protection for the spray booth and associated ductwork.



   b. Paint Bench and spray area in Marine Tech: Provide per NFPA 33.

D. The system shall be hydraulically calculated in accordance with all provisions of the Contract Documents and any authority having jurisdiction. Conduct a flow test to serve as the basis of system designs. A 2013 hydrant flow test shows good pressure is likely available:

Hydrant Flow Test Report

Test Date 15 July 13 **Test Time** 0852

Location
R-123

South Main Street @
Owls Head Line

Tested by
Shaun McNulty

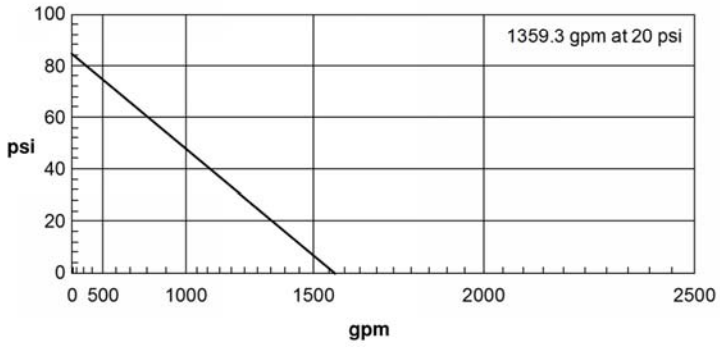
Notes
took static and residual pressures from Hydrant 0-8 (Ingraham Drive @ Ocean Ave) 78psi and 50psi respectively. Water main capacity on 6" before hill is 1126.6 gpm @ 20psi

Read Hydrant
85 psi **static pressure**
60 psi **residual pressure**
hydrant elevation

Flow Hydrant(s)

Outlet	Elev	Size	C	Pitot Pressure	Flow
#1		2	.9	57	811 gpm

Flow Graph



E. 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.

F. Aesthetics: There are many open areas with exposed piping. The layout of the piping shall be approved by the Architect.

1.05 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. 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.

1.06 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

C. NFPA Requirements: Year edition per authority of jurisdiction.

1. NFPA#1 Fire Prevention Code
2. NFPA #13 “Standard for the Installation of Sprinkler Systems”.
3. NFPA #24 Standard for the Installation of Private Fire Service Mains and Their Appurtenances
4. NFPA #101 Life Safety Code
5. NFPA 291: Recommend Practice for Flow Testing and Marking of Hydrants

1.07 COORDINATION

A. Arrange for pipe spaces, chases, slots, and openings in building structure during progress of construction, to allow for fire-suppression installations.

B. Coordinate installation of required supporting devices and set sleeves in poured-in-place concrete and other structural components as they are constructed.

C. Coordinate requirements for access panels and doors for fire-suppression items requiring access that are concealed behind finished surfaces. Access panels and doors are specified in Division 8.

1.08 EXTRA MATERIALS

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

2.01 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.

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

C. 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.

2.02 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.

2.03 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 U.L. listed heat-responsive elements.

C. Sprinkler Types and Categories: Nominal 1/2-inch orifice for "Ordinary" temperature classification rating, unless otherwise indicated or required by application.

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.

2.04 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.

Provide flexible sprinkler hose with fittings intended for use in sprinkler systems between the branch line and sprinkler (not allowed in for exposed sprinklers). Provide in accordance with NFPA 13 and the manufacturer’s installation instructions. Length: 38”.

1. U.L. 2443 listed for sprinkler hose application.
2. Flexible Hose: Corrugated Stainless Steel AISI 304
3. Slip Nuts: Brass C3771BC
4. Reducer Fitting: Yellow Zinc/Steel SPPS
5. Special Shoulder Nipple (Inlet): Yellow Zinc/Steel SPPS
6. Reducing Nipple Clamp & Bolt: Galvanized Steel SS41
7. Maximum Working Pressure of Flexible Connection: 200 PSI
8. Test Pressure of Flexible Connection: 400 PSI
9. Maximum Temperature Rating of Flexible Connection: 300 °F
10. Provide ceiling bracket.

2.05 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.

C. Manual or automatic air venting valve to exhaust trapped air in the wet sprinkler system.

2.06 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.

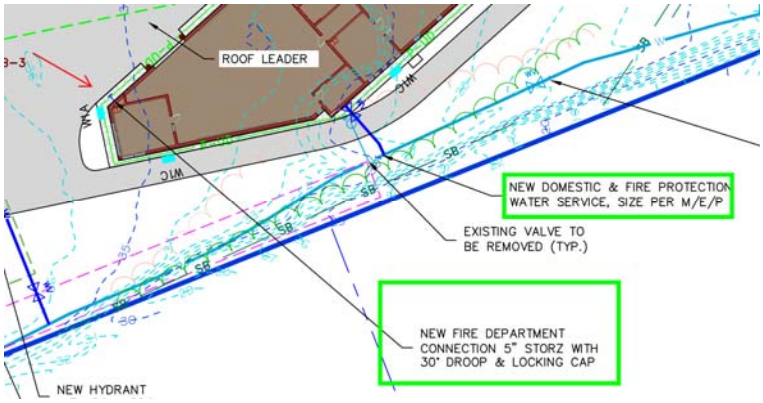
B. The alarm apparatus shall consist of a listed alarm check valve or other listed waterflow-indicating device with the necessary attachments to give an alarm.

C. The apparatus for a dry pipe system shall consist of alarm attachments to the dry pipe valve.

2.07 FIRE DEPARTMENT CONNECTION

A. A system fire department connection shall be provided on the system riser in accordance with NFPA 13. Fire department connection shall be UL Listed and Factory Mutual Approved for fire protection use.

B. The Fire Department Connection shall be at the face of the building outside the carpentry office.



C. The fire department connection shall be a 5" Storz fitting with a 30 degree droop elbow, and cap (as requested by Chief Whytock and Assistant Chief Miceli).

D. Include inlets with threads according to NFPA 1963 and local fire department requirements.

E. Provide escutcheon plate and labeling per NFPA 13.

2.08 BACKFLOW PREVENTION

A. Provide in accordance with manufacturers recommendations.

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 local 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

3.01 EARTHWORK

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

3.02 SERVICE-ENTRANCE PIPING

A. Connect fire-suppression piping to water-service piping of size and in location indicated for service entrance to building. Refer to Division 31 for exterior piping.

B. Comply with NFPA 24 for fire-service-main piping materials and installation.

C. Provide ductile-iron, water-service piping according to AWWA C600 and AWWA M41. Provide underground piping with restrained joints at horizontal and vertical changes in direction. Use

restrained-joint piping, thrust blocks, anchors, tie-rods and clamps, and other supports. Install sleeve seals for piping penetrations of concrete walls and slabs.

D. Provide shutoff valve, pressure gage, drain, and other NFPA-required accessories at connection to water-service piping.

E. Provide backflow prevention as required by the local water district.

3.03 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.

3.04 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. Electrical or Data Rooms with finished ceilings: Concealed
6. Electrical or Data Rooms without ceilings: Provide guard
7. Attics: attic sprinklers.
8. Wall Mounting: Sidewall sprinklers.
9. Spaces Subject to Freezing: Upright; pendent, dry-type; and sidewall, dry-type sprinklers.
10. Special Applications: Use extended-coverage, flow-control, and quick-response sprinklers where indicated.

B. Finishes

1. Unfinished spaces not exposed to view: rough bronze.
2. Recessed Sprinklers: White
3. Provide escutcheons with matching color for finished spaces.

3.05 SYSTEM INSTALLATIONS

A. Earthquake Protection: Provide 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: A system fire department connection shall be provided on the system riser in accordance with N.F.P.A. 13. Fire department connection exact location shall be approved by the 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. Provide "Inspector's Test Connections" in sprinkler system piping, complete with shutoff valve, sized and located according to NFPA 13

F. Provide a vent near a high point in the system to allow air to be removed from that portion of the system.

3.06 SPRINKLER INSTALLATION

A. Provide 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 per NFPA 13.

C. Provide sprinkler piping with drains for complete system drainage.

D. Hangers and Supports: Comply with NFPA 13 for hanger materials.

3.07 LABELING AND IDENTIFICATION

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

3.08 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.

3.09 CLEANING

A. Clean dirt and debris from sprinklers.

B. Remove and replace sprinklers having paint other than factory finish.

C. Clean and disinfect fire-suppression water-service piping as follows:

1. Purge new piping systems and parts of existing systems that have been altered, extended, or repaired before use.
2. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in NFPA 24 for flushing of piping. Flush piping system with clean, potable water until dirty water does not appear at points of outlet.
3. Use purging and disinfecting procedure prescribed by authorities having jurisdiction or, if method is not prescribed by authorities having jurisdiction, use procedure described in AWWA C651.
4. Prepare reports.

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

SECTION 22 05 00

COMMON WORK RESULTS FOR PLUMBING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 00, common work results for plumbing are included in this section.

END OF SECTION

SECTION 22 05 16

BRAIDED EXPANSION LOOPS AND FITTINGS FOR PLUMBING PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 16, braided expansion loops and fittings for plumbing piping are specified in this Section.

END OF SECTION

SECTION 22 05 19

THERMOMETERS AND PRESSURE GAUGES FOR PLUMBING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 19 for thermometer and pressure gauges for plumbing.

END OF SECTION

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PLUMBING PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 29 for hangers and supports for plumbing piping and equipment.

END OF SECTION

SECTION 22 05 48

SEISMIC CONTROLS FOR PLUMBING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 48 for seismic controls for plumbing.

END OF SECTION

SECTION 22 05 53

IDENTIFICATION FOR PLUMBING PIPING & EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 05 53 for identification for plumbing piping and equipment.

END OF SECTION

SECTION 22 07 00

PLUMBING INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Refer to Section 23 07 00 for plumbing insulation.

END OF SECTION

SECTION 22 11 16

DOMESTIC WATER PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 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.

1.03 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. Field quality-control reports.

1.04 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with the local building and plumbing codes.

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

2.01 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.

2.02 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.

2.03 COPPER TUBING

A. Hard Copper Tube: ASTM B 88, Types L, water tube, drawn temper.

1. Copper Pressure Fittings: ASME B16.18, cast-copper-alloy or ASME B16.22, wrought-copper, solder-joint fittings. Furnish wrought-copper fittings if indicated.
2. 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.

B. Mechanically formed copper or steel tee connections are not acceptable.

C. Viega Pro Press Fittings: Copper and copper alloy press fittings shall conform to material requirements of ASME B16.18 or ASME B16.22 and performance criteria of IAPMO PS 117. Sealing elements for press fittings shall be EPDM. Sealing elements shall be factory installed or an alternative supplied by fitting manufacturer. Press ends shall have SC (Smart Connect) feature design (leakage path). In ProPress ½" to 4" dimensions the Smart Connect Feature assures leakage of liquids and/or gases from inside the system past the sealing element of an un-pressed connection. The function of this feature is to provide the installer quick and easy identification of connections which have not been pressed prior to putting the system into operation.

2.04 AQUATHERM PIPING

A. Pipe shall be Aquatherm or approved equal by Nupi. 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 22 07 00, 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 22 07 00, 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.

2.05 PEX DOMESTIC WATER PIPING

A. Not allowed where exposed to view.

B. 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. Watts
4. Viega

C. 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.

D. 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.
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.

E. 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.

F. 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 Copper Manifold
   b. Uponor engineered plastic (EP) Manifold

3. All manifolds manufactured with the appropriate-sized ProPEX fittings on the manifold supply inlets.

G. 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.

2.06 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. Comply with MSS SP-110.

B. Wafer Check valves:

1. Provide wafer style, butterfly type, spring actuated check valves designed to be installed with gaskets between 2 standard Class 125 flanges. Construct iron body valves with pressure containing parts of valves with materials conforming to ANSI/ASTM A 126, Grade B. Support hanger pin by removable side plug.
2. 2" and Larger: Class 125, cast iron body, stainless steel trim, bronze disc, Buna-N seal: Nibco W920-W, Stockham WG970, Metraflex C-125, Hammond 9253, Milwaukee 1400, Watts ICV/ICV-F series, or approved equal.

C. 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.

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

PART 3 - EXECUTION

3.01 EXCAVATION

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

3.02 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. Piping 5" and larger: Grooved joints may be used on aboveground grooved-end piping.

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. NPS 4: Type L copper or Aquatherm.

F. Underground piping within the building (permitted where indicated): PEX, no joints allowed underground.

3.03 VALVE APPLICATIONS

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

1. Shutoff Duty: Use bronze ball 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.
4. Drain Duty: Hose-end drain valves.

3.04 VALVE INSTALLATION

A. Provide sectional valve close to water main on each branch and riser serving plumbing fixtures or equipment.

B. Provide shutoff valve on each water supply to equipment and on each water supply to plumbing fixtures without supply stops.

C. Provide 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.

3.05 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. Provide underground ductile-iron piping according to AWWA C600 and NFPA 24.

D. Provide shutoff valve, hose-end drain valve, strainer, pressure gage, and test tee with valve, inside building at each domestic water service.

E. Provide dielectric fittings as specified in Section 23 05 00.

F. Provide water-pressure regulators downstream from shutoff valves. Refer to Division 22 Section "Plumbing Specialties" for water-pressure regulators. Set outlet pressure at 80 psig maximum.

G. Provide aboveground domestic water piping level and plumb.

H. Provide firestopping as per Section 23 05 00 “Common Work Results for HVAC”.

I. Fill water piping. Check components to determine that they are not air bound and that piping is full of water.

J. 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.

K. Check plumbing equipment and verify proper settings, adjustments, and operation. Do not operate water heaters before filling with water.

L. Check plumbing specialties and verify proper settings, adjustments, and operation.

3.06 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. Joints shall be fabricated, joined, and tested per manufacturer’s instructions. Installers must be factory trained and approved by the local manufacturer’s representative.

3.07 PEX PIPING INSTALLATION

A. Provide PEX tubing in accordance with the tubing manufacturer's recommendations and as indicated in the installation handbook.

B. Use grommets or sleeves at the penetration for PEX tubing passing through metal studs.

C. Protect PEX tubing with sleeves where abrasion may occur. Use strike protectors where PEX tubing penetrates a stud or joist and has the potential for being struck with a screw or nail.

D. Use tubing manufacturer-supplied bend supports where bends are less than six times the outside tubing diameter.

E. PEX-a Piping Hanger Spacing: Provide 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: Provide 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.

F. PEX-a Riser Supports: Provide CTS riser clamps at the base of each floor and at the top of every other floor. Provide mid-story guides between each floor.

G. Pipe Joint Construction: PEX-a Connections: Provide per manufacturer’s recommendations. Use manufacturer-recommended cold-expansion tool for F1960 connections.

H. 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. 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.

3.08 HANGER AND SUPPORT INSTALLATION

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

3.09 CONNECTIONS

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

B. Provide piping adjacent to equipment and machines to allow service and maintenance.

C. Use transition fitting to join dissimilar piping materials.

D. Connect water piping in sizes indicated, but not smaller than sizes of unit connections.

E. Provide shutoff valve and union for each connection. Use flanges instead of unions for NPS 2-1/2 and larger.

3.10 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.

3.11 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

SECTION 22 11 19

PLUMBING SPECIALTIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

A. Drawings and general provisions of the Contract, including General and Supplementary td-1

B. Conditions and Division 1 Specification Sections, apply to this Section.

C. Related Sections include the following: Division 22 Sections.

1.02 SUMMARY

A. This Section includes plumbing specialties.

1.03 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.

1.04 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

B. Field test reports.

1.06 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 the 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

2.01 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 22 05 00.

2.02 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. 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

E. 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

2.03 UTILITY WATER METERS

A. Provide the meter per Water District requirements. Contractor shall pay for meter.

B. Provide meter furnished by Water District or provide meter in accordance with Water District specifications.

C. Remote Registration System: Complying with AWWA; modified with signal-transmitting assembly, low-voltage connecting wiring, and remote register assembly as required by utility company.

2.04 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. Provide a water pressure regulator at the building water entrance.

C. 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.

2.05 BALANCING VALVES

A. DHW Recirculation Balancing Valves

1. Furnish and install as indicated on the plans, Circuit Solver in the domestic hot water piping. Circuit Solver shall be self-contained and fully automatic without additional piping or control mechanisms. Valve shall be Circuit Solver as manufactured by ThermOmegaTech or equivalent.
2. Circuit Solver shall regulate the flow of recirculated domestic hot water based on water temperature entering Circuit Solver regardless of system operating pressure.
3. When fully closed valve shall bypass a minimum flow to maintain dynamic control of the recirculating loop and provide a means for system sanitizing.
4. Valve shall be factory adjustable from 105°F to 140°F as required by project conditions. Valve shall modulate between open and closed position within a 10°F range.
5. Valve body and all internal components shall be constructed of stainless steel with major components constructed of type 303 stainless steel.
6. Valve shall be rated to 200 PSIG maximum working pressure. Valve s shall be rated to 300°F maximum working temperature.
7. Valve s shall be standard tapered female pipe thread, NPT.
8. Circuit Solver shall be ANSI/AWWA C800 compliant. Circuit Solvers shall be NSF-61 certified with zero lead content for use in all domestic water systems.
9. Thermal actuator shall be spring operated and self-cleaning, delivering closing thrust sufficient to keep orifice opening free of scale deposits. Thermal actuator shall be rated for a minimum of 200,000 cycles.

2.06 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 6NB-LF complete water temperature control station. 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. 2” bottom inlet connections (copper tube)
3. 2” top outlet connection (copper tube)
4. 1 1/4” return line size with piping method #5 (226 GPM maximum flow).
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°F to 140°F and pressure gauge on mixed water outlet of the system.
8. Outlet Test Connection with ball valve and ¾” 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°F 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°F 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.
18. 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:

a. Refer to plumbing pump schedule on the plans.
b. Wet rotor design for quiet, maintenance free operation.
c. Stainless Steel rotor cladding and canister construction to prevent corrosion.
d. Composite impeller design for optimal application performance.
e. Built-in 6 foot, 115 volt ac line cord with a NEMA, 3 prong male plug.
f. Built-in 24 hour programmable timer.
g. UL Recognized strain relief and wire connections.
h. Fully UL Recognized.
i. Each unit shall be run and High Pot. tested.
j. Bronze sweat connections.
k. Provide circuit setter for balancing.

2.07 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.

2.08 OUTLET BOXES

A. Manufacturers:

1. Acorn Engineering Company.
2. Gray, Guy Manufacturing Co., Inc.
3. IPS Corporation.
4. LSP Products Group.
5. Oatey.
6. Symmons Industries, Inc.
7. 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. 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. Icemaker Outlet Boxes:

1. Mounting: Recessed, fire rated where applicable.
2. Material and Finish: Enameled-steel or epoxy-painted-steel box and faceplate.
3. Faucet: Valved fitting complying with ASME A112.18.1. Include NPS 1/2 or smaller copper tube outlet.
4. Supply Shutoff Fitting: NPS 3/8 ball valve and NPS 3/8 copper, water tubing.
5. Accessories: water hammer arrestors, quarter turn shutoff valve

2.09 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 Exposed-Outlet Wall Hydrants: Zurn Z1321, ASSE 1019, ¾" pipe connection; self-drainable with integral non-removable hose-connection backflow preventer, casing and operating rod to match wall thickness, projecting outlet, and wall clamp.

D. Non-freeze Concealed-Outlet Wall Hydrants: Zurn Z1322-EZ encased Ecolotrol anti-siphon; ASSE 1019, ¾" 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.

E. Hose Bibbs: Bronze body with replaceable seat disc complying with ASME A112.18.1M for compression-type faucets. Include NPS ½ 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. Equipment Rooms: Rough bronze, wheel handle,
2. Finished Rooms: Chrome plated, operating key
3. Include integral wall flange with each chrome plated hose bibb.

2.10 WATER HAMMER ARRESTORS

A. Manufacturers:

1. Zurn
2. Precision Plumbing Products, Inc.
3. Sioux Chief Manufacturing Company, Inc.

B. 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.

2.11 MISCELLANEOUS SANITARY DRAINAGE PIPING SPECIALTIES

A. Open Drains:

1. Description: Pipe fittings assembled to make a trapped receptacle similar to a floor drain but usually without a grate. They are installed with the top above the floor level, so they are not a substitute for a floor drain.
2. 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.
3. Size: Same as connected waste piping with increaser fitting of size indicated.

B. Deep-Seal Traps:

1. Description: P-traps that are made with a deeper-than-normal water seal.
2. Cast-iron or bronze casting, with inlet and outlet matching connected piping and cleanout trap-seal primer valve connection.
3. Size: Same as connected waste piping. NPS 2: 4-inch- minimum water seal. NPS 2-1/2 and Larger: 5-inch- minimum water seal.

C. Stack Flashing Fittings:

1. Description: devices for flashing around vent piping at roof penetrations.
2. Counter flashing-type, cast-iron fitting, with bottom recess for terminating roof membrane, and with threaded or hub top for extending vent pipe.
3. Size: Same as connected stack vent or vent stack.

D. Expansion Joints: telescoping pipe fittings that permit the contraction or expansion movement of vertical stacks. Standard: ASME A112.21.2M. Body: Cast iron with bronze sleeve, packing, and gland.

E. Air-Gap Fittings:

1. Standard: ASME A112.1.2, for fitting designed to ensure fixed, positive air gap between installed inlet and outlet piping.
2. Size: Same as connected waste piping and with inlet large enough for associated indirect waste piping.
3. Dishwasher: ASSE 1021, fitting suitable for use with domestic dishwashers and for deck mounting; with plastic body, chrome-plated brass cover; and capacity of at least 5 gpm; and inlet pressure of at least 5 psig at temperature of at least 140°F. Provide ports for

garbage disposal or dishwasher hoses as required; Airgap International, Inc. or approved equal.

4. Small AC condensate drain into sink trap: Airgap International, Inc. Drain Boa, Eco-Tech, or equal; Inlet port directly accepts 3/8" poly tubing. Dual plumbing code listed sink tailpiece fitting. Listed by NSF® and UPC®.
5. 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: match piping.
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. Watts Industries, Inc., Drainage Products Div.

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. Watts Industries, Inc

B. Floor drains shall comply with ASME A112.21.1M. Provide outlet type as required by piping system used.

C. Provide ½" trap primer connection as indicated on plans. Size: Same as floor drain outlet with NPS 1/2 side inlet.

D. Heavy Duty FD-1: mechanical rooms; Basis of Design ZURN Z525-P 9" diameter top drain, Dura-Coated cast iron body with 3" bottom outlet, seepage pan and adjustable extension frame with medium-duty cast iron deep slotted grate.

E. Light Duty FD-2: bathroom and finished areas; Basis of Design ZURN ZN415BZ-P, Dura-Coated cast iron body with 2" bottom outlet, combination invertible membrane clamp and adjustable collar with seepage slots, and "TYPE BZ" polished nickel bronze light-duty leveling strainer. Provide vandal secured top.

F. Funnel Floor Drain FD-3: Condensate Floor Funnel Drain: Basis of Design Zurn ZN550-Y w/Z329-9 funnel converting assembly; dura-coated cast iron body, 9" round nickel bronze rim and grate, and 8-7/8" x 3-5/8" x 3-3/4" high funnel, Sediment bucket.

G. Hinged Floor Drain FD-4: Hinged Floor Drain: Basis of Design Zurn ZN585 6" x 9" Top Drain, dura-coated cast iron body with bottom outlet, seepage pan and combination membrane flashing clamp and frame, medium duty hinged slotted grate with suspended sediment bucket.

H. Kitchen floor sinks, FS-1, FS-2:

1. Zurn Z1751 12" x 12" x 8" deep, 16 gage, All Type 304 SS light-duty Sani-Flor receptor with non-tilt, loose set grate with ½" square openings and anti-splash stainless steel interior dome strainer.
2. Provide ½ grate or ¾ grate as indicated on the food service drawings.

I. Shower drains: see plumbing fixture specification.

J. Trench Drain TD-1: Wide Reveal Trench Drain System, Basis of Design Zurn 886-HD-DGE channels are 80" long, 6-1/4" wide reveal and have a 4" throat and 3" bottom outlet. Modular channels are made of 0% water absorbent high density polyethylene. Provide vandal proof lockdown grating rated for vehicle traffic.

2.15 OIL INTERCEPTOR

A. Manufacturers

1. Zurn
2. Smith, Jay R. Mfg. Co.
3. Josam Co.
4. Watts Industries, Inc., Drainage Products Div.

B. Large Capacity Oil Interceptor OS-1 Basis of Design: Zurn Z1186-HD, 75 GPM, acid resistant coated interior and exterior fabricated steel oil interceptor, bronze cleanout plug and visible double wall trap seal, removable combination pressure equalizing flow diffusing baffle and sediment bucket, horizontal baffle, adjustable oil draw-off and vent connections either side. Complete with secured, heavy duty gasketed, non skid cover with removable lift handles and flow control fitting.

2.16 TRAP SEAL PRIMER VALVES

1. Manufacturers:

   a. Precision Plumbing Products, Inc.
   b. Josam Co.
   c. Watts.
   d. Zurn
   e. Mifab
   f. Sioux Chief

B. Trap primer make up lines must have a continuous slope to the floor drain.

C. Electronic Trap Primer – TP-1

1. Precision Plumbing Products Model MP-500
2. Operation: 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.
3. Cabinet: Surface-mounted steel box; NEMA Type 1, UL 50, 12" x 12" x 4" - 16 gauge steel w/screw on cover ANSI 61 gray polyester powder paint.
4. Electric Controls: Pre-set timer opens once for 6 seconds every 24hours. 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. 120/1/60, 0.23 Amps. Circuit Breaker, Test Switch, Timer, Solenoid Valve UL Listed. Electrical assembly listed per UL # 73.
5. Air gap fitting
6. Solenoid valve with integral strainer screen
7. Piping: ASTM B 88, Type L copper water tubing. 95-5 lead-free. Containing lead not in the excess of 0.2%; Inlet: ½" NPT male; Outlet: ½" NPT female.
8. Provide a distribution unit for multiple outlet installations.
9. Standard: ASSE 1044.

D. Water Saver Trap Primer – TP-2:

1. Precision Plumbing Products 1 1/2" Tail Piece floor drain trap priming assembly; provided with a braided 1/2" stainless steel flexible priming make up water line with 5/8" compression fitting, and chrome plated escutcheons for both the wall tube and make up water line.
2. Minimum discharge rate at 0.5 gpm is 2.5 oz.
3. Standard: ASSE 1044.

E. Automatic Trap Seal Primer – TP-3:

1. MIFAB's M-500 Series of pressure activated trap seal primers (MR-500, M1-500 and M2500) can be connected to any cold water line, and will be automatically activated when a valve or faucet, that is on the line, is opened.
2. A pressure drop of three (3) PSI shall activate the trap seal primer.
3. Trap seal primers can be disassembled in the field. Their unique design permits filter replacement without affecting the performance of the primer. The "O" ring seals are tested for reliability at a temperature range of -40 degrees to 450 degrees F.
4. The trap seal primer shall not require adjustment.
5. Standard: ASSE 1018.

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. Tyler Pipe, Wade Div.
6. Watts
7. Zurn

C. Roof Drains: Mifab R1200-EU large sump roof drain: Large Sump Roof Drain for 1-3/4 inches to 7 inches insulation. Compliance: ANSI/ASME A112.21.2M. Body: A2 deep sump body. Lacquered, ASTM-A 48, Class 25 cast iron body with anchor flange. Dome Strainer: Self-locking poly dome strainer. Free area of 136 square inches. Membrane Clamp Ring: 2-5/16-inch wide, ASTM A 48, Class 25 cast iron, waterproofing membrane clamp ring with integral gravel stop. Extension Flange: Adjustable, ASTM A 48, Class 25 cast iron, extension deck flange and under deck clamp.

D. See roof drain detail on Sheet A1.4 – roof drain shall be compatible with this detail.

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Provide 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. Provide 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).

C. Provide air-gap fittings on draining-type backflow preventers and on indirect-waste piping discharge into sanitary drainage system.

D. Provide pressure regulators with inlet strainer and shutoff valve, outlet shutoff valve and balance valve bypass. Provide pressure gages on inlet and outlet. Set field-adjustable pressure set points of water pressure-reducing valves.

E. Trap primers:

1. Provide floor-drain, trap-seal primer fittings on inlet to floor drains that require trap-seal primer connection. Primers shall be accessible for maintenance.
2. Provide 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. Do not install trap seal primers closer than 40 feet apart when using same potable water supply line.
6. 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.
7. Provide union connection above trap seal primers.
8. Provide line shut-off valve upstream of trap seal primers to shut off water supply when performing maintenance on trap seal primers.
9. Avoid direct installation to prevent foreign material from entering directly into trap seal primers.

F. Provide expansion joints on vertical risers, stacks, and conductors as required by code.

G. Cleanouts:

1. Provide 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. Provide cleanout deck plates with top flush with finished floor, for floor cleanouts for piping below floors.
3. Provide cleanout wall access covers, of types indicated, with frame and cover flush with finished wall, for cleanouts located in concealed piping.
4. Provide flashing flange and clamping device with each stack and cleanout passing through floors with waterproof membrane.

H. Provide floor drains in accordance with manufacturer's instructions at locations indicated on the drawings.

1. Protect installed floor drains from damage during construction.
2. Provide floor drains at low points of surface areas to be drained. Floor s shall be sloped to floor drains.
3. Provide floor drains plumb, level, and to correct elevation.
4. Ensure top of floor drains are flush with top of finished floor.
5. Provide floor drains using manufacturer's supplied hardware.
6. Coordinate depressed/pitched slab with concrete contractor.
7. Provide floor-drain flashing collar or flange so no leakage occurs between drain and adjoining flooring. Maintain integrity of waterproof membranes where penetrated.
8. Provide individual traps for floor drains connected to sanitary building drain, unless otherwise indicated.

I. Roof Drains:

1. Coordination: Roof drains installed and flashed by roofing contractor. 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. Provide roof drains in accordance with manufacturer's instructions at locations indicated on the drawings.
4. Provide roof drains plumb, level, and to correct elevation.
5. Provide roof drains using manufacturer's supplied hardware.
6. Protect installed roof drains from damage during construction.

J. Provide 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. Provide cleanout immediately downstream from interceptors not having integral cleanout on outlet.

K. 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. Fasten recessed-type plumbing specialties to reinforcement built into walls. Provide wood-blocking reinforcement for wall mounting and recessed-type plumbing specialties.

L. Provide individual shutoff valve in each water supply to plumbing specialties. Provide shutoff valves in accessible locations.

M. Provide air vents at piping high points. Include ball valve in inlet.

N. Provide traps on plumbing specialty drain outlets.

O. Water hammer arrestors shall be installed at commercial dishwashers, solenoid valves, 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.

P. Provide 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.

Q. Circuit Solve DHW Recirculation Balancing Valve:

1. Provide Circuit Solver in each domestic hot water return piping branch beyond last hot water device in that branch.
2. Provide suitable line size isolation valves, unions, and strainer.
3. Provide suitable access panel as required in non-accessible ceilings and walls.

3.02 ROUGHING-IN FOR UTILITY WATER METERS

A. Pay all required fees.

B. Provide water meters, piping, and specialties according to AWWA M6 and utility's requirements.

3.03 CONNECTIONS

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

B. Provide 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.

3.04 FIELD QUALITY CONTROL

A. Test each vacuum breaker, backflow preventer, and trap primer according to authorities having jurisdiction and the device's reference standard.

B. Domestic water piping specialties will be considered defective if they do not pass tests and inspections.

C. Prepare test and inspection reports.

D. Set field-adjustable temperature set points of temperature-actuated, water mixing valves.

END OF SECTION

SECTION 22 13 16

PLUMBING SANITARY AND STORM PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

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.

1.02 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.

1.03 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.

1.04 SUBMITTALS

A. Product Data: For pipe, tube, fittings, and couplings.

B. Field Test Reports: Indicate and interpret test results for compliance with performance requirements.

1.05 QUALITY ASSURANCE

A. Piping materials shall bear label, stamp, or other markings of specified testing agency.

B. Comply with the local building and plumbing codes.

C. Comply with NSF 14, "Plastics Piping Systems Components and Related Materials," for plastic piping components.

PART 2 - PRODUCTS

2.01 PIPING MATERIALS

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

2.02 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 ASTM C-1540 heavy duty couplings.
3. 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.
4. 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 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).

2.03 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.

C. Solvent cement joints for PVC pipe and fittings shall be clean from dirt and moisture. Pipe shall be cut square and pipe shall be deburred. Where surfaces to be joined are cleaned and free of dirt, moisture, oil and other foreign material, apply primer in accordance with ASTM F656.

2.04 PVC PRESSURE PIPING

A. 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. and is intended for pressure applications where the temperature will not exceed 140°F.

B. Solid Wall: 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) standards 14 and 61. Pipe shall be iron pipe size (IPS) conforming to ASTM D-1785. Fittings shall conform to ASTM D-2466.

C. Foam Core: Pipe and fittings shall be manufactured from PVC compound with a cell class of 11432 per ASTM D-4396 for pipe and 12454 per ASTM D-1784 for fittings and conform with National Sanitation Foundation (NSF) standard 14. Pipe shall be iron pipe size (IPS) conforming to ASTM F-891. Fittings shall conform to ASTM D-2665.

2.05 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

3.01 EXCAVATION

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

3.02 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. Aboveground and Underground, Soil, Waste, and Vent Piping: Use any of the following piping materials for each size range:

1. Cast iron

    a. Kitchen drains
    b. Boiler room drains – within 40 feet of boiler drains

c. Soil, Waste, and Vent Piping located in Kitchens, Boiler Rooms, or similar spaces where hot water (<140°F) may be dumped down the drain
d. Piping in return air plenums.

2. PVC or Cast iron

a. Under slab
b. Concealed
c. Vents

C. 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

D. Elevator sump pump discharge piping: Type L sweated copper.

E. Storm Drain Piping:

1. Cast iron
2. Schedule 40 PVC DWV
3. Storm Drain Piping, heat traced: Cast iron

3.03 PIPING INSTALLATION

A. Refer to Division 22 Section "Common Work Results for Plumbing" for basic piping installation.

B. Provide firestopping as per Section 23 05 00 “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 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. Provide 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.

3.04 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.

3.05 HANGER AND SUPPORT INSTALLATION

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

3.06 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.

3.07 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.

3.08 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

SECTION 22 14 29

ELEVATOR SUMP PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following: Division 22 Section "Common Work Results for Plumbing"

1.02 SUMMARY

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

1.03 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.

1.04 CLOSEOUT SUBMITTALS

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

1.05 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.

1.06 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

2.01 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
8. Bell & Gossett

2.02 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 operates, removing water not oil from the vault even when oil has been detected.

PART 3 - EXECUTION

3.01 EXAMINATION

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

3.02 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.

3.03 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.

3.04 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.

3.05 STARTUP SERVICE

A. Perform startup service.

B. Complete installation and startup checks according to manufacturer's written instructions.

3.06 ADJUSTING

A. Adjust pumps to function smoothly, and lubricate as recommended by manufacturer.

B. Adjust control set points.

3.07 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

SECTION 22 15 13

GENERAL-SERVICE COMPRESSED-AIR PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes piping and related specialties for general-service compressed-air systems.

B. Contractor shall confirm equipment compressed air needs per paragraph 3.03.

C. Related Sections include the following:

1. Section 22 15 19 "General-Service Packaged Air Compressors and Receivers" for general-service air compressors and accessories.

1.03 ACTION SUBMITTALS

A. Product Data: For the following:

1. Pipes, fittings, and valves.
2. Flexible pipe connectors.
3. Pressure regulators. Include rated capacities and operating characteristics.
4. Automatic drain valves.
5. Filters.

1.04 INFORMATIONAL SUBMITTALS

A. Brazing and welding certificates.

B. Qualification Data: For Installers.

C. Field quality-control test reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For general-service compressed-air piping specialties to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

A. Brazing: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications," or to AWS B2.2, "Standard for Brazing Procedure and Performance Qualification."

B. Welding: Qualify processes and operators according to ASME Boiler and Pressure Vessel Code: Section IX.

C. ASME Compliance:

1. Comply with ASME B31.1, "Power Piping," for high-pressure compressed-air piping.
2. Comply with ASME B31.9, "Building Services Piping," for low-pressure compressed-air piping.

PART 2 - PRODUCTS

2.01 PIPES, TUBES, AND FITTINGS

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

B. Piping, Tubes, fittings, and accessories shall be one of the following:

1. Prevost
2. Aircom
3. Trainsair
4. AIRnet

C. Acceptable Manufacturer's Sales Representatives:

1. Automotive Garage Tools, Westbrook Maine; contact Carlton Jackson, 207-878-881.
2. Maine Air Power, Auburn Maine, contact Barlow Morse, 800-427-3768.
3. D.L. Thurrott, Waterville Maine; contact Mike Achorn, 800-810-0983 xtn 4143.

D. Copper Tube: ASTM B 88, Type K or L seamless, drawn-temper, water tube.

1. Wrought-Copper Fittings: ASME B16.22, solder-joint pressure type or MSS SP-73, wrought copper with dimensions for brazed joints.
2. Cast-Copper-Alloy Flanges: ASME B16.24, Class 150 or 300.
3. Copper Unions: ASME B16.22 or MSS SP-123.

E. Aluminum

1. Pipe Specifications-

a. 200 Psi, From 14°F To +194°F
b. Inside Pressure Test: 800 Psi For 1 Hour At +68°F
c. Material: Aluminum Extrusion Alloy EN AW T6 UNI-EN 755-2 With Inside And Outside Titanium-Based, Chrome-Free And Rohs-Complying Treating And Electrocoated Outside Surface
d. Color: Blue RAL 5012 – Green Similar To RAL 6032 - Grey RAL 7001
e. Manufacturing Process: Seamless Extrusion Process

2. Fitting Specification – Aluminum body, Aluminum ring nut.
3. Tapping Flanges / Branch Drops – Technopolymer body with aluminum ring nut.
4. Assembly Tools – Provide a set of tools for the installer, and to be left on site at job completion;

    a. (2) deburring tools
    b. (2) chamfer tools
    c. (3) of each size drill bits for tapping flanges
    d. (3) Bottles of assembly fluid, by pipe manufacturer.

5. Training – Supplier of compressed air piping/fittings shall provide a minimum of (2) 8-hr days of on-site training and consultation at start of installation, and available for consultation for (1) 8hr day during second week of installation.

F. Transition Couplings for Metal Piping: Metal coupling or other manufactured fitting same size as, with pressure rating at least equal to and ends compatible with, piping to be joined.

2.02 HOSE REELS

A. Manufacturers

1. Reelcraft
2. Sagelock
3. Granger

B. **P-12** Basis of Design: Reelcraft Clean Air Hose Reel Series 7000.

1. Non corrosive stainless steel
2. Holds 50 feet of ½" ID neoprene hose
3. Base and guide arm are made from heavy gauge steel and robotically welded for strength.
4. Multi positional guide arm facilitates ceiling, wall or floor mount and adjusts with the removal/repositioning of four bolts. Provide mounting brackets.
5. Maximum mounting height: 16 feet.
6. Provide hose bumpers.
7. Compressed air inlet: Provide shutoff valve, velocity fuse, flexible hose connection, filter, regulator, pressure gauge.

2.03 JOINING MATERIALS

A. Solder Filler Metals: ASTM B 32, lead-free alloys. Include water-flushable flux according to ASTM B 813.

B. Brazing Filler Metals: AWS A5.8/A5.8M, BCuP Series, copper-phosphorus alloys for general-duty brazing, unless otherwise indicated.

C. Solvent Cements for Joining Plastic Piping: PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

2.04 VALVES

A. Ball Valves:

1. Branch and main lines isolation: full port compatible with piping system used. Brass or stainless steel, or by piping manufacturer, or type 316 stainless steel stems and balls, reinforced Teflon seats and seals, blowout proof stems and adjustable stem gland. Rated for 400# WOG and 350 F minimum.
2. Air drop drain mini ball valve: standard port compatible with piping system used. 2-piece forged brass construction, 600 PSI WOG and 370 F. Teflon seats, blowout proof brass stem, hard chrome plated brass ball, zinc die cast tee handle.

2.05 DIELECTRIC FITTINGS

A. General Requirements: Assembly of copper alloy and ferrous materials with separating nonconductive insulating material. Include end connections compatible with pipes to be joined.

B. Dielectric Unions:

1. Standard: ASSE 1079.
2. Pressure Rating: 200 psig.
3. End Connections: Solder-joint copper alloy and threaded ferrous.

C. Dielectric Flanges:

1. Standard: ASSE 1079.
2. Factory-fabricated, bolted, companion-flange assembly.
3. Pressure Rating: 200 psig.
4. End Connections: Solder-joint copper alloy and threaded ferrous; threaded solder-joint copper alloy and threaded ferrous.

2.06 FLEXIBLE PIPE CONNECTORS

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

1. Flex-Hose Co., Inc.
2. Flexicraft Industries.
3. Hyspan Precision Products, Inc.
4. Mercer Rubber Co.
5. Metraflex, Inc.

B. Stainless-Steel-Hose Flexible Pipe Connectors: Corrugated-stainless-steel tubing with stainless-steel wire-braid covering and ends welded to inner tubing.

1. Working-Pressure Rating: 250 psig minimum.
2. End Connections: Threaded steel pipe nipple.

2.07 SPECIALTIES

A. Manufacturers

1. Wilkerson
2. Parker
3. Arrow
4. Prevost

B. Safety Valves: ASME Boiler and Pressure Vessel Code: Section VIII, "Pressure Vessels," construction; National Board certified, labeled, and factory sealed; constructed of bronze body with poppet-type safety valve for compressed-air service. Pressure Settings: Higher than discharge pressure and same or lower than receiver pressure rating.

C. Pressure Regulators at Equipment

1. Arrow or equal.
2. Aluminum body, 3-position knob adjustment, brass spring.
3. Pipe size to match equipment connection.
4. Max flow: 100 CFM.
5. Rated for 250-psig inlet pressure, operating range 5 to 125 psig.
6. Provide a zero to 125 psig gauge at each pressure regulator.

D. Automatic Drain Valves: Stainless-steel body and internal parts, rated for 200-psig minimum working pressure, capable of automatic discharge of collected condensate. Include mounting bracket if wall mounting is appropriate.

E. Velocity Fuses – Arrow Pneumatics #5074 (1/2”) or 5076 (3/4”) or equal. Provide for every air drop and hose reel; designed to protect workers from accidents caused by air hose whip, a potentially dangerous situation that occurs when air hoses snap while under high pressure loads. When an air hose ruptures, the flow check valve senses an increase in airflow and automatically reduces the flow to a safe level. Trigger point rated flow range: 90 to 110 cfm @ 100psi. ¾” NPT connections. 300PSI maximum operating pressure. 160°F maximum operating temperature. Integrated exhaust bleed rate of 9cfm @ 100psi.

F. Double & Single Outlet Manifold: By piping manufacturer, aluminum body manifold, pre-assembled with the following:

1. Drain port with mini ball valve at 150 PSI service, forged brass construction.
2. OSHA approved pressure relieving safety quick couplers. ISI interchange.



G. Quick Disconnect Fittings: 316 SS or plated brass stem and body set, 500 psig rated, double end shut-off style, (DESO).

1. OSHA approved.
2. End Connection, Equipment / Flexible Tube Side: Coordinate with Owner Requirements.

PART 3 - EXECUTION

3.01 PIPING APPLICATIONS

A. Compressed-Air Piping: Use aluminum or Type K or L, copper tube; wrought-copper fittings; and brazed joints.

B. Drain Piping: Use Type M copper tube; wrought-copper fittings; and brazed or soldered joints.

3.02 VALVE APPLICATIONS

A. Low-Pressure Compressed Air: Valve types specified for low-pressure compressed air.

B. Equipment Isolation: Safety-exhaust, copper-alloy ball valve with exhaust vent and pressure rating at least as great as piping system operating pressure.

3.03 PIPING INSTALLATION

A. Drawing plans, schematics, and diagrams indicate general location and arrangement of compressed-air piping. Indicated locations and arrangements were used to size pipe and calculate friction loss, expansion, air-compressor sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved.

B. **Confirm pipe sizes required for connection to existing equipment prior to installing branch piping. Discuss with Owner on site, look at existing equipment to confirm hookup requirements. Confirm exact location of equipment prior to rough-ins.**

1. Pipe size, assume ¾" for bidding. Drops at ½" are allowed if large enough for the connected equipment.
2. Pressure needed.
3. CFM airflow.

C. Install piping concealed from view and protected from physical contact by building occupants, unless otherwise indicated and except in equipment rooms and service areas.

D. Install piping indicated to be exposed and piping in equipment rooms and service areas at right angles or parallel to building walls. Diagonal runs are prohibited, unless otherwise indicated.

E. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and to coordinate with other services occupying that space.

F. Install piping adjacent to equipment and machines to allow service and maintenance.

G. Install nipples, flanges, unions, transition and special fittings, and valves with pressure ratings same as or higher than system pressure rating, unless otherwise indicated.

H. Equipment and Specialty Flanged Connections: Use cast-copper-alloy companion flange with gasket and brazed joint for connection to copper tube. Do not use soldered joints for connection to air compressors or to equipment or machines producing shock or vibration.

I. Extended-tee outlets with brazed branch connection may be used for copper tubing, within extruded-tee connection diameter to run tube diameter ratio for tube type, according to Extruded Tee Connections Sizes and Wall Thickness for Copper Tube (Inches) Table in ASTM F 2014.

J. Install eccentric reducers where compressed-air piping is reduced in direction of flow, with bottoms of both pipes and reducer fitting flush.

K. Install branch connections to compressed-air mains from top of main. Provide drain leg and drain trap at end of each main, end of each branch, and at low points. Provide a ½" globe valve in the drop legs.

L. Install piping to permit valve servicing.

M. Install piping free of sags and bends.

N. Install fittings for changes in direction and branch connections.

O. Install sleeves for piping penetrations of walls, ceilings, and floors.

P. Install identifying labels and devices for general-service compressed-air piping, valves, and specialties. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment."

3.04 JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints: Thread pipe with tapered pipe threads according to ASME B1.20.1. Cut threads full and clean using sharp dies. Ream threaded pipe ends to remove burrs and restore full ID. Join pipe fittings and valves as follows:

1. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
2. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Brazed Joints for Copper Tubing: Join according to AWS's "Brazing Handbook," "Pipe and Tube" Chapter.

E. Flanged Joints: Use asbestos-free, nonmetallic gasket suitable for compressed air. Join flanges with gasket and bolts according to ASME B31.9 for bolting procedure.

F. Grooved Joints: not permitted.

G. Dissimilar Metal Piping Material Joints: Use dielectric fittings.

3.05 VALVE INSTALLATION

A. Install shutoff valves and unions or flanged joints at compressed-air piping to air compressors.

B. Install shutoff valve at inlet to each automatic drain valve, filter, lubricator, and pressure regulator.

C. Install check valves to maintain correct direction of compressed-air flow to and from compressed-air piping specialties and equipment.

3.06 DIELECTRIC FITTING INSTALLATION

A. Install dielectric fittings in piping at connections of dissimilar metal piping and tubing.

B. NPS 2 and Smaller: Use dielectric unions.

3.07 FLEXIBLE PIPE CONNECTOR INSTALLATION

A. Install flexible pipe connectors in discharge piping of each air compressor.

3.08 SPECIALTY INSTALLATION

A. Install air-main pressure regulators in compressed-air piping at or near air compressors.

B. Install filters and automatic drain valves as indicated.

C. Install quick couplings at piping terminals for hose connections.

D. Provide hookups to equipment per equipment manufacturer’s instructions.

3.09 CONNECTIONS

A. Install unions adjacent to each valve and at final connection to each piece of equipment and machine.

B. Provide hookups to equipment per equipment manufacturer’s instructions.

3.10 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

B. Vertical Piping: MSS Type 8 or 42, clamps.

C. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, clevis hangers.

D. Support horizontal piping within 12 inchesof each fitting and coupling.

E. Rod diameter may be reduced 1 size for double-rod hangers, with 3/8-inch minimum rods.

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

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

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

3.11 FIELD QUALITY CONTROL

A. Perform field tests and inspections.

B. Blow out/purge piping prior to installing all manifolds.

C. Tests and Inspections:

1. Piping Leak Tests for Metal Compressed-Air Piping: Test new and modified parts of existing piping. Cap and fill general-service compressed-air piping with oil-free dry air or gaseous nitrogen to pressure of 50 psig above system operating pressure, but not less than 150 psig. Isolate test source and let stand for four hours to equalize temperature. Refill system, if required, to test pressure; hold for two hours with no drop in pressure.
2. Repair leaks and retest until no leaks exist.
3. Inspect filters, lubricators, and pressure regulators for proper operation.

D. Prepare test reports.

END OF SECTION

SECTION 22 15 19

GENERAL-SERVICE PACKAGED AIR COMPRESSORS AND RECEIVERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Reciprocating air compressors.
2. Filters.
3. Refrigerant compressed-air dryers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: Include diagrams for power, signal, and control wiring.

1.04 CLOSEOUT SUBMITTALS

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

1.05 COORDINATION

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

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

2.02 RECIPROCATING AIR COMPRESSORS

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

1. Quincy – Basis of Design (Barlow Morse, Maine Air Power)
2. Atlas Copco.

3. Ingersoll-Rand; Air Solutions Group.
4. Kaeser Compressors, Inc.
5. Powerex, Inc.

B. Construction

1. Honda engine
2. Compressor Head, Gaskets and Valves

    a. Aluminum head for cooler operating temperatures and longer life.
    b. Graphite cylinder and head gaskets for positive sealing and improved performance.
    c. Stainless-steel, corrosion resistant reed valves with controlled lift for maximum efficiency.

3. Inter-stage Intercooler: Finned-copper-tubed intercooler dissipates excess heat from the first stage of compression to the second-stage, helping to eliminate carbon build up in the head and increase valve life.
4. Flywheel: Large, balanced cast-iron flywheel for smoother operation, angled for maximum cooling across the compressor for longer life.
5. Rings: High performance, automotive-style rings allow less than 6 PPM oil carryover.
6. Crankshaft: Balanced counter-weighted crankshaft for smooth, trouble-free operation.
7. Extra-capacity oil reservoir assures low oil temperatures for lasting performance.

C. Components:

1. Tank pressure gauge
2. Oil gauge
3. Service valve
4. Pressure switch.
5. OSHA belt guard.

D. Provide the Quincy “QT-Max” option:

1. ODP Slow Speed Motor
2. Motor Overload Protection
3. Automatic Tank Drain
4. Automatic Start/Stop
5. Dual Control
6. Low Oil Level Shutdown
7. Air Cooled Aftercooler
8. Vibration isolators.

E. Provide a dual power source duplex control panel.

F. Provide manual/electronic tank drains.

2.03 ACCESSORIES

A. Oil/water separator: Quincy QCS100

1. Removes compressor lubricants
2. Clean, carbon free filter media
3. Light-weight, easily changeable, disposable filter cartridge.

B. Pre and After-filters:

1. SMC AFF22B-N10D-T
2. 99% efficiency at 3 microns.
3. Designed to eliminate impurities such as oil and foreign matter.
4. Provide auto drain and piping.

2.04 REFRIGERANT COMPRESSED-AIR DRYERS

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

1. SMC
2. Beko
3. Zeks.
4. Atlas Copco
5. Ingersoll-Rand Company; Compressed Air Solutions.
6. Kaeser Compressors, Inc.
7. Wilkerson Operations; Pneumatic Division.
8. Zeks Compressed Air Solutions.

B. Dryer Features

1. U.L. Listed
2. R407C refrigerant.
3. Flow Specifications as per CAGI Standard ADF100
4. Simple control system, incorporating easy to read evaporator gauge
5. Stainless steel heat exchanger providing long life and low pressure drops
6. Compact design with staggered inlet/outlet ports for ease of installation
7. 3/8” push-in condensate drain port

PART 3 - EXECUTION

3.01 EQUIPMENT INSTALLATION

A. Equipment Mounting: Install air compressors on cast-in-place concrete equipment bases.

B. Install compressed-air equipment anchored to substrate.

C. Arrange equipment so controls and devices are accessible for servicing.

D. Maintain manufacturer's recommended clearances for service and maintenance.

3.02 CONNECTIONS

A. Comply with requirements for piping specified in Section 22 15 13 "General-Service Compressed-Air Piping." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to machine, allow space for service and maintenance.

3.03 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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

3.04 DEMONSTRATION

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

END OF SECTION

SECTION 22 40 00

PLUMBING FIXTURES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 22 Section "Common Work Results for Plumbing"
2. Section 22 11 16 – “Domestic Water Piping”.
3. Division 22 Section "Plumbing Specialties"

1.02 SUMMARY

A. This Section includes Plumbing Fixtures.

1.03 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.

1.04 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 the 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. Comply with UL 1951 - Standard for Electric Plumbing Accessories

G. Water line components shall be lead-free.

1.05 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

2.01 GENERAL

A. Common Plumbing Fixture Requirements

1. 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. Fixture color shall be white except as specified herein.
2. Provide combinations of fixtures and trim, faucets, fittings, and other components that are compatible. Fixtures shall be equipped with appurtenances such as traps, faucets, stop valves, and drain fittings.
3. Coordinate fixture rough in dimensions for conflicts with surrounding structure, prior to submitting.
4. Each fixture and piece of equipment requiring connections to the drainage system shall be equipped with a trap.
5. 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.
6. 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.
7. Provide access panels to concealed valves and components. All components shall have proper access in accordance with manufactures' recommendations. Refer to Section 22 05 00.
8. Mounting heights: Refer to Architectural Plans.

2.02 FLUSH VALVE WATER CLOSETS

A. Manufacturers:

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

B. Water Closets - Common Requirements:

1. Comply with ASME A112.19.2 – Ceramic Plumbing Fixtures; Comply with ADA
2. Material: Vitreous china.
3. Type: Siphon jet.
4. Style: Flushometer valve.
5. Rim Contour: Elongated.
6. Water Consumption: 1.28 GPF.
7. Spud Size and Location: NPS 1-1/2; top.
8. Toilet Seats: Standard: IAPMO/ANSI Z124.5; solid polypropylene with special surface that inhibits the growth of stain and odor causing bacteria, mold and mildew on the surface; commercial heavy duty; Shape: Elongated rim, open front; Seat Cover: Not required. Color: White.
9. Flushometer: See Flushometer paragraphs below.

C. **P-1A** & **P-1B**: Basis of Design: American Standard Afwall Millennium FloWise 1.28 GPF Flushometer Toilet System with Everclean, Model 2856.128; Wall mounted, Exposed Top Spud Bowl and Manual Flush Valve.

1. Water Closet Carrier: Standard: ASME A112.6.1M.
2. Waste-fitting assembly, as required to match drainage piping material and arrangement; with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture. Mounting Height: See Architectural plan.
3. Bowl: Wall mount elongated flushometer valve toilet, vitreous china, High Efficiency operation, permanent EverClean surface, condensation channel, direct fed siphon jet action, fully glazed 2-1/8" trapway.
4. Flushometer: Exposed top spud, manual flush valve, ADA compliant Lever-Handle, self-cleaning brass piston with integral wiper spring, piston valves remains closed and does not need to be reset after loss of water pressure, can be installed left or right handed, see plans for orientation.



D. **P-1C**: Basis of Design: American Standard Madera FloWise 16-1/2" Height, 1.1 GPF Flushometer Toilet System with Everclean, Model 2854.1.1; Floor mounted, Exposed Top Spud Bowl and Manual Flush Valve. Description: Waste-fitting assembly, as required to match drainage piping material and arrangement; with faceplates, couplings gaskets, and feet; bolts and hardware matching fixture.

1. Bowl: Floor mount elongated flushometer valve toilet, vitreous china, High Efficiency operation, permanent EverClean surface, condensation channel, direct fed siphon jet action, fully glazed 2-1/8" trapway.
2. Flushometer: Exposed top spud, manual flush valve, ADA compliant Lever-Handle, self-cleaning brass piston with integral wiper spring, piston valves remains closed and does not need to be reset after loss of water pressure, can be installed left or right handed, see plans for orientation.



2.03 URINALS

A. Manufacturers

1. Sloan
2. American Standard, Inc.
3. Kohler Co.
4. Toto

B. Urinals - Common Requirements:

1. Comply with ASME A112.19.2 – Ceramic Plumbing Fixtures; Comply with ADA
2. Urinal shall be EPA Water Sense Certified.
3. Material: Vitreous china, white color.
4. Provide permanent EverClean surface to inhibit the growth of stain and odor causing bacteria, mold and mildew on the surface
5. Type: Siphon jet, wall hung.
6. Style: Flushometer valve.
7. Vandal-resistant strainer with integral trap.
8. Water Consumption: 1/8 GPF.
9. Spud Size and Location: NPS 1-1/2; top.
10. Outlet Size and Location: NPS 2, back.
11. Support: Type I Urinal Carrier with fixture support plates and coupling with seal and fixture bolts and hardware matching fixture. Include rectangular, steel uprights. Standard: ASME A112.6.1M.
12. Urinal Mounting Height: See Architectural Plans.
13. Flushometers: See Flushometer paragraph below.

C. **P-2A** & **P-2B**: Basis of Design: American Standard Washbrook FloWise 6590.503, Universal Urinal; Standard Wash-down Urinal.
1. Urinal: Vitreous China, Ultra High Efficiency, Flushing rim, Elongated 14” rim from finished wall, Washout flush action, extended sides for privacy, top spud, strainer included.
2. Flushometer: Exposed top spud, manual flush valve, 0.125 GPF, ADA compliant Lever-Handle, self-cleaning brass piston with integral wiper spring, piston valves remains closed and does not need to be reset after loss of water pressure, can be installed left or right handed, see plans for orientation.



2.04 VITREOUS-CHINA LAVATORIES

A. Lavatory Manufacturers:
1. American Standard
2. Kohler
3. Toto
4. Zurn
5. Duravit

B. Lavatories – Common Requirements:

1. Standard: ASME A112.19.2/CSA B45.1; ADA.
2. Faucet-Hole Punching: Match faucet, coordinate hole locations.
3. Provide a permanent surface that inhibits the growth of stain and odor causing bacteria, mold and mildew on the surface
4. Provide overflow.
5. Provide 304 stainless steel grid drain unless noted otherwise.
6. 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 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.
7. Waste Fittings: Standard: ASME A112.18.2
8. Drain: Stainless steel grid type with NPS 1-1/4 offset and straight tailpiece.
9. 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.
10. Provide ADA trim kits for exposed piping.
11. Faucets: See LAVATORY & SINK FAUCETS paragraph below.

C. Under-counter: Meets ASME A112.19.2M
1. **P-3A**: Basis of Design: American Standard Ovalyn Model 0497.221; Bowl Size: 19”W, 15-3/8” front to back, 5-1/2”D. Overall size: 21-1/2” x 17-3/8”. Oval undermount sink made from vitreous china, front overflow, supplied with mounting kit.



D. Wall Mounted: Provide ASME A112.6.1 M lavatory carrier. Lavatory mounting height: See architectural plans

1. **P-3B** Basis of Design: American Standard “Murro” 0955.001EC; Nominal Size: Rectangular, 21-7/16” x 17-3/4”, with 0059.020EC shroud. Vitreous china with EverClean, recessed self-draining deck, concealed arm support, ADA compliant.



2. **P-3C** Basis of Design: Wheelchair Users Lavatory, Model 9140.047, center hole only, vitreous china, front overflow, for concealed arm support, faucet ledge.



2.05 COUNTER MOUNTED SINKS

A. See Sheet A7.1 for sink installation details.

B. Stainless Steel Sink Manufacturers:

1. Elkay Manufacturing Co.
2. Just Manufacturing Co.
3. Moen

C. Polyethylene Sink Manufacturers

1. Orion
2. Thermo Fisher Scientific

D. Sinks – Common Requirements:

1. Standard: ASME A112.19.2/CSA B45.1; ADA.
2. Faucet-Hole Punching: Match faucet, coordinate hole locations.
3. 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.
4. Waste Fittings: Standard: ASME A112.18.2
5. P-trap: heavy cast brass adjustable body, with slip nut, with cleanout, box flange and seamless tubular wall bend.
6. Grid drains, where indicated, shall be 304SS.
7. Provide ADA trim kits for exposed piping.
8. Faucets: See LAVATORY & SINK FAUCETS paragraph below.

E. **P-4A** & **P-4B**: Basis of Design: Elkay LRADQ172065 Top mounted self-rimming counter sink, 18 gauge; type 304 stainless steel. 17” x 20” outside dimensions and 14” x 14” inside dimensions. ADA bowl depth: 6 1/2”.

1. Drain Opening: 5” off rear centered drain location.
2. Drain: type 304 stainless grid drain
3. Drain Fitting: type 304 stainless steel body and removable conical basket strainer with metal stem and rubber stopper; fits 3-1/2" opening; polished finish; chrome plated solid brass construction.



F. **P-4C**: Lab Sink, Trim Only
1. Supplies: NPS 1/2 chrome-plated copper with stops.
2. Drain: Zurn Z9A-WA waste assembly for use in chemical drainage sinks.
3. Drain Piping: 2” chrome-plated cast-brass trap, 0.045-inch- thick tubular brass waste to wall, and wall escutcheon.
4. Accessories: Refer to specification section 221119 for point of use neutralization tanks.
5. Faucets: See LAVATORY & SINK FAUCETS paragraph below.
6. Provide chemical resistant basket strainer

G. **P-4D** Wall Mounted Stainless Steel Single Bowl Sink, ADA Accessible

1. Sink Basis of Design: Advance Tabco, Model 7-PS-45, One piece deep drawn sink, heavy gauge type 304 stainless steel, with two handled faucet.

   a. 16”x20”x8” sink bowl size.
   b. Two handled gooseneck faucet included, mounted on backsplash, lever handles.
   c. (2) Support Brackets, hardware included
   d. Drain Opening: 1-1/2” stainless steel basket.



2.06 LAVATORY & SINK FAUCETS

A. Faucet Manufacturers

1. Chicago
2. Moen
3. Zurn
4. American Standard

B. Faucets - Common Requirements:

1. Comply with ASME A112.18.1M, NSF372-2011, ADA; UL 1951

2. Body Material: Commercial, solid cast brass.
3. Lead Free: Faucet contains ≤ 0.25% total lead content by weighted average
4. Thermostatic mixing valves (TMV), as indicated: 20" flexible stainless steel inlet hoses with 3/8" compression fittings. ASSE 1070 certified down to 0.35 gpm

C. Manual Type:

1. **P-3A, P-3B** & **P-3C** lavatory faucets: Basis of Design: American Standard Colony Pro, Model #7075.054 Single Control Lavatory, metal lever handle, less pop up drain, rod and hole. Metal body, washer-less ceramic disc valve cartridge with integral hot limit safety stop, 24" color coded braided flexible supply hoses with compression connections. Pressure compensating vandal resistant spray with 0.5 GPM maximum flow rate aerator.



2. **P-4A**: Health Care Sink Faucet: Basis of Design: Chicago Faucets 201-AGN2AE36-317AB, Deck mounted 8" fixed centers, concealed hot and cold water sink faucet, 5-1/4" rigid gooseneck spout, 1.5 GPM none aerating laminar outlet, 4" vandal proof wrist blade handles, Quaturn compression cartridge. Lifetime limited faucet warranty.



3. **P-4B**: Kitchen Sink Faucet: Basis of Design: Chicago Faucets 201-AGN2AE35ABCP, Deck mounted 8" fixed centers, hot and cold water sink faucet, 5-1/4" rigid gooseneck spout, 1.5 GPM aerator, 2-3/8" vandal proof lever handles, Quaturn compression cartridge. Lifetime limited faucet warranty.



4. **P-4C**: Lab Sink Faucet: Basis of Design: Chicago Faucet Model 930-VR369CP, Deck mounted single-hole vandal proof hot and cold water mixing faucet with vacuum breaker. 6" rigid gooseneck spout with atmospheric vacuum breaker, full flow nozzle, 2-3/8" vandal proof lever handles, Quaturn compression operating cartridge; 1.5 GPM. Lifetime limited faucet warranty.



2.07 SHOWERS

A. Shower Manufacturers

1. Aquatic
2. Aquarius.
3. LASCO Bathware
4. Freedom
5. Aqua Bath Co., Inc.

B. Faucet Manufacturers

1. Symmons
2. Moen
3. Powers

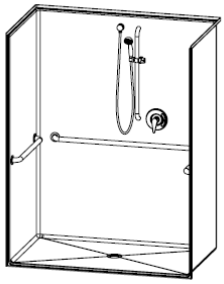
C. Roll In Shower (ADA Accessible)

1. **P-5**: Basis of Design: Aquatic Model 16034BFS; 62” x 37” x 77-3/4” outside dimensions. Inside dimensions: 60” x 34” x 76-3/4”, less seat, lifetime limited warranty.

    a. Color: White.
    b. Material: AcrylX, applied acrylic
    c. Code compliant when fully equipped and installed according to guidelines; Barrier-free design
    d. Center drain location; provide a brass chrome plated drain.
    e. Slip resistant, textured bottom; ASTM F-462.
    f. Fully equipped with two 28” (side walls) and one 48” (back wall) 1-1⁄2” diameter stainless steel grab bars.
    g. Coordinate left hand or right hand configuration
    h. Soap tray: molded in recessed.
    i. Curtain rod: 1” OD 18-gauge SS grommet style. Provide a white, weighted shower curtain.
    j. Provide blocking on both side walls for future seat installation, and blocking under shower base for additional weight support, especially around center drain location.

2. Shower Trim: Basis of Design: Symmons Temptrol Shower and Hand Shower System, Model C-96-500-B30-V-VP. Symmons commercial series shower hand shower system with lever handle, Temptrol pressure balancing mixing valve with adjustable stop screw to limit handle turn, separate dual outlet diverter valve, showerhead with cast brass single

mode adjustable spray, showerhead mounting bracket and flange, wall/hand shower with six foot flexible metal hose, in line vacuum breaker and wall connection, 30” slide bar for mounting hand shower, with flow restrictor to limit flow to 2.0 GPM, integral check stops, vandal resistant.





2.08 MOP SERVICE BASINS

A. Manufacturers:

1. Zurn
2. Fiat
3. Stern-Williams

B. Provide check valves at HW and CW connections.

C. **P-6A** Basis of Design: Fiat MSB 2424. Molded one piece 24 x 24 x 10” H Mop Service Basin; stainless steel drain body and stainless steel dome strainer.

1. Stainless Steel Wall Guard (MSG2424) 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 (889-CC): Stainless steel 24" long x 3" wide with three rubber tool grips
3. Hose and hose bracket (832-AA)
4. Bumper Guards (E-88-AA) Provide 20 gage type 304 stainless steel bumper guards to protect top edge of basin.

D. Chicago Faucets No. 897-CP, wall mounted. 8" adjustable centers, Hot and cold water sink faucet, chrome plated solid brass construction. Vacuum breaker spout with 3/4" male hose thread and pail hook, 2 3/8" metal lever handles with sixteen point tapered broach and secured blue and red buttons. Quarter-turn re-buildable compression cartridge, opens and closes 90°, closes with water pressure, features square tapered stem. Straight 2" inlet supply arm with wall flange with 1/2" NPT female thread inlet. Provide atmospheric vacuum breaker. ECAST® construction with less than 0.25% lead content by weighted average. Provide per ADA ANSI/ICC A117.1 requirements and shall be tested and certified to industry standards: ASME A112.18.1/CSA B125.1, California Health and Safety Code 116875 (AB1953-2006), Vermont Bill S.152, and NSF/ANSI 372 Low Lead Content.



E. **P-6B** Basis of Design: Fiat MSB 3624. Molded one piece 36 x 24 x 10" H Mop Service Basin; stainless steel drain body and stainless steel dome strainer.

1. Provide same options and faucet as P-6A.

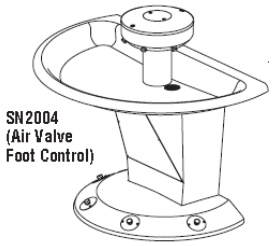
2.09 SEMI-CIRCULAR MULTI WASHFOUNTAIN

A. Manufacturers:

1. Bradley
2. Intersan
3. Willoughby
4. Acorn

B. **P-7** Basis of Design: Bradley SN2004, 54" wide, standard height, Sentry Semi-Circular Shallow Bowl Wash fountain, with air valve foot control, vandal resistant. Certifications: UPC, IPC approved through the International Association of Plumbing and Mechanical Officials (IAPMO). Manufactured in compliance with IGC 156-2009, CSA B$% Seroes-2002 (R08) & ASME A112.18.1-2005/CSA B125.1-205. ADA compliant.

1. Push button activated air metering control accommodates four users.
2. Flow rate: 0.5 GPM
3. Bowl and pedestal construction: Type 304 stainless steel. Pedestal and access panels, frame foot control housing, support tube and sprayhead are heavy gauge stainless steel.
4. Navigator thermostatic mixing valve, flexible stainless steel supply hoses and stops.
5. Pushbutton pneumatically actuates a non-hold open air single temperature valve with slow closing upon release of foot pressure.



2.10 ELECTRIC WATER COOLERS

A. Manufacturers

1. Elkay Manufacturing Co.
2. Halsey Taylor.
3. Haws Corporation.
4. Oasis Corporation.

B. General

1. Adjust fixture flow regulators for proper flow and stream height. Adjust water-cooler temperature settings.
2. Waterways shall be 100% lead-free.
3. Laminar flow shall produce an even flow and eliminate splashing
4. Barrier free for full ADA access

C. **P-8** Basis of Design: Elkay EZH20 VRCTL8WS Bottle filler Station – Bi-Level electric water cooler with bottle filling station, shall deliver 8 GPH of 50F drinking water at 90 degree F ambient temperature. Stainless steel construction and vandal resistant bubbler. Bottle filling unit shall include an automatic 20 second shut off timer. Display count indicating count of plastic bottles saved from waste. Bottle filler shall provide 1.1-1.5 gpm flow rate with laminar flow to minimize splashing. Meets ADA guidelines, is lead free and certified to NSF/ANSI 60 and 372 and meets federal and state low lead requirements.

1. Compressor: hermetically sealed, reciprocating type, single phase. Sealed in lifetime lubrication.
2. Condenser: fan cooled, copper tube with aluminum fins. Fan motor is permanently lubricated.
3. Cooling unit: combination tube-tank type. Self-cleaning, continuous copper tubing with stainless steel fully insulated tank.
4. Refrigerant control: refrigerant R134a is controlled by accurately calibrated capillary tube.
5. Temperature control: Easily accessible enclosed adjustable thermostat is factory preset.
6. Electrical: 115V/60Hz

a. FL Amps : 5A
b. Watts: 370W



2.11 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. **P-9** Basis of Design: Guardian G5046BP Wall Mount Hand-Held Hose Spray

1. Dual purpose eyewash / drench hose for wall mounting. Unit meets the provisions of ANSI Z358.1-2014 as both an eyewash and a drench hose.
2. Spray head assembly: Two GS Plus spray heads mounted side by side. Each head has a flip top dust cover, internal flow control and filter to remove impurities from the water flow.
3. Valve: forged brass squeeze valve activated by stainless steel lever handle. Valve has replaceable stainless steel sear for durability. Locking clip engages when the handle is depressed. Valve stays open until locking clip is released.
4. Hose: 12' reinforced nylon retractable coiled hose. 180 PSI maximum rated working pressure.
5. Mounting: Bracket with spring clips to hold unit on wall. Clips position spray heads and handle to face forward at all times.
6. Backflow preventer: in line dual check backflow preventer installed on inlet of hose.
7. Temperature mixing valve: G3600LF thermostatic mixing valve blends hot and cold water to deliver warm water as provided by ANSI Z358.1-2014. Set mixing valve to deliver 85°F water.



E. **P-10** Basis of Design: Guardian GBF1994, All Stainless Steel Barrier Free Safety Station with Wide Area Eye / Face Wash. Shower head and pull rod are extended for improved access. Bowl is lowered and extended to permit access by wheelchair users. Unit complies with ADA requirements.

1. Shower head: 10" diameter stainless steel
2. Shower valve: 1" IPS type 316 stainless steel stay open ball valve.
3. Spray head assembly: Four GS-Plus spray heads. Each head has a flip top dust cover, internal flow control and filter.
4. Eye/Face Wash Bowl: 11-1/2" stainless steel
5. Eye/Face Wash Valve: ½" IPS type 316 stainless steel stay open ball valve.
6. Pipe and Fittings: brushed stainless steel
7. Supply: 1-1/4" NPT female top or side outlet
8. Waste: 1-1/4" NPT female outlet.
9. Sign: Furnished with ANSI compliant identification sign.
10. Temperature mixing valve: G3800LF thermostatic mixing valve blends hot and cold water to deliver warm water as provided by ANSI Z358.1-2014. Set mixing valve to deliver 85°F water.



PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in of water supply and sanitary drainage and vent piping systems to verify actual locations of piping connections before 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.

3.02 FIXTURE INSTALLATION - GENERAL

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

B. Provide fixtures level and plumb according to manufacturers' written instructions and roughing-in drawings.

C. Provide 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. Provide stops in locations where they can be easily reached for operation.

D. Provide traps on fixture outlets as required.

1. Provide level and plumb according to roughing-in drawings.

E. Provide supports and connections to fixtures per manufacturer’s instructions.

F. Provide 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.

G. Set floor mounted fixtures in a leveling bed of cement grout as per fixture manufacturer’s instructions.

H. Joint Sealing: Seal joints between fixtures and walls, floors, and counters using sanitary-type, one-part, mildew-resistant, silicone sealant. Match sealant color to water-closet color. Comply with sealant requirements specified in Division 9.

I. Wall Flange and Escutcheon Installation: Provide wall flanges or escutcheons at piping wall penetrations in exposed, finished locations and within cabinets and millwork. Provide deep-pattern escutcheons if required to conceal protruding fittings.

3.03 WATER CLOSET & URINAL INSTALLATION

A. Provide accessible, wall-mounted water closets at mounting height for handicapped/elderly, according to ICC/ANSI A117.1.

B. Provide lever-handle flushometer valves for accessible fixtures with handle mounted on open side of fixture. Provide actuators in locations that are easy for people with disabilities to reach.

C. Attach supply piping to supports or substrate within pipe spaces behind fixtures.

D. Provide toilet seats on water closets.

3.04 SINKS AND LAVATORIES

A. Provide supports, affixed to building substrate, for wall-mounted lavatories.

B. Operate and adjust lavatories and controls. Replace damaged and malfunctioning lavatories, fittings, and controls. Adjust water pressure at faucets to produce proper flow.

3.05 HOOK UPS

A. Foodservice Equipment, coordinate with 114000; Provide:

1. Rough-ins
2. Piping for supply and waste lines.
3. Traps, grease traps, line strainers, tail pieces, valves, stops, shutoffs, and miscellaneous fittings required for complete installation.
4. Final connection, including mounting of foodservice equipment contractor supplied faucets and waste assemblies.

B. Provide rough-in piping, traps, tailpieces, indirect waste lines and make final and necessary connections for foodservice equipment. Provide faucets, spray units, drains, lever drains, vacuum breakers, solenoid valves, check-valves, flow control valves, water inlet fittings, filters, strainers, pressure reducing valves and gas valves furnished by foodservice equipment contractor. Provide condensate drain piping from cooler and freezer evaporators. Make all final and necessary plumbing connections.

C. Provide plumbing hookups to Fixtures and Equipment Specified in Division 11. Connect fixtures and equipment with water supplies Use size fittings required to match fixtures and equipment. Connect to plumbing piping.

D. Residential Dishwasher: When the sink is equipped with a garbage disposal unit, the dishwasher waster shall be connected to the inlet side of the disposal after passing through the required air gap fitting. When the sink is not equipped with a garbage disposal unit, the

dishwasher waste shall be connected to the continuous waste of the sink using a wye-branch fitting, after passing through the required air gap fitting. The wye branch fitting may be installed in any vertical section of the continuous waste on the inlet side of the trap. The wye branch fitting shall not be installed in a horizontal run.

E. Provide disposer in outlet of sinks indicated to have disposer. Provide switch where indicated or in wall adjacent to sink if location is not indicated.

F. Provide hot-water dispensers in back top surface of sink or in counter with spout over sink.

3.06 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.

3.07 FIELD QUALITY CONTROL

A. Verify that installed fixtures are categories and types specified for locations where installed. Check that fixtures are complete with trim, faucets, fittings, and other specified components. Inspect installed fixtures for damage. Replace damaged fixtures and components.

B. Test installed fixtures after water systems are pressurized for proper operation. Replace malfunctioning fixtures and components, then retest. Repeat procedure until units operate properly.

C. Operate and adjust fixtures. Replace damaged and malfunctioning fixtures, fittings, and controls.

D. Adjust water pressure to produce proper flow and stream.

E. Replace washers and seals of leaking and dripping faucets and stops.

3.08 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.

3.09 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

SECTION 22 62 13

VACUUM PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes relocation of the vacuum system for Marine Technology.

1.03 SUBMITTALS

A. Product Data: For the following:

1. Vacuum pipes and fittings.
2. Vacuum gauge

B. Operation and Maintenance Data

1.04 COORDINATION

A. Coordinate layout with owner.

PART 2 - PRODUCTS

2.01 TUBES, AND FITTINGS

A. PVC Pipe: ASTM D 1785, Schedule 40.

B. PVC Fittings: ASTM D 2466, Schedule 40; socket type.

C. Solvent Cement for Joining PVC Piping: ASTM D 2564. Include primer complying with ASTM F 656.

2.02 SPECIALTIES

A. Ball valve, bronze full port, Solid brass ball, plated; 600 psig CWP, non-shock; rated for vacuum service to 29 in. Hg.

B. Vacuum Gauge: Weiss Trade Line, or equal; drawn steel case; 2” dial; 1/4" NPT connections. Gauges shall conform to ANSI B40.1 accuracy Grade B-2% mid-scale. Range: 0-30”HG. Provide a brass gauge cock.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. Install piping concealed from view and protected from physical contact by building occupants unless otherwise indicated and except in equipment rooms and service areas.

B. 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.

C. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal and coordinate with other services occupying that space.

D. Install piping adjacent to equipment and specialties to allow service and maintenance.

E. Install vacuum piping with 1 percent slope downward in direction of flow.

F. Install piping free of sags and bends.

G. Install fittings for changes in direction and for branch connections. Extruded-tee branch outlets in copper tubing may be made where specified.

3.02 EQUIPMENT

A. Provide in accordance with manufacturer’s instructions.

3.03 HANGER AND SUPPORT INSTALLATION

A. Comply with requirements in Division 22 Section "Hangers and Supports for Plumbing Piping and Equipment" for pipe hanger and support devices.

3.04 FIELD QUALITY CONTROL

A. Start, test, and commission per manufactures instructions.

B. Test piping according to procedures of authorities having jurisdiction.

END OF SECTION

SECTION 22 66 00

CHEMICAL-WASTE SYSTEMS FOR LABORATORY FACILITIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Single-wall waste & vent piping.
2. Piping specialties.
3. Neutralization tanks.

1.03 PERFORMANCE REQUIREMENTS

A. Single-Wall Piping Pressure Rating: 10 feet head of water.

1.04 ACTION SUBMITTALS

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

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For chemical-waste specialties and neutralization tanks, to include in emergency, operation, and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Neutralization-Tank Limestone: Equal to 200 percent of amount required for each tank sump initial charge. Furnish limestone in 50-lb bags.

1.07 QUALITY ASSURANCE

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

B. NFPA Compliance: Comply with NFPA 70, "National Electrical Code."

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver and store piping and specialties with sealing plugs in ends or with end protection.

B. Do not store plastic pipe or fittings in direct sunlight.

C. Protect pipe, fittings, and seals from dirt and damage.

PART 2 - PRODUCTS

2.01 MANUFACTURERS:

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

1. Orion Fittings, Inc.; a division of Watts Water Technologies, Inc.
2. Sloane, George Fischer Inc.
3. Town & Country Plastics, Inc.
4. Watts Industries (Canada) Inc.
5. Zurn Plumbing Products Group; Chemical Drainage Systems.

2.02 SINGLE-WALL PIPE AND FITTINGS

A. PP Drainage Pipe and Fittings: The corrosive waste drainage system, conforming to ASTM F1412, shall be Orion's Blueline flame retardant pipe and fittings. Pipe and fittings shall be joined using the Orion socket fusion system conforming to ASTM D2657. The pipe shall be supplied in 10-ft lengths. The fittings shall meet or exceed Schedule 40 dimensions. The polypropylene material shall conform to ASTM D4101.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, and gaskets; compatible with piping and system liquid; made for joining different piping materials.

2.03 JOINING MATERIALS

A. Couplings: Assemblies with combination of clamps, gaskets, sleeves, and threaded or flanged parts; compatible with piping and system liquid; and made by piping manufacturer for joining system piping.

B. Adapters and Transition Fittings: Assemblies with combination of clamps, couplings, adapters, gaskets, and threaded or flanged parts; compatible with piping and system liquid; and made for joining different piping materials.

C. Flanges: Assemblies of companion flanges and gaskets complying with ASME B16.21 and compatible with system liquid, and bolts and nuts.

2.04 NEUTRALIZATION TANK

A. Description: Tanks shall be of seamless construction manufactured from rotationally molded virgin polyethylene / polypropylene resin.

B. **NT-1**: Basis of Design Orion Tank Style: 10 Rectangular Tank, Neutralization/Dilution

1. Tank Capacity: 5 Gallon
2. Dimensions: 10”x16”x8”high
3. Cover: Light-duty plastic, bolted with cleanout in the center for access.
4. Limestone: Shall be certified as having a calcium carbonate content in excess of 90%. This high purity is essential to the successful neutralization of the acidic waste and to minimize sludge build up in the tank. The limestone chips should be 1” - 3” in size and be of irregular pattern to facilitate liquid percolation throughout the limestone bed.

C. **NT-2**: Basis of Design Orion Tank Style: 10 Rectangular Tank, Neutralization/Dilution

1. Tank Capacity: 15 Gallon
2. Dimensions: 12”x24”x12”high
3. Cover: Light-duty plastic, bolted with cleanout in the center for access.
4. Limestone: Shall be certified as having a calcium carbonate content in excess of 90%. This high purity is essential to the successful neutralization of the acidic waste and to minimize sludge build up in the tank. The limestone chips should be 1” - 3” in size and be of irregular pattern to facilitate liquid percolation throughout the limestone bed.

PART 3 - EXECUTION

3.01 PIPING INSTALLATION

A. Chemical-Waste & Vent Piping Inside the Building:

1. Install piping next to equipment, accessories, and specialties to allow service and maintenance.
2. Transition and special fittings with pressure ratings at least equal to piping pressure rating may be used unless otherwise indicated.
3. Flanges may be used on aboveground piping unless otherwise indicated.
4. Install piping in concealed locations unless otherwise indicated and except in equipment rooms and service areas.
5. 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.
6. Install piping above accessible ceilings to allow sufficient space for ceiling panel removal.
7. Install piping at indicated slopes.
8. Install piping free of sags and bends.
9. Install fittings for changes in direction and branch connections.
10. Verify final equipment locations for roughing-in.
11. Install sleeves for piping penetrations of walls, ceilings, and floors.

3.02 JOINT CONSTRUCTION

A. Chemical-Waste piping Inside the Building: Plastic-Piping Electrofusion Joints: Make polyolefin drainage-piping joints according to ASTM F 1290.

3.03 HANGER AND SUPPORT INSTALLATION

A. Pipe sizes in this article refer to aboveground, single-wall piping.

B. Install the following:

1. Vertical Piping: MSS Type 8 or MSS Type 42, riser clamps.
2. Individual, Straight, Horizontal Piping Runs: MSS Type 1, adjustable, steel clevis hangers.

C. Comply with requirements in Section 22 05 29 "Hangers and Supports for Plumbing Piping and Equipment" for installation of supports.

D. Support horizontal piping and tubing within 12 inches of each fitting and coupling.

E. Support vertical piping and tubing at base and at each floor.

F. Rod diameter may be reduced 1 size for double-rod hangers, to minimum of 3/8 inch.

G. Install vinyl-coated hangers for PP piping with the following maximum horizontal spacing and minimum rod diameters:

1. NPS 2: 33 inches with 3/8-inch rod.
2. NPS 2-1/2 and NPS 3: 42 inches with 1/2-inch rod.
3. NPS 4: 48 inches with 5/8-inch rod.

H. Install supports for vertical PP piping every 72 inches.

3.04 NEUTRALIZATION TANK INSTALLATION

A. Install exterior neutralization tanks, complete with appurtenances indicated.

3.05 CONNECTIONS

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

B. Install piping adjacent to equipment to allow service and maintenance.

3.06 LABELING AND IDENTIFICATION

A. Comply with requirements in Section 22 05 53 "Identification for Plumbing Piping and Equipment" for labeling of equipment and piping.

3.07 FIELD QUALITY CONTROL

A. Inspect interior of sewerage piping to determine whether line displacement or other damage has occurred. Inspect after approximately 24 inches of backfill is in place and again at completion of Project.

1. Defects requiring correction include the following:

    a. Alignment: Less than full diameter of inside of pipe is visible between inspection points.
    b. Deflection: Flexible piping with deflection that prevents passage of ball or cylinder of size not less than 92.5 percent of piping diameter.
    c. Crushed, broken, cracked, or otherwise damaged piping.
    d. Hydrostatic Tests for Drainage Piping:

        1) Allowable leakage is a maximum of 50 gal./inch of nominal pipe size per mile of pipe, during 24-hour period.
        2) Close openings in system and fill with water.
        3) Purge air and refill with water.
        4) Disconnect water supply.
        5) Test and inspect joints for leaks.

    e. Air Tests for Drainage Piping: Comply with UNI-B-6.

2. Leaks and loss in test pressure constitute defects that must be repaired.
3. Submit separate reports for each test.

B. Replace leaking sewerage piping using new materials, and repeat testing until leakage is within allowances specified.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

D. Perform 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.

E. Tests and Inspections:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.

F. Chemical-waste piping will be considered defective if it does not pass tests and inspections.

G. Prepare test and inspection reports.

3.08 CLEANING

A. Use procedures prescribed by authorities having jurisdiction or, if not prescribed, use procedures described below:

1. Purge new piping and parts of existing piping that have been altered, extended, or repaired before using.
2. Clean piping by flushing with potable water.

END OF SECTION

SECTION 23 05 00

COMMON WORK RESULTS FOR MECHANICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. This section applies to Division 21, 22, & 23 sections.

C. 23 05 00 Appendix (at the end of this section)

1.02 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. Provide equipment and components to comply with manufacturer's written installation instructions and published drawings for products and applications indicated.

F. This contractor will be responsible to carry out the commissioning requirements specified. Refer to Division 1 for additional requirements.

G. Equipment Hookups: Equipment locations are diagrammatically shown in proposed locations on the plans, final equipment locations shall be determined in field prior to installing rough-ins and connection devices (power, ducts, piping, etc.).

1.03 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. http://www.efficiencymaine.com/at-work/business-programs/
3. Review plans and specifications for compliance with Efficiency Maine standards for applicable systems and technologies.
4. 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.

1. Boilers
2. VFD's
3. Ductless splits
4. Demand control ventilation

1.04 DEFINITIONS

A. "Furnish": Supply and deliver to Project site, ready for unloading, unpacking, assembly, installation, and similar operations.

B. "Provide": Furnish and install, complete and ready for the intended use.

C. "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.

D. 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.

E. Exposed, Interior Installations: Exposed to view indoors. Examples include finished occupied spaces and mechanical equipment rooms.

F. Exposed, Exterior Installations: Exposed to view outdoors or subject to outdoor ambient temperatures and weather conditions. Examples include rooftop locations.

G. Concealed, Interior Installations: Concealed from view and protected from physical contact by building occupants. Examples include above ceilings and in duct shafts.

H. 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.

I. Terminal: A point where the controlled medium, such as fluid or energy, enters or leaves the distribution system.

1.05 SUBMITTALS

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

1.06 SUBSTITUTIONS

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

1.07 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.

1.08 PRODUCT DELIVERY, STORAGE, AND HANDLING

A. Provide in accordance with Division 1.

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.

1.09 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. This contractor shall provide all access panels. Access door shall be a Acudor UF-5000 or approved equal. Fire-rated wall access panels shall have a UL - 1-1/2 hour "B" label. Access doors shall be universal flush access door for walls and ceilings; designed for installation in drywall, plaster, masonry, tile or any flush surface. The door panel shall feature rounded safety corners for an architecturally pleasing appearance. The one-piece trim flange shall not rack, sag or distort. A continuous concealed hinge shall not bind or corrode, allowing the door to operate freely. For easy installation, the mounting frame shall be 1-1/4" deep, giving maximum clearance behind the doorframe. Set frames accurately in position and attach securely to supports with plane of face panels aligned with adjacent finish surfaces. Provide doors flush with adjacent finish surfaces or recessed to receive finish material.

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 Contractor 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.

PART 2 - PRODUCT

2.01 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.

2.02 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, BAg1, 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.

2.03 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.

2.04 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.

2.05 SLEEVES

A. Cast-Iron Wall Pipes: Cast or fabricated of cast or ductile iron and equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop unless otherwise indicated.

B. Galvanized-Steel Wall Pipes: ASTM A 53/A 53M, Schedule 40, with plain ends and welded steel collar; zinc coated.

C. Galvanized-Steel-Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, zinc coated, with plain ends.

D. Galvanized-Steel-Sheet Sleeves: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint.

E. Molded-PE or -PP Sleeves: Removable, tapered-cup shaped, and smooth outer surface with nailing flange for attaching to wooden forms.

F. Mechanical Sleeve Seals: 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.

2.06 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.

2.07 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.

2.08 ROOFING

A. Coordinate roofing with Division 7.

2.09 VIBRATION ISOLATION

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

PART 3 - EXECUTION

3.01 COMMON REQUIREMENTS

A. Provide piping, ductwork, and equipment to allow maximum possible headroom unless specific mounting heights are indicated. Provide equipment level and plumb, parallel and perpendicular to other building systems and components in exposed interior spaces, unless otherwise indicated.

B. Provide 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.

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. Provide piping and ductwork in concealed locations, unless otherwise indicated and except in equipment rooms and service areas.

F. Provide 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. Provide systems above accessible ceilings to allow sufficient space for ceiling panel removal.

H. Provide piping to permit valve servicing.

I. Provide equipment and other components to allow right of way for piping installed at required slope.

J. Provide free of sags and bends.

K. Provide unions or flanges at connections to equipment.

L. Provide 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.

3.02 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. Provide 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.

3.03 PIPE PENETRATIONS & SLEEVES

A. Provide sealants for all pipe penetrations. All pipe penetrations shall be sealed.

B. Refer to Section 23 07 00 “Mechanical Insulation”.

C. Sleeve Clearance: Sleeve through floors, walls, partitions, and beams 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. Provide sleeves for pipes passing through concrete and masonry construction. Galvanized-Steel Sheet: 0.0239-inch minimum thickness; round tube closed with welded longitudinal joint. Cut sleeves to length for mounting flush with both surfaces. Provide sleeves in new walls and slabs as new walls and slabs are constructed. Provide steel pipe sleeves that are large enough to provide 1/4-inch annular clear space between sleeve and pipe or pipe insulation. Piping through concrete or masonry shall not be subject to any load from the building construction.

1. Sleeves are not required in drywall construction.
2. Sleeves are not required for core-drilled holes.

E. Fire-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials. Comply with requirements for firestopping specified in Division 7.

F. Exterior- Pipe Penetrations:

1. Provide sleeve-seal systems in sleeves 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.

G. Escutcheons: Provide for penetrations in finished spaces where pipes are exposed. Install escutcheons with ID to closely fit around pipe, tube, and insulation of piping and with OD that completely covers opening.

H. 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.

3.04 PIPING CONNECTIONS

A. Make connections according to the following, unless otherwise indicated: Provide unions, in piping NPS 2 and smaller, adjacent to each valve and at final connection to each piece of equipment. Provide flanges in piping NPS 2-1/2 and larger, adjacent to valves and at final connection to each piece of equipment.

B. Provide dielectric fittings at connection between copper and ferrous metal.

C. Swing Connections for Expansion: Connect risers and branch connections to mains with at least five pipe fittings, including tee in main. Connect mains and branch connections to terminal units with at least four pipe fittings, including tee in main.

3.05 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. Provide fasteners without splitting wood members.

C. Attach to substrates as required to support applied loads.

3.06 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.

3.07 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.

3.08 FIRESTOPPING

A. Provide through-penetration firestop systems. Refer to Division 7 for materials. Seal penetrations through fire-or smoke-rated wall, partition, ceiling, or roof assemblies with firestopping systems. Refer to Architectural plans for location of rated assemblies.

3.09 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.

3.10 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 equipment manufacturer to ensure adequate space, embedment and prevent edge breakout failures.

C. Construct concrete bases not less than 4 inches larger in both directions than supported unit.

D. Housekeeping Pads must be adequately reinforced and adequately sized for proper installation of equipment anchors. [Refer to seismic restraint manufacturer's written instructions.]

E. Provide 4" high (+/-) housekeeping pads for the following:

1. Boilers
2. DHW Heaters
3. Base Mounted Pumps
4. Glycol Feed System
5. Expansion Tanks
6. Water to water heat pumps
7. As noted on plans
8. As recommended by Equipment manufacturer.

F. Exterior Pads: Provided by site contractor; coordinate size.

3.11 ROOFING

A. Refer to Division 7.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

3.12 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. In addition, provide the following.

1. An O&M manual describing basic data relating to the operation and maintenance of systems and equipment as installed.
2. HVAC control information consisting of diagrams, schedules, control sequence narratives, and maintenance and/or calibration information.
3. TAB report
4. Construction drawings of record, control drawings and final design drawings.

END OF SECTION

SECTION 23 05 16

BRAIDED EXPANSION LOOPS AND FITTINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Division 23 Section “Common Work Results for Mechanical”

1.02 SUMMARY

A. This Section includes braided pipe expansion loops.

1.03 PERFORMANCE REQUIREMENTS

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

1.04 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.

C. Delegated-Design Submittal: For each anchor and alignment guide 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 requirements for thermal expansion of piping systems and for selecting and designing expansion joints, loops, and swing connections.
2. Anchor Details: Detail fabrication of each anchor indicated. Show dimensions and methods of assembly and attachment to building structure.
3. Alignment Guide Details: Detail field assembly and attachment to building structure.
4. Schedule: Indicate type, manufacturer's number, size, material, pressure rating, end connections, and location for each expansion joint.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Metraflex Co.
2. Flex Hose Co., Inc.
3. Flexicraft

2.02 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.

B. Corrugated Hose: Stainless Steel: Type 304; Bronze (copper pipe runs). Braid: 304 Stainless Steel braid shall be used for any series 300 stainless steel hose; Bronze braid shall be used for any bronze hose.

C. Loops shall be NSF-372 lead free certified.

D. Flexible loops shall have a factory supplied, center support nut located at the bottom of the 180° return, and a drain/air release plug.

E. 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.

F. Materials of construction and end fitting type shall be consistent with pipe material and equipment/ pipe connection fittings.

G. Flexible hose expansion loops shall be furnished with a plugged FPT to be used for a drain or air release vent.

H. For tight pipe runs, provide nested loops.

I. Size for 4” end-to-end movement.

2.03 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.

2.04 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.

B. Provide a guide be used on each side of the Metraloop if any of the hanger rods deflect 4° or more due to the pipe movement.

2.05 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

3.01 BRAIDED EXPANSION LOOP INSTALLATION

A. Provide and guide per manufacturers' installation instructions and Mechanical Contractors Association of America "Guidelines for Quality Piping Installations".

B. Flexible hose expansion loop return fitting shall be supported to allow movement.

C. Inspect joint for shipping damage, insure that the shipping bar is intact.

D. During installation, make sure that the sections of flexible hose and braid are protected from damage and overextension. Weld splatter must be kept away from the flexible legs.

E. Nesting Clearance. Often several Metraloops are nested inside of each other, when this is the case the installer shall verify that there is enough clearance between the Metraloops after insulation to allow for the full expected movement.

F. Provide expansion fittings in sizes matching pipe size in which they are installed.

G. Align expansion fittings to avoid end-loading and torsional stress.

H. Loops can be installed in a neutral, pre-compressed or pre-extended condition as required for the application.

I. Provide 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.

3.02 ALIGNMENT-GUIDE AND ANCHOR INSTALLATION

A. 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.

B. Provide 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.

C. Anchor Attachments:

1. Anchor Attachment to Steel Pipe: Attach by welding. Comply with ASME B31.9 and ASME Boiler and Pressure Vessel Code: Section IX, "Welding and Brazing Qualifications."
2. Anchor Attachment to Copper Tubing: Attach with pipe hangers. Use MSS SP-69, Type 24, U-bolts bolted to anchor.

D. Fabricate and install steel anchors by welding steel shapes, plates, and bars. Comply with ASME B31.9 and AWS D1.1/D1.1M.

E. Provide grout to form flat bearing surfaces for guides and anchors attached to concrete.

END OF SECTION

SECTION 23 05 19

THERMOMETERS AND PRESSURE GAUGES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

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.

1.02 SUMMARY

A. This Section includes thermometers and pressure gauges.

1.03 ACTION SUBMITTALS

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

1.04 CLOSEOUT SUBMITTALS

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

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Ashcroft
2. Weksler
3. Ernst Gauge Co.
4. Trerice: H. O. Trerice Co.
5. Weiss Instruments, Inc.

2.02 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. Geothermal Water: 0 to 100°F, with 1°F scale divisions.
4. Chilled Water: 0 to 100°F, with 1°F scale divisions.
5. Heating Hot Water: 30 to 180°F, with 2°F scale divisions.
6. Heating/cooling changeover: 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.

2.03 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. Provide 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. HVAC Water: 0 to 60 psi

2.04 TEST PLUGS

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

1. Flow Design, Inc.
2. Peterson Equipment Co., Inc.
3. Trerice, H. O. Co.
4. Watts Regulator Co.; a div. of Watts Water Technologies, Inc.
5. Weiss Instruments, Inc.

B. Description: Test-station fitting made for insertion into piping tee fitting.

C. Body: Brass or stainless steel with core inserts and gasketed and threaded cap. Include extended stem on units to be installed in insulated piping.

D. Thread Size: NPS 1/4 or NPS 1/2, ASME B1.20.1 pipe thread.

E. Minimum Pressure and Temperature Rating: 500 psig at 200 deg F.

F. Core Inserts: Chlorosulfonated polyethylene synthetic and EPDM self-sealing rubber.

PART 3 - EXECUTION

3.01 INSTALLATION

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

B. Provide thermometers and adjust vertical and tilted positions. Provide thermowells with extension on insulated piping. Provide separable sockets in vertical position in piping tees.

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

3.02 CONNECTIONS

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

3.03 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

SECTION 22 05 29

HANGERS AND SUPPORTS FOR PIPING AND EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 23 Section "Common Work Results for Mechanical"
2. Division 23 Section “Mechanical Insulation”

1.02 SUMMARY

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

1.03 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.

1.04 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

2.01 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

2.02 PIPE HANGERS AND SUPPORTS

A. Conform to Manufacturers Standardization Society ANSI/MSS SP-69 & SP-58 – Types indicated below.

B. Hangers:

1. Uninsulated pipes 2 inch and smaller:

   a. Adjustable steel swivel ring (band type) hanger, Type 10, B-Line B3170.
   b. Adjustable steel swivel J-hanger, Type 5, B-Line B3690.
   c. Malleable iron ring hanger, Type 12, B-Line B3198R or hinged ring hanger, B3198H.
   d. Adjustable steel clevis hanger, Type 1, B-Line B3100.

2. Uninsulated pipes 2-1/2 inch and larger:

   a. Adjustable steel clevis hanger, Type 1, B-Line B3100.
   b. Pipe roll with sockets, Type 41, B-Line B3114.

c. Adjustable steel yoke pipe roll, Type 43, B-Line B3110.

3. Insulated pipe- Hot piping:

a. 2 inch and smaller pipes: use adjustable steel clevis with galvanized sheet metal shield. Type 1, B-Line B3100 with Type 40, B-Line B3151 series insulation protection shield.
b. 2-1/2 inch and larger pipes: Type 41 or Type 43 with Type 39A/39B, B3160-B3165 series pipe covering protection saddle.

4. Insulated pipe – Cold, change-over, or chilled water piping:

a. 5 inch and smaller pipes: use adjustable steel clevis with galvanized sheet metal shield. Type 1, B-Line B3100 with Type 40, B-Line B3151 series insulation protection shield.
b. 6 inch and larger pipes: Type 41 or Type 43 with Type 39A/39B, B3160-B3165 series pipe covering protection saddle.

C. Pipe Clamps: When flexibility in the hanger assembly is required due to horizontal movement, use pipe clamps with weldless eye nuts, Type 4, B-Line B3140. For insulated lines use double bolted pipe clamps, Type 3, B-Line B3144.

D. 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: Strut mounted roller support, B-Line B3126. Use pipe protection shield or saddles on insulated lines. Strut mounted pipe guide, B-Line B2417.

E. Wall Supports

1. Pipes 4 inch and smaller: Carbon steel J-hanger, B-Line B3690.
2. Pipes larger than 4 inch: Welded strut bracket and pipe straps, Type 31 light welded steel bracket, B-Line B3064. Provide Type 32 or Type 33 for heavier loads.

F. Floor Supports

1. 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. Type 38 adjustable pipe saddle, B-Line B3093 and B3088T base stand; or Type 39, B3090 and B3088 base stand. Pipe saddle shall be screwed or welded to appropriate base stand.
2. Hot piping 6 inch and larger: Adjustable Roller stand with base plate, Type 46, B3118SL. Adjustable roller support and steel support sized for elevation, B-Line B3124.

G. Vertical Supports: Steel riser clamp sized to fit OD of pipe, Type 8, B-Line B3373.

H. Copper Tubing Supports

1. Hangers shall be sized to fit copper tubing outside diameters.

a. Adjustable steel swivel ring (band type) hanger, Type 10, B-Line B3170CT.

b. Malleable iron ring hanger, Type 12, B-Line B3198RCT or hinged ring hanger B3198HCT.
c. Adjustable steel clevis hanger, Type 1, 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.

I. Plastic Pipe Supports: V-Bottom clevis hanger with galvanized 18-gauge continuous support channel, Type 1, B-Line B3106 and B3106V plastic pipe support channel, to form a continuous support system for plastic pipe or flexible tubing.

J. 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.

K. Sagging or snaking of exposed plastic piping such as PEX or Aquatherm piping is not acceptable. For 1-1/2" or smaller pipes, Provide Walraven BISMAT 5000, or equal: hangers and pipe to extend pipe hanging distance and prohibit "snaking".

2.03 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, Type 23, B-Line B351L. Refer to manufacturer's recommendation for setscrew torque. Retaining straps shall be used to maintain the clamps position on the beam where required.

B. Concrete Inserts

1. Cast in place spot concrete inserts shall be used where applicable; either steel or malleable iron body, Type 18, 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.

2.04 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.

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.

2.05 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.

2.06 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.

2.07 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.

2.08 PIPE STANDS

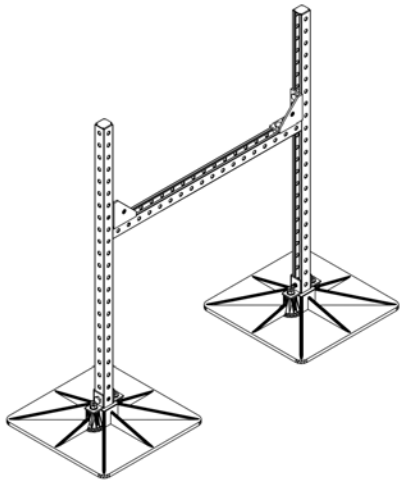
A. General Requirements for Pipe Stands: Shop- or field-fabricated assemblies made of manufactured corrosion-resistant components to support roof-mounted piping.

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. Chiller Piping - Exterior:

1. Description: Assembly of base, vertical and horizontal members, and pipe support, for roof installation without membrane penetration. PHP Model PSL, or approved equal.
2. The supports shall be designed for installation without roof penetrations, flashing or damage to the roofing material.
3. Bases Injection molded high density/high impact polypropylene with UV-inhibitors and Antioxidants
4. Members: Hot Dip Galvanized per ASTM A 123
5. Nuts and Washers: Hot Dip Galvanized or 304 Stainless Steel



PART 3 - EXECUTION

3.01 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: 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. 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: Provide per manufactures recommendations and calculations. Pipe Stand Types except Curb-Mounted Type: Assemble components and mount on smooth roof surface. Do not penetrate roof membrane. 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. Piping shall be supported in such a manner as to maintain its alignment and prevent sagging.

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.

3.02 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.

3.03 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. Use materials and methods that minimize distortion and develop strength and corrosion resistance of base metals. Obtain fusion without undercut or overlap. Remove welding flux immediately. Finish welds at exposed connections so no roughness shows after finishing and so contours of welded surfaces match adjacent contours.

3.04 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.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces. 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.

3.06 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.

3.07 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 ¾ 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.

C. Provide hangers for drawn-temper copper piping with the following maximum horizontal spacing and minimum rod sizes:

1. NPS ½ and 3/4: Maximum span, 5 feet; minimum rod size, 3/8 inch.
2. NPS 1 to 1-1/2": Maximum span, 6 feet; minimum rod size, 3/8 inch.
3. NPS 2: Maximum span, 9 feet; minimum rod size, 1/2 inch.
4. NPS 2-1/2: Maximum span, 9 feet; minimum rod size, 1/2 inch.
5. NPS 3: Maximum span, 10 feet; minimum rod size, 1/2 inch.
6. NPS 4: Maximum span, 10 feet; minimum rod size, 1/2 inch.
7. 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. Hangers shall be placed next to the pipe joint not more than 18" from the point joint.

5. Maximum horizontal spacing and minimum rod diameters (pipe temperature 100°F or lower).

   a. Solvent cemented PVC

      1) NPS 1 and smaller: 48” with 3/8-inch rod.
      2) NPS 1-1/4 to NPS 3: 48” with 3/8-inch rod.
      3) NPS 3: 48” with 1/2-inch rod.
      4) NPS 4: 48” with 5/8-inch rod.
      5) NPS 6 and 8: 48” with 3/4-inch rod.

   b. Solvent cemented CPVC

      1) NPS 1 and smaller: 36” with 3/8-inch rod.
      2) NPS 1-1/4 to NPS 3: 48” with 3/8-inch rod.
      3) NPS 3: 48” with 1/2-inch rod.
      4) NPS 4: 48” with 5/8-inch rod.
      5) NPS 6 and 8: 48” with 3/4-inch rod.

   c. PEX or PP

      1) NPS 1 and smaller: 32” with 3/8-inch rod.
      2) NPS 1-1/4 to NPS 3: 48” with 3/8-inch rod.
      3) NPS 3: 48” with 1/2-inch rod.

6. Provide supports for vertical piping every 10 feet.

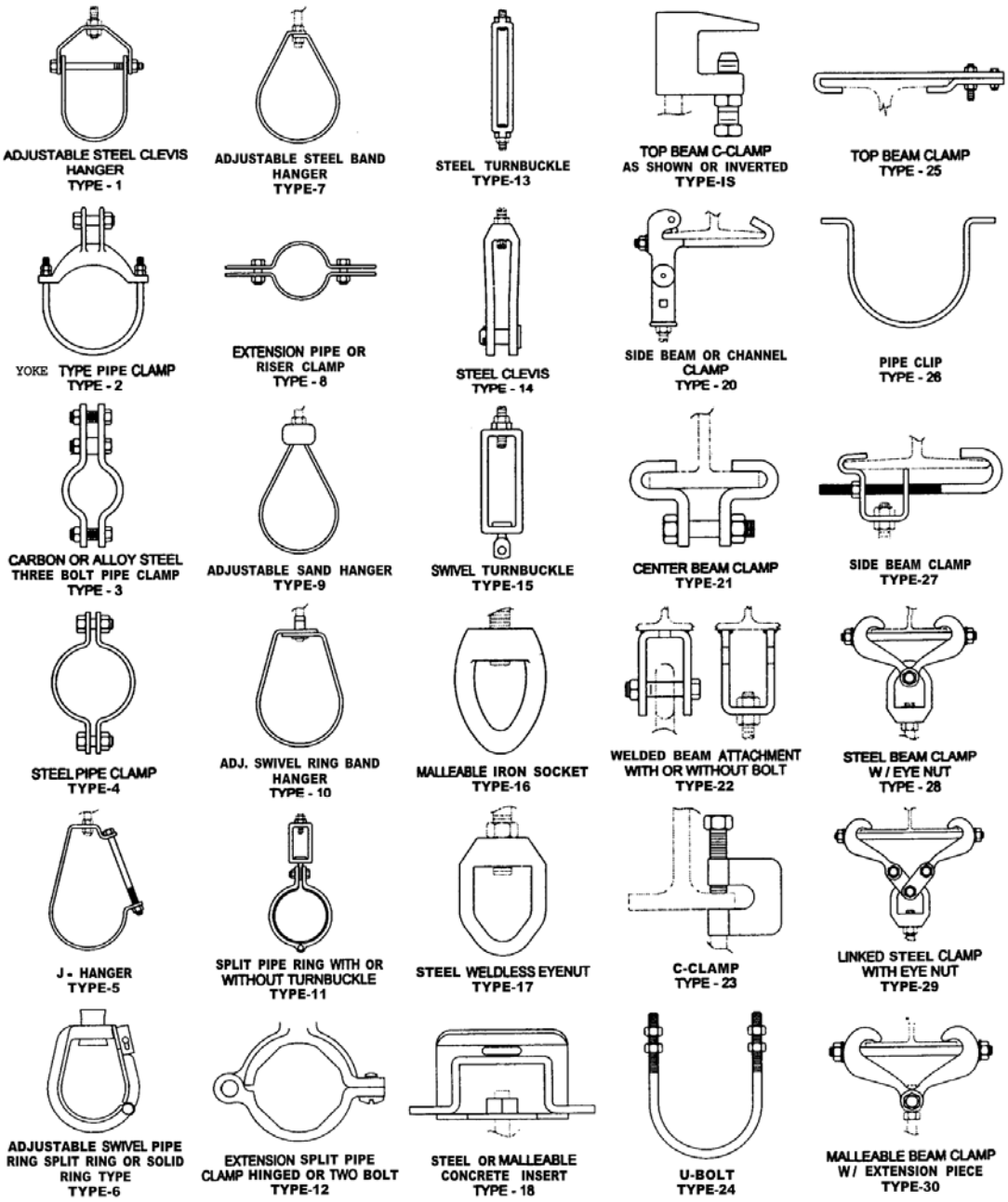
E. Support vertical piping independently of connected horizontal piping. Support vertical pipes at base and at every floor. Wherever possible, locate riser clamps directly below pipe couplings or shear lugs.

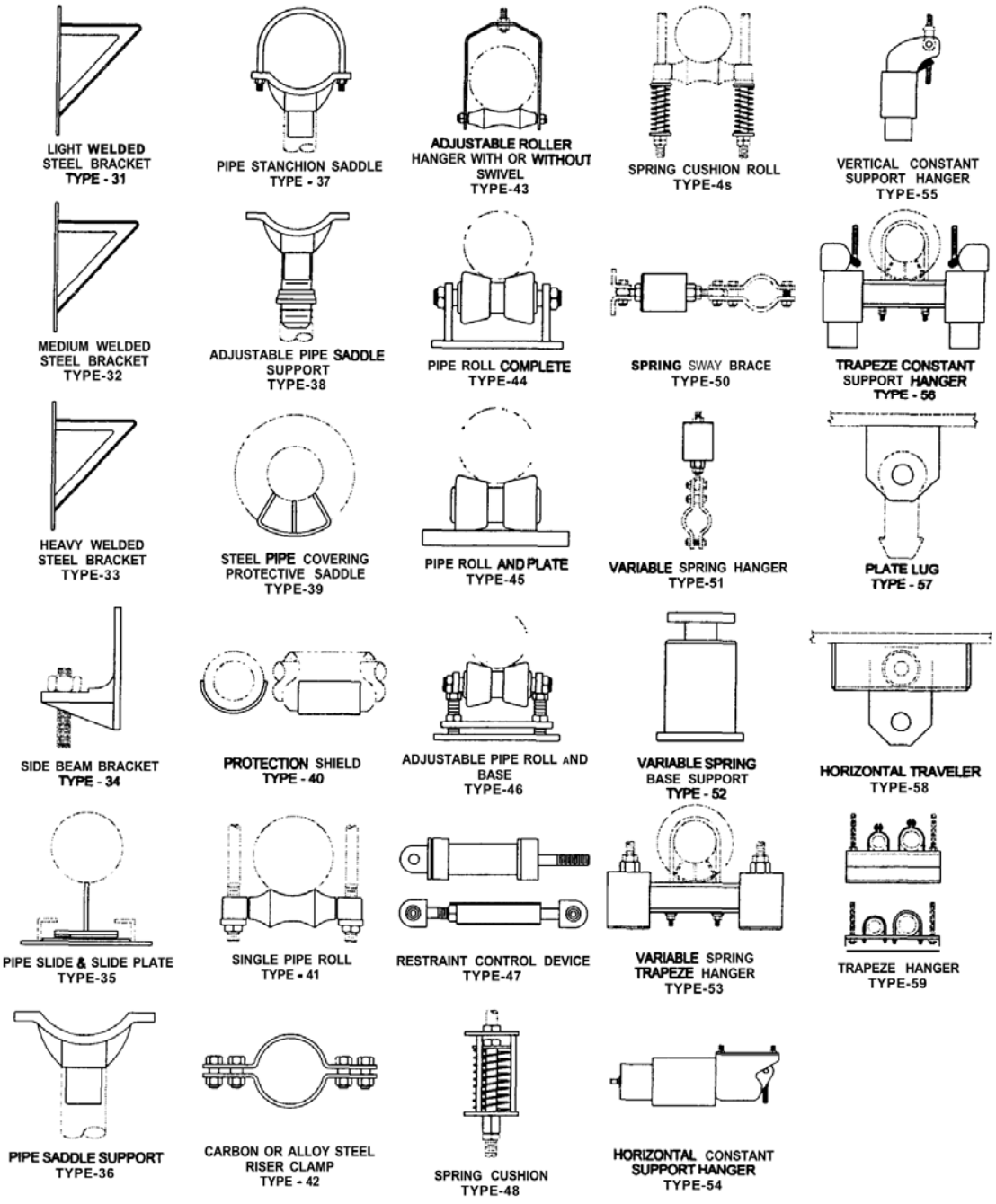
F. Place a hanger within 12 inches of each horizontal elbow.

G. Horizontal pipe isolation:

1. The first four pipe hangers in the main lines near chillers or water-to-water heat pumps shall be Mason Type PC30N, or approved equal. Brace hanger rods with SRC clamps.
2. Floor supported piping shall rest on Type SLR isolators.
3. Hanger locations that also have seismic restraints attached must have type RW Rebound Washers to limit uplift.
4. Where piping connects to mechanical equipment install expansion joints stainless hoses if expansion joints are not suitable for the service.
5. Adjust active height of spring isolators. Adjust isolators after piping systems have been filled and equipment is at operating weight. 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.

3.08 MSS SP-69 REFERENCE





END OF SECTION

SECTION 23 05 53

IDENTIFICATION FOR MECHANICAL

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Division 23 Section "Common Work Results for Mechanical”

1.02 SUMMARY

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

1.03 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.]

1.04 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.

1.05 COORDINATION

A. Coordinate installation of identifying devices with completion of covering and painting of surfaces where devices are to be applied.

B. Coordinate installation of identifying devices with location of access panels and doors.

C. Provide identifying devices before installing acoustical ceilings and similar concealment.

PART 2 - PRODUCTS

2.01 EQUIPMENT IDENTIFICATION DEVICES

A. Terminology: Match schedules as closely as possible.

B. Tag and description: Example: “EF-1 - Bathroom Exhaust”

C. Equipment Markers: Custom Vinyl Decals with a clear polyester overlaminate to endure outdoor conditions and are UV and scuff resistant. Decals shall be made of flexible vinyl with a permanent pressure-sensitive adhesive backing suitable for curved surfaces. Service temperature range of -40°F to 176°F.

D. In addition to the equipment tag, equipment located above the ceiling that requires servicing shall be labeled on the ceiling grid using a labeling machine.

2.02 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 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.

2.03 DUCT IDENTIFICATION DEVICES

A. Duct Markers: Engraved, color-coded laminated plastic. Include direction and quantity of airflow and duct service (such as supply, return, and exhaust). Include contact-type, permanent adhesive.

2.04 WARNING TAGS

A. Warning Tags: Preprinted or partially preprinted, accident-prevention tags; of plasticized card stock with matte finish suitable for writing.

1. Size: 3 by 5-1/4 inches minimum.
2. Fasteners: Brass grommet and wire.
3. Nomenclature: Large-size primary caption such as DANGER, CAUTION, or DO NOT OPERATE.
4. Color: Yellow background with black lettering.

PART 3 - EXECUTION

3.01 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.

3.02 EQUIPMENT IDENTIFICATION

A. Provide equipment markers on each item of scheduled 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.

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.

C. GAS monitor/transmitters: shall have engraved tag mounted to device showing “Installed xx/xx/xx (date)” and “Replacement xx/xx/xx (date)”. The replacement date shall be specific for the gas being monitored.

3.03 PIPING IDENTIFICATION

A. Provide manufactured pipe markers indicating service on each piping system.

1. Provide pipe markers to manufacturer's instructions.
2. Identify piping, concealed or exposed. Include service and flow direction.
3. Provide 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 and similar access points that permit view of concealed piping.
6. At least one per room.

B. 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.

3.04 WARNING-TAG INSTALLATION

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

3.05 ADJUSTING

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

3.06 CLEANING

A. Clean faces of mechanical identification devices.

END OF SECTION

SECTION 23 05 93

TESTING, ADJUSTING, AND BALANCING FOR HVAC

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes Testing, Adjusting, & Balancing

1.03 ACTION SUBMITTALS

A. Use standard forms from AABC's "National Standards for Testing and Balancing Heating, Ventilating, and Air Conditioning Systems." NEBB's "Procedural Standards for Testing, Adjusting, and Balancing of Environmental Systems." SMACNA's TABB "HVAC Systems - Testing, Adjusting, and Balancing." TAB firm's forms approved by Architect. TABB "Contractors Certification Manual."

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: Within 30 days of Contractor's Notice to Proceed, submit documentation that the TAB specialist and this Project's TAB team members meet the qualifications specified in "Quality Assurance" Article.

1.05 QUALITY ASSURANCE

A. Instrumentation Type, Quantity, Accuracy, and Calibration: Comply with requirements in ASHRAE 111, Section 4, "Instrumentation."

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 7.2.2 - "Air Balancing."

C. ASHRAE/IESNA Compliance: Applicable requirements in ASHRAE/IESNA 90.1, Section 6.7.2.3 - "System Balancing."

PART 2 - PRODUCTS (Not Applicable)

PART 3 - EXECUTION

3.01 EXAMINATION

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

B. Examine installed systems for balancing devices, such as test ports, gage cocks, thermometer wells, flow-control devices, balancing valves and fittings, and manual volume dampers. Verify that locations of these balancing devices are applicable for intended purpose and are accessible.

C. Examine the approved submittals for HVAC systems and equipment.

D. Examine design data including HVAC system descriptions, statements of design assumptions for environmental conditions and systems output, and statements of philosophies and assumptions about HVAC system and equipment controls.

E. Examine equipment performance data. Relate performance data to Project conditions and requirements, including system effects that can create undesired or unpredicted conditions that cause reduced capacities in all or part of a system. Calculate system-effect factors to reduce performance ratings of HVAC equipment when installed under conditions different from the conditions used to rate equipment performance.

F. Examine system and equipment installations and verify that field quality-control testing, cleaning, and adjusting specified in individual Sections have been performed.

G. Examine test reports specified in individual system and equipment Sections.

H. Examine HVAC equipment and verify that equipment is installed per manufacturer's recommendations with functioning controls and ready for operation.

I. Hydronic Systems: Examine strainers. Verify that startup screens have been replaced by permanent screens with indicated perforations. Examine control valves for proper installation for their intended function of throttling, diverting, or mixing fluid flows. Examine heat-transfer coils for correct piping connections and for clean and straight fins. Examine system pumps to ensure absence of entrained air in the suction piping.

J. Examine operating safety interlocks and controls on HVAC equipment.

K. Report deficiencies discovered before and during performance of TAB procedures. Observe and record system reactions to changes in conditions. Record default set points if different from indicated values.

3.02 PREPARATION

A. Prepare a TAB plan that includes the following:

1. Equipment and systems to be tested.
2. Strategies and step-by-step procedures for balancing the systems.

3. Instrumentation to be used.
4. Sample forms with specific identification for all equipment.

B. Perform system-readiness checks of HVAC systems and equipment to verify system readiness for TAB work. Include, at a minimum, the following:

1. Airside:

a. Verify that leakage and pressure tests on air distribution systems have been satisfactorily completed.
b. Duct systems are complete with terminals installed.
c. Dampers are open and functional.
d. Clean filters are installed.
e. Fans are operating, free of vibration, and rotating in correct direction.
f. Variable-frequency controllers' startup is complete and safeties are verified.
g. Automatic temperature-control systems are operational.
h. Ceilings are installed.
i. Windows and doors are installed.
j. Suitable access to balancing devices and equipment is provided.

2. Hydronics:

a. Verify leakage and pressure tests on water distribution systems have been satisfactorily completed.
b. Piping is complete with terminals installed.
c. Water treatment is complete.
d. Systems are flushed, filled, and air purged.
e. Strainers are pulled and cleaned.
f. Control valves are functioning per the sequence of operation.
g. Shutoff and balance valves have been verified to be 100 percent open.
h. Pumps are started and proper rotation is verified.
i. Pump gage connections are installed directly at pump inlet and outlet flanges or in discharge and suction pipe prior to valves or strainers.
j. Variable-frequency controllers' startup is complete and safeties are verified.
k. Suitable access to balancing devices and equipment is provided.

3.03 GENERAL PROCEDURES FOR TESTING AND BALANCING

A. Perform testing and balancing procedures on each system according to the procedures contained in AABC's "National Standards for Total System Balance", ASHRAE 111 or SMACNA's "HVAC Systems - Testing, Adjusting, and Balancing" and in this Section.

B. Cut insulation, ducts, pipes, and equipment cabinets for installation of test probes to the minimum extent necessary for TAB procedures. After testing and balancing, patch probe holes in ducts with same material and thickness as used to construct ducts. Install and join new insulation that matches removed materials. Restore insulation, coverings, vapor barrier, and finish according to the mechanical insulation specification.

C. Mark equipment and balancing devices, including damper-control positions, valve position indicators, VFD’s, and similar controls and devices, with paint or other suitable, permanent identification material to show final settings.

D. Take and report testing and balancing measurements in inch-pound (IP) units.

3.04 GENERAL PROCEDURES FOR BALANCING AIR SYSTEMS

A. Prepare test reports for both fans and outlets. Obtain manufacturer's outlet factors and recommended testing procedures. Cross-check the summation of required outlet volumes with required fan volumes.

B. Prepare schematic diagrams of systems' "as-built" duct layouts.

C. For variable-air-volume systems, develop a plan to simulate diversity.

D. Determine the best locations in main and branch ducts for accurate duct-airflow measurements.

E. Locate start-stop and disconnect switches, electrical interlocks, VFD's, and motor starters. Verify that motor starters are equipped with properly sized thermal protection.

F. Check dampers for proper position to achieve desired airflow path.

G. Check for airflow blockages.

H. Check condensate drains for proper connections and functioning.

I. Check for proper sealing of air-handling-unit components. Verify that air duct system is sealed as specified in the ductwork specification.

3.05 PROCEDURES FOR CONSTANT-VOLUME AIR SYSTEMS

A. Adjust fans to deliver total indicated airflows within the maximum allowable fan speed listed by fan manufacturer.

1. Measure total airflow.

    a. Set for proper position that simulates minimum outdoor-air conditions.
    b. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    c. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    d. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

2. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report artificial loading of filters at the time static pressures are measured.

3. Review Record Documents to determine variations in design static pressures versus actual static pressures. Calculate actual system-effect factors. Recommend adjustments to accommodate actual conditions.
4. Do not make fan-speed adjustments that result in motor overload. Consult equipment manufacturers about fan-speed safety factors. Modulate dampers and measure fan-motor amperage to ensure that no overload occurs. Measure amperage all operating modes to determine the maximum required brake horsepower.

B. Adjust volume dampers for main duct, submain ducts, and major branch ducts to indicated airflows.

1. Measure airflow of submain and branch ducts.
2. Adjust submain and branch duct volume dampers for specified airflow.
3. Re-measure each submain and branch duct after all have been adjusted.

C. Adjust air inlets and outlets for each space to indicated airflows.

1. Set airflow patterns of adjustable outlets for proper distribution without drafts.
2. Measure inlets and outlets airflow.
3. Adjust each inlet and outlet for specified airflow.
4. Re-measure each inlet and outlet after they have been adjusted.

D. Verify final system conditions.

1. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to design if necessary.
2. Re-measure and confirm that total airflow is within design.
3. Re-measure all final fan operating data, rpms, volts, amps, and static profile.
4. Mark all final settings.
5. Test system in economizer mode. Verify proper operation and adjust if necessary.
6. Measure and record all operating data.
7. Record final fan-performance data.

3.06 PROCEDURES FOR VARIABLE-AIR-VOLUME SYSTEMS

A. Adjust the variable-air-volume systems as follows:

1. Verify that the system static pressure sensor is located two-thirds of the distance down the duct from the fan discharge.
2. Verify that the system is under static pressure control.
3. Select the terminal unit that is most critical to the supply-fan airflow. Measure inlet static pressure, and adjust system static pressure control set point so the entering static pressure for the critical terminal unit is not less than the sum of the terminal-unit manufacturer's recommended minimum inlet static pressure plus the static pressure needed to overcome terminal-unit discharge system losses.
4. Calibrate and balance each terminal unit for maximum and minimum design airflow as follows:

    a. Adjust controls so that terminal is calling for maximum airflow. Some controllers require starting with minimum airflow. Verify calibration procedure for specific project.
    b. Measure airflow and adjust calibration factor as required for design maximum airflow. Record calibration factor.
    c. When maximum airflow is correct, balance the air outlets downstream from terminal units.
    d. Adjust controls so that terminal is calling for minimum airflow.
    e. Measure airflow and adjust calibration factor as required for design minimum airflow. Record calibration factor. If no minimum calibration is available, note any deviation from design airflow.

5. After terminals have been calibrated and balanced, test and adjust system for total airflow. Adjust fans to deliver total design airflows within the maximum allowable fan speed listed by fan manufacturer.

    a. Set dampers for proper position that simulates minimum outdoor-air conditions.
    b. Set terminals for maximum airflow. If system design includes diversity, adjust terminals for maximum and minimum airflow so that connected total matches fan selection and simulates actual load in the building.
    c. Where duct conditions allow, measure airflow by Pitot-tube traverse. If necessary, perform multiple Pitot-tube traverses to obtain total airflow.
    d. Where duct conditions are not suitable for Pitot-tube traverse measurements, a coil traverse may be acceptable.
    e. If a reliable Pitot-tube traverse or coil traverse is not possible, measure airflow at terminals and calculate the total airflow.

6. Measure fan static pressures as follows:

    a. Measure static pressure directly at the fan outlet or through the flexible connection.
    b. Measure static pressure directly at the fan inlet or through the flexible connection.
    c. Measure static pressure across each component that makes up the air-handling system.
    d. Report any artificial loading of filters at the time static pressures are measured.

7. Set final return and outside airflow to the fan while operating at maximum return airflow and minimum outdoor airflow.

    a. Balance the return-air ducts and inlets the same as described for constant-volume air systems.
    b. Verify that terminal units are meeting design airflow under system maximum flow.

8. Re-measure the inlet static pressure at the most critical terminal unit and adjust the system static pressure set point to the most energy-efficient set point to maintain the optimum system static pressure. Record set point and give to controls contractor.
9. Verify final system conditions as follows:

    a. Re-measure and confirm that minimum outdoor, return, and relief airflows are within design. Readjust to match design if necessary.
    b. Re-measure and confirm that total airflow is within design.
    c. Re-measure final fan operating data, rpms, volts, amps, and static profile.
    d. Mark final settings.
10. Test system in economizer mode. Verify proper operation and adjust if necessary. Measure and record all operating data. Verify the minimum OA setpoint by measuring the temperature of the mixed air, return air, and OA to calculate the % of OA.

3.07 GENERAL PROCEDURES FOR HYDRONIC SYSTEMS

A. Prepare test reports for pumps, coils, and heat exchangers. Obtain approved submittals and manufacturer-recommended testing procedures. Crosscheck the summation of required coil and heat exchanger flow rates with pump design flow rate.

B. Prepare schematic diagrams of systems' "as-built" piping layouts.

C. In addition to requirements in "Preparation" Article, prepare hydronic systems for testing and balancing as follows:

1. Check liquid level in expansion tank.
2. Check highest vent for adequate pressure.
3. Check flow-control valves for proper position.
4. Locate start-stop and disconnect switches, electrical interlocks, and motor starters.
5. Verify that motor starters are equipped with properly sized thermal protection.
6. Check that air has been purged from the system.

D. Measure total water flow.

1. Position valves for full flow through coils.
2. Determine flow by pump TDH.

    a. Measure discharge pressure directly at the pump outlet flange or in discharge pipe prior to any valves.
    b. Measure inlet pressure directly at the pump inlet flange or in suction pipe prior to any valves or strainers.
    c. Convert pressure to head and correct for differences in gage heights.
    d. Verify pump impeller size by measuring the TDH with the discharge valve closed. Note the point on manufacturer's pump curve at zero flow, and verify that the pump has the intended impeller size.
    e. With valves open, read pump TDH. Adjust pump discharge valve until design water flow is achieved.

3. Monitor motor performance during procedures and do not operate motor in an overloaded condition.

E. Adjust flow-measuring devices installed in mains and branches to design water flows.

1. Measure flow in main and branch pipes.
2. Adjust main and branch balance valves for design flow.
3. Re-measure each main and branch after all have been adjusted.

F. Adjust flow-measuring devices installed at terminals for each space to design water flows.

1. Measure flow at terminals.
2. Adjust each terminal to design flow.
3. Re-measure each terminal after it is adjusted.
4. Position control valves to bypass the coil, and adjust the bypass valve to maintain design flow.
5. Perform temperature tests after flows have been balanced.

G. Verify final system conditions as follows:

1. Re-measure and confirm that total water flow is within design.
2. Re-measure final pumps' operating data, TDH, volts, amps, and static profile.
3. Mark final settings.
4. Verify that memory stops have been set.

3.08 PROCEDURES FOR CONSTANT-FLOW HYDRONIC SYSTEMS

A. Adjust pumps to deliver total design gpm.

3.09 PROCEDURES FOR VARIABLE-FLOW HYDRONIC SYSTEMS

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

B. Adjust the variable-flow hydronic system as follows:

1. Verify that the differential-pressure sensor is located as indicated.
2. Determine whether there is diversity in the system.

C. For systems with no diversity:

1. Adjust pumps to deliver total design gpm.
2. Prior to verifying final system conditions, determine the system differential-pressure set point.
3. If the pump discharge valve was used to set total system flow with variable-frequency controller at 60 Hz, at completion open discharge valve 100 percent and allow variable-frequency controller to control system differential-pressure set point. Record pump data under both conditions.

D. For systems with diversity:

1. Determine diversity factor.
2. Simulate system diversity by closing required number of control valves, as approved by the design engineer.

E. Procedures For Primary-Secondary Hydronic Systems

1. Balance the primary circuit flow first.
2. Balance the secondary circuits after the primary circuits are complete.

3.10 PROCEDURES FOR MOTORS

A. Motors 1/2 HP and Larger: Test at final balanced conditions and record the following data:

1. Manufacturer's name, model number, and serial number.
2. Motor horsepower rating.
3. Motor rpm.
4. Phase and hertz.
5. Nameplate and measured voltage, each phase.
6. Nameplate and measured amperage, each phase.
7. Starter size and thermal-protection-element rating.
8. Service factor and frame size.

B. Motors Driven by Variable-Frequency Controllers: Test manual bypass of controller to prove proper operation.

3.11 PROCEDURES FOR CHILLERS OR WATER-TO-WATER HEAT PUMPS

A. Balance water flow through each heat exchanger to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not

exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:

1. Heat exchanger water entering and leaving temperatures, pressure drop, and water flow.
2. Kilowatt input if factory-installed instrumentation is furnished for measuring kilowatts.
3. Verify condenser-fan rotation and record fan and motor data including number of fans and entering- and leaving-air temperatures.

3.12 PROCEDURES FOR BOILERS

A. Hydronic Boilers:

1. Measure and record entering- and leaving-water temperatures.
2. Measure and record water flow.
3. Record relief valve pressure setting.

3.13 PROCEDURES FOR HEAT-TRANSFER COILS

A. Measure, adjust, and record the following data for each water coil:

1. Entering- and leaving-water temperature.
2. Water flow rate.
3. Water pressure drop.
4. Airflow.

B. Measure, adjust, and record the following data for each electric heating coil:

1. Nameplate data.
2. Airflow.
3. Entering- and leaving-air temperature at full load.
4. Voltage and amperage input of each phase at full load.
5. Calculated kilowatt at full load.
6. Fuse or circuit-breaker rating for overload protection.

C. Measure, adjust, and record the following data for each steam coil:

1. Dry-bulb temperature of entering and leaving air.
2. Airflow.

D. Measure, adjust, and record the following data for each refrigerant coil:

1. Dry-bulb temperature of entering and leaving air.
2. Wet-bulb temperature of entering and leaving air.
3. Airflow.

3.14 DUCT LEAKAGE TESTS

A. Witness the duct pressure testing performed by Installer.

B. Verify that proper test methods are used and that leakage rates are within specified tolerances.

C. Report deficiencies observed.

3.15 CONTROLS VERIFICATION

A. In conjunction with system balancing, perform the following:

1. Verify temperature control system is operating within the design limitations.
2. Confirm that the sequences of operation are in compliance with Contract Documents.
3. Verify that controllers are calibrated and function as intended.
4. Verify that controller set points are as indicated.
5. Verify the operation of lockout or interlock systems.
6. Verify the operation of valve and damper actuators.
7. Verify that controlled devices are properly installed and connected to correct controller.
8. Verify that controlled devices travel freely and are in position indicated by controller: open, closed, or modulating.
9. Verify location and installation of sensors to ensure that they sense only intended temperature, humidity, or pressure.

B. Reporting: Include a summary of verifications performed, remaining deficiencies, and variations from indicated conditions.

3.16 PROCEDURES FOR DOMESTIC HOT WATER RECIRCULATION SYSTEMS

A. Prepare test reports with pertinent design data and number in sequence starting at pump to end of system.

B. System Diagrams: Include schematic layouts of as-built domestic hot water systems. Present each system with single-line diagram and include the following:

1. Water flow rates.
2. Pipe and valve sizes and locations.
3. Recirculation valve settings/flows

C. Balancing shall include the following minimum data:

1. Pump flow
2. Balancing valve flows: proportionally balance flow to each recirculation loop.

D. Pumps:

1. Adjust balancing valves at pumps to obtain design water flow. Record pressure rise across pumps and GPM flow from pump curve. Permanently mark the balanced position for each valve. (Note: If discharge valves on the pumps are used for balancing, record the head being restricted by the valves).
2. Do not deadhead the pumps. Check pump-motor load. If motor is overloaded, throttle main flow-balancing device so motor nameplate rating is not exceeded. Running amps and brake horsepower of pump motor under full flow and no flow conditions.
3. Calculate impeller size by plotting the shutoff head on pump curves and include the following pump test report data:
4. Unit Data:

    a. Unit identification.
    b. Location.
    c. Service.
    d. Make and size.
    e. Model and serial numbers.

f. Water flow rate in gpm.
g. Water pressure differential in feet of head or psig.
h. Pump rpm.
i. Impeller diameter in inches.
j. Seal type.
k. Motor Data: as specified herein before.

5. Test Data (Indicated and Actual Values):

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

3.17 PROCEDURES FOR EXHAUST HOODS

A. Commercial Kitchen Hoods

1. Measure, adjust, and record the airflow of each kitchen hood. For kitchen hoods designed with integral makeup air, measure and adjust the exhaust and makeup airflow. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, provide an explanation in the report of the reason(s) why and also the reason why the method used was chosen.
2. The sheet metal contractor will provide welded test ports with caps in the exhaust duct for the duct Pitot tube traverse. Coordinate required locations with the sheet metal contractor.
3. After balancing is complete, do the following:

a. Measure and record the static pressure at the hood exhaust-duct connection.
b. Measure and record the hood face velocity. Make measurements at multiple points across the face of the hood. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter. Calculate the average of the measurements recorded. Verify that the hood average face velocity complies with the Contract Documents and governing codes.
c. Check the hood for capture and containment of smoke using a smoke-emitting device. Observe the smoke pattern. Make adjustments to room airflow patterns to achieve optimum results.

4. Visually inspect the hood exhaust duct throughout its entire length in compliance with authorities having jurisdiction. Begin at the hood connection and end at the point it discharges outdoors. Report findings.

a. Check duct slopes as required.
b. Verify that duct access is installed as required.
c. Verify that point of termination is as required.
d. Verify that duct air velocity is within the range required.
e. Verify that duct is within a fire-rated enclosure.

5. Report deficiencies.

B. Procedures For Laboratory Fume Hoods

1. Follow hood manufacturer's recommendations.
2. Before performing laboratory fume hood testing, measure, adjust and record the supply airflow and airflow patterns of each supply air outlet that is located in the same room as the hood. Adjust the air outlet flow pattern to minimize turbulence and to achieve the desired airflow patterns at the face and inside the hood. Verify that adequate makeup air is available to achieve the indicated flow of the hood.
3. Measure, adjust, and record the airflow of each laboratory fume hood by duct Pitot-tube traverse with the laboratory fume hood sash in the design open position.
4. For laboratory fume hoods installed in variable exhaust systems, measure, adjust, and record the hood exhaust airflow at maximum and at minimum airflow conditions.
5. After balancing is complete, do the following:

    a. Measure and record the static pressure at the hood duct connection with the hood operating at indicated airflow.
    b. Measure and record the face velocity across the open sash face area. Measure the face velocity at each point in a grid pattern. Perform measurements at a maximum of 12 inches between points and between any point and the perimeter of the opening.

        1) For laboratory fume hoods designed to maintain a constant face velocity at varying sash positions, also measure and record the face velocity at 50 and 25 percent of the design open sash position.
        2) Calculate and report the average face velocity by averaging all velocity measurements.
        3) Calculate and report the exhaust airflow by multiplying the calculated average face velocity by the sash open area. Compare this quantity with the exhaust airflow measured by duct Pitot-tube traverse. Report differences.
        4) If the average face velocity is less than the indicated face velocity, retest the average face velocity and adjust hood baffles, fan drives, and other parts of the system to provide the indicated average face velocity.

    c. Check each laboratory fume hood for the capture and containment of smoke by using a hand-held emitting device. Observe the capture and containment of smoke flow pattern across the open face and inside the hood. Make adjustments necessary to achieve the desired results.

C. Procedures For Exhaust Capture Systems

1. Measure, adjust, and record the airflow of each exhaust hood and drop. Measure airflow by duct Pitot-tube traverse. If a duct Pitot-tube traverse is not possible, explain why, in the report, and explain the test method used.
2. Follow hood manufacturer's TAB recommendations.
3. After balancing is complete, measure and record the static pressure at the hood exhaust-duct connection. Check the hood for capture and containment of smoke using a smoke emitting device. Observe the smoke pattern. Make adjustments to achieve optimum results.

3.18 TOLERANCES

A. Set HVAC system's airflow rates and water flow rates within the following tolerances:

1. Fans: Plus or minus 10 percent.
2. Air Outlets and Inlets: Plus or minus 10 percent.
3. Water Flow Rate: Plus or minus 10 percent.

B. Maintaining pressure relationships as designed shall have priority over the tolerances specified above.

3.19 PROGRESS REPORTING

A. Initial Construction-Phase Report: Based on examination of the Contract Documents as specified in "Examination" Article, prepare a report on the adequacy of design for systems balancing devices. Recommend changes and additions to systems balancing devices to facilitate proper performance measuring and balancing. Recommend changes and additions to HVAC systems and general construction to allow access for performance measuring and balancing devices.

3.20 FINAL REPORT

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

1. Include a certification sheet at the front of the report's binder, signed and sealed by the certified testing and balancing engineer.
2. Include a list of instruments used for procedures, along with proof of calibration.
3. Certify validity and accuracy of field data.

B. Final Report Contents: In addition to certified field-report data, include the following:

1. Flow curves.
2. Manufacturers' test data.
3. Field test reports prepared by system and equipment installers.
4. Other information relative to equipment performance; do not include Shop Drawings and Product Data.

C. General Report Data: In addition to form titles and entries, include the following data:

1. Title page.
2. Name and address of the TAB specialist.
3. Project name.
4. Project location.
5. Architect's name and address.
6. Engineer's name and address.
7. Contractor's name and address.
8. Report date.
9. Signature of TAB supervisor who certifies the report.
10. Table of Contents with the total number of pages defined for each section of the report. Number each page in the report.

11. Summary of contents including the following:

    a. Indicated versus final performance.
    b. Notable characteristics of systems.
    c. Description of system operation sequence if it varies from the Contract Documents.

12. Nomenclature sheets for each item of equipment.
13. Data for terminal units, including manufacturer's name, type, size, and fittings.
14. Notes to explain why certain final data in the body of reports vary from indicated values.
15. Test conditions for fans and pump performance forms including the following:

    a. Settings for OA-RA-EA dampers.
    b. Conditions of filters.
    c. VFD settings for variable-air-volume systems.
    d. Settings for supply-air, static-pressure controller.
    e. Other system operating conditions that affect performance.

D. System Diagrams: Include schematic layouts of air and hydronic distribution systems. Present each system with single-line diagram and include the following:
   1. Flow rates.
   2. Duct, outlet, and inlet sizes.
   3. Pipe and valve sizes and locations.
   4. Terminal units.
   5. Balancing stations.
   6. Position of balancing devices.

E. Air-Handling-Unit Test Reports: For air-handling units with coils, include the following:

   1. Unit Data:

      a. Unit identification.
      b. Location.
      c. Make and type.
      d. Model number and unit size.
      e. Manufacturer's serial number.
      f. Unit arrangement and class.
      g. Discharge arrangement.
      h. Number, type, and size of filters.

   2. Motor Data:

      a. Motor make, and frame type and size.
      b. Horsepower and rpm.
      c. Volts, phase, and hertz.
      d. Full-load amperage and service factor.

   3. Test Data (Indicated and Actual Values):

      a. Total airflow rate in cfm.
      b. Total system static pressure in inches wg.
      c. Fan rpm.
      d. Discharge static pressure in inches wg.
      e. Filter static-pressure differential in inches wg.
      f. Coil static-pressure differential in inches wg.

g. Outdoor airflow in cfm.
h. Return airflow in cfm.
i. Outdoor-air damper position.
j. Return-air damper position.
k. VFD Hz.

F. Apparatus-Coil Test Reports:

1. Coil Data:

a. System identification.
b. Location.
c. Coil type.
d. Number of rows.
e. Fin spacing in fins per inch
f. Make and model number.
g. Face area in sq. ft.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Air pressure drop in inches wg.
c. Water flow rate in gpm.
d. Water pressure differential in feet of head or psig.
e. Entering-water temperature in deg F.
f. Leaving-water temperature in deg F.

G. Gas-Fired Heat Apparatus Test Reports: In addition to manufacturer's factory startup equipment reports, include the following:

1. Unit Data:

a. System identification.
b. Location.
c. Make and type.
d. Model number and unit size.
e. Manufacturer's serial number.
f. Fuel type in input data.
g. Output capacity in Btu/h.
h. Motor horsepower and rpm.
i. Motor volts, phase, and hertz.
j. Motor full-load amperage and service factor.
k. Sheave make, size in inches, and bore.

2. Test Data (Indicated and Actual Values):

a. Total airflow rate in cfm.
b. Entering-air temperature in deg F.
c. Leaving-air temperature in deg F.
d. Air temperature differential in deg F.
e. Entering-air static pressure in inches wg.
f. Leaving-air static pressure in inches wg.
g. Air static-pressure differential in inches wg.
h. Motor voltage at each connection.
i. Motor amperage for each phase.

H. Air-to-Air Energy-Recovery Unit Reports

1. Unit Data:

   a. Unit identification.
   b. Location.
   c. Service.
   d. Make and type.
   e. Model and serial numbers.

2. Motor Data: as specified herein before.
3. Test Data (Indicated and Actual Values):

   a. Total exhaust airflow rate in cfm.
   b. Outside airflow rate in cfm.
   c. Total exhaust fan static pressure in inches wg.
   d. Total outside-air fan static pressure in inches wg.
   e. Pressure drop on each side of heat exchanger in inches wg.
   f. Exhaust air temperature entering in deg F.
   g. Exhaust air temperature leaving in deg F.
   h. Outside-air temperature entering in deg F.
   i. Outside-air temperature leaving in deg F.

I. Fan Test Reports, include the following:

1. Fan Data:

   a. System identification.
   b. Location.
   c. Make and type.
   d. Model number and size.
   e. Manufacturer's serial number.
   f. Arrangement and class.

2. Motor Data:

   a. Motor make, and frame type and size.
   b. Horsepower and rpm.
   c. Volts, phase, and hertz.
   d. Full-load amperage and service factor.

3. Test Data (Indicated and Actual Values):

   a. Total airflow rate in cfm.
   b. Total system static pressure in inches wg.
   c. Fan rpm.
   d. Discharge static pressure in inches wg.
   e. Suction static pressure in inches wg.

J. Duct Traverse Reports: Include a diagram with a grid representing the duct cross-section and record the following:

1. Report Data:

   a. System and air-handling-unit number.

b. Location and zone.
c. Traverse air temperature in deg F.
d. Duct static pressure in inches wg.
e. Duct size in inches.
f. Duct area in sq. ft.
g. Indicated airflow rate in cfm.
h. Indicated velocity in fpm.
i. Actual airflow rate in cfm.
j. Actual average velocity in fpm.

K. Air-Terminal-Device Reports:

1. Unit Data:

a. System and air-handling unit identification.
b. Location and zone.
c. Apparatus used for test.
d. Area served.
e. Make.
f. Number from system diagram.
g. Type and model number.
h. Size.

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.

L. Terminal Unit Coil Reports: For coils of terminal units, include the following:

1. Unit Data:

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

2. Test Data (Indicated and Actual Values):

a. Airflow rate in cfm.
b. Entering-water temperature in deg F.
c. Leaving-water temperature in deg F.
d. Water pressure drop in feet of head or psig.

M. Radiant Manifolds: Balance each manifold per circuit flows indicated in the Radiant Floor Circuit Schedule

1. Unit Data:

a. Unit identification.
b. Location.
c. Service.
d. Make and type.
e. Model and serial numbers.
f. Ratings.

2. Water and Test Data (Indicated and Actual Values, each tube circuit):

    a. Entering-water temperature in deg F.
    b. Leaving-water temperature in deg F.
    c. Entering-water pressure in feet of head or psig.
    d. Water pressure differential in feet of head or psig.
    e. Water flow rate in gpm.

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

1. Unit Data:

    a. Unit identification.
    b. Location.
    c. Service.
    d. Make and size.
    e. Model number and serial number.
    f. Water flow rate in gpm.
    g. Water pressure differential in feet of head or psig.
    h. Required net positive suction head in feet of head or psig.
    i. Pump rpm.
    j. Impeller diameter in inches.
    k. Motor make and frame size.
    l. Motor horsepower and rpm.
    m. Voltage at each connection.
    n. Amperage for each phase.
    o. Full-load amperage and service factor.

2. Test Data (Indicated and Actual Values):

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

O. Procedures for Heat Exchangers

1. Measure water flow through all circuits. Adjust water flow to within specified tolerances. Measure inlet and outlet water temperatures. Check the setting and operation of safety and relief valves. Record settings.
2. Heat-Exchanger Test Reports: Include the following:

    a. Unit Data:

        1) Unit identification.
        2) Location.

3) Service.
4) Make and type.
5) Model and serial numbers.

b. Steam Test Data (Indicated and Actual Values): Inlet pressure in psig.
c. Primary Water Test Data (Indicated and Actual Values):

1) Entering-water temperature in deg F.
2) Leaving-water temperature in deg F.
3) Entering-water pressure in feet of head.
4) Water pressure differential in feet of head.
5) Water flow rate in gpm.

d. Secondary Water Test Data (Indicated and Actual Values):

1) Entering-water temperature in deg F.
2) Leaving-water temperature in deg F.
3) Entering-water pressure in feet of head.
4) Water pressure differential in feet of head.
5) Water flow rate in gpm.

P. Procedures for Chillers or water-to-water heat pumps.

1. Balance water flow through each heat exchanger to within specified tolerances of indicated flow with all pumps operating. With only one chiller operating in a multiple chiller installation, do not exceed the flow for the maximum tube velocity recommended by the chiller manufacturer. Measure and record the following data with each chiller operating at design conditions:
2. Chiller Test Reports:

a. Unit Data:

1) Unit identification.
2) Make and model number.
3) Manufacturer's serial number.

b. Test Reports (Indicated and Actual Values):

1) Entering-water temperature in deg F.
2) Leaving-water temperature in deg F.
3) Entering-water pressure in feet of head or psig.
4) Water pressure differential in feet of head or psig.
5) Minimum-flow bypass GPM.
6) GPM flow

Q. Procedures for Boilers

1. Measure entering- and leaving-water temperatures and water flow.
2. Boiler Test Reports:

a. Unit Data:

1) Unit identification.
2) Location.
3) Service.

4) Make and type.
5) Model and serial numbers.
6) Voltage at each connection.
7) Amperage for each phase.

b. Test Data (Indicated and Actual Values):

1) Operating pressure in psig.
2) Operating temperature in deg F.
3) Water pressure differential in feet of head.
4) GPM flow
5) Voltage at each connection.
6) Amperage for each phase.

R. Instrument Calibration Reports:

1. Report Data:

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

3.21 VERIFICATION OF TAB REPORT

A. Owner or Commissioning authority will randomly select measurements, documented in the final report, to be rechecked. Rechecking shall be limited to either 10 percent of the total measurements recorded or the extent of measurements that can be accomplished in a normal 8-hour business day.

B. If rechecks yield measurements that differ from the measurements documented in the final report by more than the tolerances allowed, the measurements shall be noted as "FAILED."

C. If the number of "FAILED" measurements is greater than 10 percent of the total measurements checked during the final inspection, the testing and balancing shall be considered incomplete and shall be rejected.

D. If TAB work fails, proceed as follows:

1. TAB specialists shall recheck all measurements and make adjustments. Revise the final report and balancing device settings to include all changes; resubmit the final report and request a second final inspection.
2. If the second final inspection also fails, Owner may contract the services of another TAB specialist to complete TAB work according to the Contract Documents and deduct the cost of the services from the original TAB specialist's final payment.

E. Prepare test and inspection reports.

3.22 ADDITIONAL TESTS

A. Within 90 days of completing TAB, perform additional TAB to verify that balanced conditions are being maintained throughout and to correct unusual conditions.

B. Seasonal Periods: If initial TAB procedures were not performed during near-peak summer and winter conditions, perform additional TAB during near-peak summer and winter conditions.

END OF SECTION

SECTION 23 07 00

MECHANICAL INSULATION

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

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.

1.02 SUMMARY

A. This Section includes insulation and related components.

1.03 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. For adhesives and sealants, provide documentation including printed a statement of VOC content.

1.04 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.

1.05 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.

1.06 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

2.01 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.

2.02 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 23 05 29 “Hangers and Supports for Piping and Equipment”.

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.

E. Pipe & Tank Insulation: Glass Fiber, Knauf with ECOSE Technology or equivalent; semi-rigid, limited combustible meeting requirements of NRC 1.36; ASTM C 795 and MIL-I-24244 C; k

value: ASTM C 177, 0.25 at 75°F mean temperature. Maximum Service Temperature: 850°F. Compressive Strength: not less than 150 PSF @ 10% deformation for 2 inch thickness per ASTM C 165. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type II. Johns Manville Micro-Flex® Large Diameter Pipe and Tank Wrap meeting ASTM C1393, Type III. Limited combustible meeting k value: ASTM C 177, 0.25 at 75°F mean temperature. Maximum Service Temperature: 850°F. Compressive Strength: not less than 150 PSF @ 10% deformation for 2 inch thickness per ASTM C 165. Vapor Retarder Jacket: ASJ conforming to ASTM C 1136 Type II

F. Solar Thermal: UT Solaflex Tube and Roll Insulation - High Temperature & UV Resistant; provide outside array piping insulation with a capability of withstanding 300 degrees F. Protect outside piping insulation from water damage and ultraviolet degradation with a suitable outer coating. 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

2.03 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.

2.04 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.

B. Rigid Fiber Glass Board: Johns Manville's 817 Series Spin-Glas® or Knauf Insulation Board with ECOSE Technology meeting ASTM C 612 Type IA and IB; rigid. Maximum Service Temperature: 450°. Density: Minimum 6 PCF; k value: ASTM C177, 0.22 at 75°F mean temperature. Vapor Retarder Jacket: ASJ conforming to ASTM C1136 Type I, or FSK or PSK conforming to ASTM C1136 Type II in combination with protective jacket where necessary.

C. Fire Protection Wrap: Thermal Ceramics FireMaster FastWrap XL or Pyroscat Duct Wrap XL shall be installed by qualified installer directly to the duct to provide a zero-clearance and 2-hour fire resistance-rated grease duct enclosure as required by IBC and as detailed in UL Listing HNKT.G-18 and tested per ASTM E 2336. Product shall be UL classified and labelled for the

application. Provide for adequate clean out of commercial kitchen grease duct: Thermal Ceramics FastDoor XL; Access Doors to be installed by qualified installer as per UL Listing HNKT.G-18.

D. Exterior Ductwork: 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°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.

2.05 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.

PART 3 - EXECUTION

3.01 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.

3.02 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.

3.03 PIPE AND DUCTWORK PENETRATIONS

A. Insulation Installation at Roof or Aboveground Exterior Wall Penetrations: Install insulation continuously through penetrations.

1. Seal penetrations with flashing sealant.
2. For applications requiring only indoor insulation, terminate insulation above roof/wall surface and seal with joint sealant. For applications requiring indoor and outdoor insulation, install insulation for outdoor applications tightly joined to indoor insulation ends. Seal joint with joint sealant.
3. Extend jacket of outdoor insulation outside 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.

3.04 INSTALLATION OF PIPING INSULATION

A. Metal shields shall be installed between hangers or supports and the piping insulation. Provide in accordance with Section 23 05 29.

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. Locate seams in the least visible location.

F. 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.

G. 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.

3.05 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. Board Insulation Installation on Ducts and Plenums: Secure with adhesive and insulation pins.

1. Apply adhesives according to manufacturer's recommended coverage rates per unit area, for 100 percent coverage of duct and plenum surfaces.
2. Apply adhesive to entire circumference of ducts and to all surfaces of fittings and transitions.
3. Install either capacitor-discharge-weld pins and speed washers or cupped-head, capacitor-discharge-weld pins on sides and bottom of horizontal ducts and sides of vertical ducts as follows:

a. On duct sides with dimensions 18 inches and smaller, place pins along longitudinal centerline of duct. Space 3 inches maximum from insulation end joints, and 16 inches o.c.
b. On duct sides with dimensions larger than 18 inches, space pins 16 inches o.c. each way, and 3 inches maximum from insulation joints. Install additional pins to hold insulation tightly against surface at cross bracing.
c. Pins may be omitted from top surface of horizontal, rectangular ducts and plenums.
d. Do not over-compress insulation during installation.
e. Cut excess portion of pins extending beyond speed washers or bend parallel with insulation surface. Cover exposed pins and washers with tape matching insulation facing.

4. Install insulation on rectangular duct elbows and transitions with a full insulation section for each surface. Groove and score insulation to fit as closely as possible to outside and inside radius of elbows. Install insulation on round and flat-oval duct elbows with individually mitered gores cut to fit the elbow.

5. 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.

C. 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.

D. Fire-rated insulation system installation: Where fire-rated insulation system is indicated, secure system to ducts and duct hangers and supports to maintain a continuous fire rating. Insulate duct access panels and doors to achieve same fire rating as duct.

3.06 INSTALLATION OF EQUIPMENT/ TANK INSULATION

A. Fiber Glass

1. Apply insulation to the equipment surface with joints firmly butted and as close as possible to the equipment surface. Insulation shall be secured as required with mechanical fasteners or banding material. Fasteners shall be located a maximum of 3″ from each edge and spaced no greater than 12″ on center.
2. For below ambient systems, vapor retarder jacketing shall overlap a minimum of 2″ at all seams and be sealed with appropriate pressure-sensitive tape or mastic. All penetrations and facing damage shall be covered with a minimum 2″ overlap of tape or mastic.

B. Flexible Elastomeric:

1. Install insulation over entire surface of tanks and vessels.
2. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive.
3. Seal longitudinal seams and end joints.

C. Insulation Installation on Pumps: Insulate chilled water pumps by forming a box around the pump housing. The box shall be constructed by forming the bottom and sides using joints that do not leave raw ends of insulation exposed. Bottom and sides shall be banded to form a rigid housing that does not rest on the pump. Joints between top cover and sides shall fit tightly. The top cover shall have a joint forming a female shiplap joint on the side pieces and a male joint on the top cover, making the top cover removable. Two coats of Class I adhesive shall be applied over insulation, including removable sections, with a layer of glass cloth embedded between the coats. A parting line shall be provided between the box and the removable sections allowing the removable sections to be removed without disturbing the insulation coating. The total dry thickness of the finish shall be 1/16 inch. Caulking shall be applied to parting line of the removable sections and penetrations.

3.07 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.

3.08 FINISHES

A. Pipe Insulation with ASJ, Glass-Cloth, or other paintable jacket material: Paint jacket with paint system identified below and as specified in Division 9.

B. Color: Final color as selected by Architect. Vary first and second coats to allow visual inspection of the completed Work.

3.09 FIELD QUALITY CONTROL

A. Tests and Inspections: Inspect pipe, fittings, strainers, and valves, randomly selected by Architect, by removing field-applied jacket and insulation in layers in reverse order of their installation. Extent of inspection shall be limited to three locations of straight pipe, three locations of threaded fittings, three locations of welded fittings, two locations of threaded strainers, two locations of welded strainers, three locations of threaded valves, and three locations of flanged valves for each pipe service defined in the "Piping Insulation Schedule, General" Article.

B. All insulation applications will be considered defective Work if sample inspection reveals noncompliance with requirements.

3.10 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 the local energy code, or thicknesses indicated, whichever is of superior insulating performance. If piping type is omitted from list below, provide insulation per energy code or as per similar duty.

E. Provide PVC jackets in the following locations:
   1. Exposed vertical piping in finished spaces.

F. Domestic hot water: R4 minimum.

G. Domestic cold water: Glass Fiber, ½" thickness.

H. Rainwater conductors: Glass Fiber, 1" thickness. Provide for all horizontal piping and any vertical piping within 10 feet of the roof drain. Alternative: Roof drain bowls may be insulated with 2" of closed-cell spray-foam provided by Division 7. Coordinate with Division 7.

I. Roof Drain Bodies: Flexible Elastomeric, ½" thickness.

J. AC pan drain or other cold drain piping: Flexible Elastomeric, ½" thickness. Or provide pre-insulated hose as specified with heat pumps.

K. Freezer evaporator drain piping: Insulated and heat traced by 114000.

L. Cooler evaporator drain piping: Insulated by 114000.

M. Ductless split: Provide in accordance with Section 238130.

N. Heating/cooling hydronic supply and return:

   1. Pipe size 1-1/4" and less: Glass Fiber; 1" thickness.
   2. Pipe size 1-1/2" and larger: Glass Fiber; 1-1/2" thickness.

O. Heating supply and return:

   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. Insulation is not required for exposed piping through floor for convectors and radiators.
   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.

P. Chilled Water:

   1. Pipe size 3/4" and less: Glass Fiber, ½" thickness.
   2. Pipe size 1" to 6": Glass Fiber, 1" thickness.
   3. Pipe size 8" and larger: Glass Fiber, 1-1/2" thickness.
   4. Chilled Water, outdoors: Closed Cell Pipe Insulation; 2" thickness. Provide aluminum jacket

Q. Ground water heat pump well water piping:

   1. Pipe size 3/4" and less: Glass Fiber, ½" thickness.
   2. Pipe size 1" to 6": Glass Fiber, 1" thickness.
   3. Pipe size 8" and larger: Glass Fiber, 1-1/2" thickness.

R. Solar Water Piping: Armacell UT Solaflex, ½" thickness.

3.11 EQUIPMENT INSULATION

A. For equipment not indicated, insulate to with a similar thickness and type as those specified.

B. Install insulation over entire surface of tanks and vessels. Apply 100 percent coverage of adhesive to surface with manufacturer's recommended adhesive. Seal longitudinal seams and end joints.

C. For Equipment insulation exposed in mechanical rooms or subject to mechanical abuse, finish with minimum 0.020 inch thick PVC jacketing or metal or laminated self-adhesive water and weather seals. All other insulation shall be finished as appropriate for the location and service or as specified on the drawings.

D. For below ambient services, install a vapor barrier at seams, joints, and penetrations. Seal between flanges with replaceable gasket material to form a vapor barrier.

E. Omit insulation from the following, except for cold surfaces, which shall be provided with removable covers:

1. Hot water expansion tanks
2. Hot water pumps
3. Vibration-control devices.
4. Testing agency labels and stamps.
5. Nameplates and data plates.
6. Manholes, hand holes, or cleanouts.

F. Removable Covers for Maintenance Access: Construct insulation on parts of equipment such as chilled water pumps; or other equipment which must be opened periodically for maintenance or repair, so insulation can be removed and replaced without damage. Use ¾” flexible elastomeric insulation.

G. Cooling & heating system expansion tanks, chemical feed tanks, buffer tanks and similar equipment: same as water piping.

H. Air separators, low loss headers, and similar equipment: same as water piping.

3.12 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 the local energy code, 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.
5. Double-wall ducts (where indicated on the plans).

3.13 DUCT AND PLENUM APPLICATION SCHEDULE

A. Supply Ducts: Flexible Fiber Glass Blanket;
   1. Concealed or Unconditioned Space: R-6 minimum, 1.5” thickness.
   2. Return Air Plenums: None
   3. Exposed to Conditioned Space: None

B. Return ducts within conditioned space: None required.

C. Exterior Supply & Return Ducts: 2-1/2" Rigid Roof Insulation Board with high performance jacket; R10 minimum.

D. Concealed outside air intake, relief, or exhaust ducts and plenums: Flexible Fiber Glass Blanket; R-8, 2” thickness.

E. Exposed outside air intake, relief, or exhaust ducts and plenums: Rigid Fiber Glass Board; R-8, 2” thickness.

F. Range Hood Exhaust: Provide fire protection wrap at GWB wall penetrations for zero clearance to combustibles.

G. Boiler direct vent combustion air: R-6, 1.5” thickness.

END OF SECTION

SECTION 23 09 00

DIRECT DIGITAL CONTROL (DDC) SYSTEM

PART 1 - GENERAL

1.01 SUMMARY

A. Provide all labor, materials, equipment, and service necessary for a complete and operating building automation system.

B. The Controls Contractor's work shall consist of the provision of all labor, materials, special tools, equipment, enclosures, power supplies, software, software licenses, project-specific software configurations and database entries, interfaces, wiring, tubing, installation, labeling, engineering, calibration, documentation, submittals, testing, verification, training services, permits and licenses, transportation, shipping, handling, administration, supervision, management, insurance, warranty, specified services and items required by the Contract that are required for the functional turn-key operation of the complete and fully functional Controls Systems. Documents are diagrammatic only. Equipment and labor not specifically referred to herein or on the plans, which are required to meet the functional intent, shall be provided without additional cost to the Owner.

C. Related Sections include the following:

1. Drawings and general provisions of the Contract, including General and Supplementary Conditions and Division 1 Specification Sections, apply to this Section.
2. Division 13 Section "Fire Alarm"
3. Division 23 Section "Common Work Results for Mechanical"
4. Division 23 Sections with controller interfaces shall be integrated with the work of this Section.
5. Division 23 Section "Testing, Adjusting, and Balancing"
6. Division 26

1.02 ACTION SUBMITTALS

A. Product Data: For each type of product include the following:

1. Construction details, material descriptions, dimensions of individual components and profiles, and finishes.
2. Operating characteristics, electrical characteristics, and furnished accessories indicating process operating range, accuracy over range, control signal over range, default control signal with loss of power, calibration data specific to each unique application, electrical power requirements, and limitations of ambient operating environment, including temperature and humidity.
3. Product description with complete technical data, performance curves, and product specification sheets.
4. Installation, operation and maintenance instructions including factors effecting performance.
5. Bill of materials of indicating quantity, manufacturer, and extended model number for each unique product.

6. When manufacturer's product datasheets apply to a product series rather than a specific product model, clearly indicate and highlight only applicable information.
7. Each submitted piece of product literature shall clearly cross reference specification and drawings that submittal is to cover.

B. Software Submittal:

1. Cross-referenced listing of software to be loaded on each operator workstation and DDC controller.
2. Description and technical data of all software provided, and cross-referenced to products in which software will be installed.
3. Operating system software, operator interface and programming software, color graphic software, DDC controller software, maintenance management software, and third-party software.
4. Include a flow diagram and an outline of each subroutine that indicates each program variable name and units of measure.
5. Description of operator interface to alphanumeric and graphic programming.
6. Description of each network communication protocol.
7. Description of each application program and device drivers to be generated, including specific information on data acquisition and control strategies showing their relationship to system timing, speed, processing burden and system throughout.
8. Controlled Systems: Instrumentation list with element name, type of device, manufacturer, model number, and product data. Include written description of sequence of operation including schematic diagram.

C. Shop Drawings:

1. General Requirements:

   a. Include cover drawing with Project name, location, Owner, Architect, Contractor and issue date with each Shop Drawings submission.
   b. Include a drawing index sheet listing each drawing number and title that matches information in each title block.
   c. Prepare Drawings using CAD.

2. Schematic drawings for each controlled HVAC system indicating the following:

   a. I/O points labeled with point names shown. Indicate instrument range, normal operating set points, and alarm set points. Indicate fail position of each damper and valve, if included in Project.
   b. I/O listed in table format showing point name, type of device, manufacturer, model number, and cross-reference to product data sheet number.
   c. A graphic showing location of control I/O in proper relationship to HVAC system.
   d. Wiring diagram with each I/O point having a unique identification and indicating labels for all wiring terminals.
   e. Unique identification of each I/O that shall be consistently used between different drawings showing same point.
   f. Elementary wiring diagrams of controls for HVAC equipment motor circuits including interlocks, switches, relays and interface to DDC controllers.
   g. Narrative sequence of operation.
   h. Graphic sequence of operation, showing all inputs and output logical blocks.

3. Control panel drawings indicating the following:

    a. Panel dimensions, materials, size, and location of field cable, raceways, and tubing connections.
    b. Interior subpanel layout, drawn to scale and showing all internal components, cabling and wiring raceways, nameplates and allocated spare space.
    c. Front, rear, and side elevations and nameplate legend.
    d. Unique drawing for each panel.

4. DDC system network riser diagram indicating the following:

    a. Each device connected to network with unique identification for each.
    b. Interconnection of each different network in DDC system.
    c. For each network, indicate communication protocol, speed and physical means of interconnecting network devices, such as copper cable type, or fiber-optic cable type. Indicate raceway type and size for each.
    d. Each network port for connection of an operator workstation or other type of operator interface with unique identification for each.

5. DDC system electrical power riser diagram indicating the following:

    a. Each point of connection to field power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    b. Each control power supply including, as applicable, transformers, power-line conditioners, transient voltage suppression and high filter noise units, DC power supplies, and UPS units with unique identification for each.
    c. Each product requiring power with requirements (volts/phase//hertz/amperes/connection type) listed for each.
    d. Power wiring type and size, race type, and size for each.

6. Monitoring and control signal diagrams indicating the following:

    a. Control signal cable and wiring between controllers and I/O.
    b. Point-to-point schematic wiring diagrams for each product.

7. Color graphics indicating the following:

    a. Itemized list of color graphic displays to be provided.
    b. For each display screen to be provided, a true color copy showing layout of pictures, graphics and data displayed.

D. System Description:

1. Full description of DDC system architecture, network configuration, operator interfaces and peripherals, servers, controller types and applications, gateways, routers and other network devices, and power supplies.
2. Complete listing and description of each report, log and trend for format and timing and events which initiate generation.
3. System and product operation under each potential failure condition including, but not limited to, the following:

    a. Loss of power.
    b. Loss of network communication signal.
    c. Loss of controller signals to inputs and outpoints.
    d. Operator workstation failure.

e. Server failure.
f. Gateway failure.
g. Network failure
h. Controller failure.
i. Instrument failure.
j. Control damper and valve actuator failure.

4. Complete bibliography of documentation and media to be delivered to Owner.
5. Description of testing plans and procedures.
6. Description of Owner training.

E. Delegated-Design Submittal: For DDC system products and installation indicated as being delegated.

1. Supporting documentation showing DDC system design complies with performance requirements indicated, including calculations and other documentation necessary to prove compliance.
2. Schedule and design calculations for control dampers and actuators.

a. Flow at Project design and minimum flow conditions.
b. Face velocity at Project design and minimum airflow conditions.
c. Pressure drop across damper at Project design and minimum airflow conditions.
d. AMCA 500-D damper installation arrangement used to calculate and schedule pressure drop, as applicable to installation.
e. Maximum close-off pressure.
f. Leakage airflow at maximum system pressure differential (fan close-off pressure).
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

3. Schedule and design calculations for control valves and actuators.

a. Flow at Project design and minimum flow conditions.
b. Pressure-differential drop across valve at Project design flow condition.
c. Maximum system pressure-differential drop (pump close-off pressure) across valve at Project minimum flow condition.
d. Design and minimum control valve coefficient with corresponding valve position.
e. Maximum close-off pressure.
f. Leakage flow at maximum system pressure differential.
g. Torque required at worst case condition for sizing actuator.
h. Actuator selection indicating torque provided.
i. Actuator signal to control damper (on, close or modulate).
j. Actuator position on loss of power.
k. Actuator position on loss of control signal.

4. Schedule and design calculations for selecting flow instruments.

a. Instrument flow range.
b. Project design and minimum flow conditions with corresponding accuracy, control signal to transmitter and output signal for remote control.
c. Extreme points of extended flow range with corresponding accuracy, control signal to transmitter and output signal for remote control.
d. Pressure-differential loss across instrument at Project design flow conditions.

e. Where flow sensors are mated with pressure transmitters, provide information for each instrument separately and as an operating pair.

1.03 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Division 1, include the following:

a. Project Record Drawings of as-built versions of submittal Shop Drawings provided in electronic PDF format.
b. Testing and commissioning reports and checklists of completed final versions of reports, checklists, and trend logs.
c. As-built versions of submittal Product Data.
d. Names, addresses, e-mail addresses and 24-hour telephone numbers of Installer and service representatives for DDC system and products.
e. Operator's manual with procedures for operating control systems including logging on and off, handling alarms, producing point reports, trending data, overriding computer control and changing set points and variables.
f. Programming manuals with description of programming language and syntax, of statements for algorithms and calculations used, of point database creation and modification, of program creation and modification, and of editor use.
g. Engineering, installation, and maintenance manuals that explain how to:

1) Design and install new points, panels, and other hardware.
2) Perform preventive maintenance and calibration.
3) Debug hardware problems.
4) Repair or replace hardware.

h. Documentation of all programs created using custom programming language including set points, tuning parameters, and object database.
i. Backup copy of graphic files, programs, and database on electronic media such as DVDs.
j. List of recommended spare parts with part numbers and suppliers.
k. Complete original-issue documentation, installation, and maintenance information for furnished third-party hardware including computer equipment and sensors.
l. Complete original-issue copies of furnished software, including operating systems, custom programming language, operator workstation software, and graphics software.
m. Licenses, guarantees, and warranty documents.
n. Recommended preventive maintenance procedures for system components, including schedule of tasks such as inspection, cleaning, and calibration; time between tasks; and task descriptions.
o. Owner training materials.

1.04 QUALITY ASSURANCE

A. All products used in this project installation shall be new and currently under manufacture and shall have been applied in similar installations for a minimum of two years. This installation shall not be used as a test site for any new products unless explicitly approved by the owner’s representative in writing. Spare parts shall be available for at least five years after completion of this contract.

B. All work described in this section shall be installed, wired, circuit tested and calibrated by factory certified technicians qualified for this work and in the regular employment of the temperature control system manufacturer. Use only employees who are qualified, skilled, experienced, manufacturer trained and familiar with the specific equipment, software and configurations to be provided for this Project.

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.

1.05 CONTRACTOR QUALIFICATIONS

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

1. Schneider Electric I/A, (Maine Controls)
2. Johnson Controls, Inc.
3. Honeywell
4. Siemens
5. Approved bidders. Bids from other vendors, franchised dealers, manufacturer's representatives, or from contractors who are authorized to represent the above named manufacturers must be pre-approved.

B. Installer Qualifications: Automatic control system manufacturer's authorized representative who is trained and approved for installation of system components required for this Project.

C. The above list of manufacturers applies to operator workstation software, controller software, the custom application programming language, and controllers. All other products specified herein (e.g., sensors, valves, dampers, and actuators) need not be manufactured by the above manufacturers.

D. Longevity: The Facilities Management System contractor shall have a minimum of ten years experience installing, and servicing computerized Building Automation Systems (BAS). All subcontractors utilized by the BAS contractor shall have a minimum of five-year experience within their appropriate trades.

E. Past Projects: The BAS contractor shall have completed a minimum of ten projects within the last five years that are at least equal in dollar value and scope to this project. A list of similar projects, dollar volume, scope, contact name and contact number shall be provided by the BAS contractor if asked for by the owner.

F. Personnel, Coverage and Response Capabilities: The BAS contractor shall have a minimum of ten full time electronic service personnel within a 120 mile radius of the project location. One of the five full time electronic service personnel must work within a 60-mile radius of the project location.

G. The BAS contractor shall have an established 24-hour emergency service organization. A dedicated telephone number shall be provided to the owner for requesting emergency service. A maximum of four hour, electronic service technician on sight, response time shall be guaranteed by the BAS contractor.

H. Parts Stocking: The BAS contractor shall have an independently verifiable inventory of electronic service parts. This electronic service parts inventory must have a worth of at least $100,000 per year over the last five years.

1.06 COORDINATION

A. Where the mechanical work will be installed in close proximity to, or will interfere with, work of other trades, the contractor shall assist in working out space conditions to make a satisfactory adjustment. If the contractor installs his/her work before coordinating with other trades, so as to cause any interference with work of other trades, the contractor shall make the necessary changes in his/her work to correct the condition.

B. Coordinate details of telephone line, internet service provider, and associated requirements.

C. Coordinate and schedule work with all other work in the same area, or with work that is dependent upon other work, to facilitate mutual progress.

D. Coordinate location of thermostats and other exposed control sensors with plans and room details before installation.

E. Coordination with controls specified in other sections or divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the controls system specified in this section. These controls shall be integrated into the system and coordinated by the contractor.

F. 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 unit manufacturer.

G. Sheet Metal Subcontractor:

1. Installation of duct-mounted control devices.
2. Access doors where indicated and as required for proper servicing.
3. Furnishing and installing of smoke dampers and actuators required for duct smoke isolation. The BAS contractor shall interlock these dampers to the air systems as described in Sequences of Operation.

H. HVAC Contractor:

1. Installation of immersion wells and sockets, along with associated shut-off cocks.
2. Installation of pipe-mounted control devices.

I. Testing and Balancing Contractor:

1. The contractor shall furnish a single set of all tools necessary to interface to the control system for test and balance purposes.
2. The contractor shall provide training in the use of these tools. This training will be planned for a minimum of 4 hours.
3. In addition, the contractor shall provide a qualified technician to assist in the test and balance process, until the first 20 terminal units are balanced.
4. The tools used during the test and balance process shall be returned at the completion of the testing and balancing.

J. Electrical Subcontractor: Complying with the principle of "unit responsibility" all electrical work for automatic controls, except as otherwise specified, or shown on the electrical drawings shall be included in Division 23. Electrical work shall, in general, comply with the following, unless otherwise directed by Division 26:

1. Power wiring.
2. All control wiring shown on electric plans such as unit heater line-voltage room thermostats.
3. Duct smoke detectors required for air handler shutdown are supplied under Division 26. Coordinate required length of sampling tube, for full span of ductwork. The contractor shall connect the DDC system to the auxiliary contacts provided on the smoke detector for system safeties and to provide alarms to the DDC system.
4. All electrical work shall comply with the N.E.C. and local electrical codes.
5. All safety devices shall be wired through both hand and auto positions of motor starting device to insure 100% safety shut-off.
6. The motor starter supplier shall provide auxiliary contacts as required for interlock by BAS Contractor; the supplier shall estimate an allowance of at least one auxiliary contract per starter.

K. Coordinate with controls specified in other sections of divisions. Other sections and/or divisions of this specification include controls and control devices that are to be part of or interfaced to the control system specified in this section. These controls shall be integrated into the system and coordinated by the BAS contractor as follows:

1. All communication media and equipment shall be provided as specified hereinafter.
2. Each supplier of a control product is responsible for the configuration, programming, start-up, and testing of that product to meet the sequences of operation described in this section.
3. The BAS contractor shall coordinate and resolve any incompatibility issues that arise between the control products provided under this section and those provided under other sections or divisions of this specification.
4. The BAS contractor is responsible for providing all controls described in the contract documents regardless of where within the contract documents these controls are described.
5. The contractor is responsible for the interface of control products provided by multiple suppliers regardless of where this interface is described within the contract documents.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Factory-Mounted Components: Where control devices specified in this Section are indicated to be factory mounted on equipment, arrange for shipping of control devices to equipment manufacturer.

B. System Software: Update to latest version of software at Project completion.

1.08 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

2.01 BUILDING AUTOMATION SYSTEM

A. Microprocessor-based monitoring and control including analog/digital conversion and program logic. A control loop or subsystem in which digital and analog information is received and processed by a microprocessor, and digital control signals are generated based on control algorithms and transmitted to field devices to achieve a set of predefined conditions.

B. DDC system shall consist of a high-speed, peer-to-peer network of distributed DDC controllers, other network devices, operator interfaces, and software. System shall use the

BACnet protocol for communication to the operator workstation or web server and for communication between control modules.

C. Provide new wiring and network devices as required to provide a complete and workable control network.

D. DDC system shall be Web based or Web compatible.

1. Web-Based Access to DDC System:

a. DDC system software shall be based on server thin-client architecture, designed around open standards of Web technology. DDC system server shall be accessed using a Web browser over DDC system network, using Owner's LAN, and remotely over Internet through Owner's LAN.
b. Intent of thin-client architecture is to provide operators complete access to DDC system via a Web browser. No special software other than a Web browser shall be required to access graphics, point displays, and trends; to configure trends, points, and controllers; and to edit programming.
c. Web access shall be password protected.

2. Web-Compatible Access to DDC System:

a. Operator workstation shall perform overall system supervision and configuration, graphical user interface, management report generation, and alarm annunciation.
b. DDC system shall support Web browser access to building data. Operator using a standard Web browser shall be able to access control graphics and change adjustable set points.
c. Web access shall be password protected.

2.02 PERFORMANCE REQUIREMENTS

A. Delegated Design: Engage a qualified professional to design DDC system to satisfy requirements indicated. System Performance Objectives:

1. DDC system shall manage HVAC systems.
2. DDC system control shall operate HVAC systems to achieve optimum operating costs while using least possible energy and maintaining specified performance.
3. DDC system shall respond to power failures, HVAC equipment failures, and adverse and emergency conditions encountered through connected I/O points.
4. DDC system shall operate while unattended by an operator and through operator interaction.
5. DDC system shall record trends and transaction of events and produce report information such as performance, energy, occupancies, and equipment operation.

B. DDC System Data Storage:

1. Include server(s) with disk drive data storage to archive not less than 36 consecutive months of historical data for all I/O points connected to system, including alarms, event histories, transaction logs, trends and other information indicated.
2. When logged onto a server, operator shall be able to also interact with any DDC controller connected to DDC system as required for functional operation of DDC system.
3. Server(s) shall be used for application configuration; for archiving, reporting and trending of data; for operator transaction archiving and reporting; for network information

management; for alarm annunciation; and for operator interface tasks and controls application management.

4. Server(s) shall use IT industry-standard database platforms such as Microsoft SQL Server and Microsoft Data Engine (MSDE).

C. Performance Standards. System shall conform to the following minimum standards over network connections. Systems shall be tested using manufacturer's recommended hardware and software for operator workstation (server and browser for web-based systems).

1. Graphic Display. A graphic with 20 dynamic points shall display with current data within 10 sec.
2. Graphic Refresh. A graphic with 20 dynamic points shall update with current data within 8 sec. and shall automatically refresh every 15 sec.
3. Configuration and Tuning Screens. Screens used for configuring, calibrating, or tuning points, PID loops, and similar control logic shall automatically refresh within 6 sec.
4. Object Command. Devices shall react to command of a binary object within 2 sec. Devices shall begin reacting to command of an analog object within 2 sec.
5. Alarm Response Time. An object that goes into alarm shall be annunciated at the workstation within 45 sec.
6. Program Execution Frequency. Custom and standard applications shall be capable of running as often as once every 5 sec. Select execution times consistent with the mechanical process under control.
7. Performance. Programmable controllers shall be able to completely execute DDC PID control loops at a frequency adjustable down to once per sec. Select execution times consistent with the mechanical process under control.
8. Multiple Alarm Annunciation. Each workstation on the network shall receive alarms within 5 sec of other workstations.
9. Reporting Accuracy. System shall report values with minimum end-to-end accuracy listed in Table 1.
10. Control Stability and Accuracy. Control loops shall maintain measured variable at setpoint within tolerances listed below.
11. Measured Variable and Reported Accuracy

    a. Space Temperature; ±0.5ºC (±1ºF)
    b. Ducted Air: ±0.5ºC (±1ºF)
    c. Outside Air: ±1.0ºC (±2ºF)
    d. Dew Point: ±1.5ºC (±3ºF)
    e. Water Temperature: ±0.5ºC (±1ºF)
    f. Delta-T: ±0.15º (±0.25ºF)
    g. Relative Humidity: ±5% RH
    h. Water Flow: ±2% of full scale
    i. Airflow (terminal): ±10% of full scale; Accuracy applies to 10%–100% of scale
    j. Air Pressure (ducts): ±25 Pa (±0.1 in. w.g.)
    k. Air Pressure (space): ±3 Pa (±0.01 in. w.g.)
    l. Water Pressure: ±2% of full scale
    m. Electrical: ±1% of reading, Not including utility-supplied meters
    n. Carbon Monoxide (CO): ±5% of reading
    o. Carbon Dioxide (CO2): ±50 ppm

12. Control Stability and Accuracy

    a. Air Pressure: ±50 Pa (±0.2 in. w.g.); Range of Medium: 0–1.5 kPa (0–6 in. w.g.)
    b. Air Pressure: ±3 Pa (±0.01 in. w.g.); Range of Medium: 25 to 25 Pa (-0.1 to 0.1 in. w.g.)
    c. Airflow: ±10% of full scale
    d. Space Temperature: ±1.0ºC (±2.0ºF)

e. Duct Temperature: ±1.5ºC (±3ºF)
f. Humidity: ±5% RH
g. Fluid Pressure: ±10 kPa (±1.5 psi); Range of Medium: 1–150 psi

D. Environmental Conditions for Controllers, Gateways, Routers, Instruments and Actuators: Products shall operate without performance degradation under ambient environmental temperature, pressure and humidity conditions encountered for installed location. If product alone cannot comply with requirement, install product in a protective enclosure that is isolated and protected from conditions impacting performance. Enclosure shall be internally insulated, electrically heated, cooled and ventilated as required by product and application. Products shall be protected with NEMA enclosures suitable for the location where installed.

E. Continuity of Operation after Electric Power Interruption: Equipment and associated factory-installed controls, field-installed controls, electrical equipment, and power supply connected to building normal and backup power systems shall automatically return equipment and associated controls to operating state occurring immediately before loss of normal power, without need for manual intervention by operator when power is restored either through backup power source or through normal power if restored before backup power is brought online.

2.03 COMMUNICATION

A. Control products, communication media, connectors, repeaters, hubs, and routers shall comprise a BACnet internetwork. Controller and operator interface communication shall conform to ANSI/ASHRAE Standard 135, BACnet.

B. Install new wiring and network devices as required to provide a complete and workable control network.

C. Each controller shall have a communication port for temporary connection to a laptop computer or other operator interface. Connection shall support memory downloads and other commissioning and troubleshooting operations.

D. Internetwork operator interface and value passing shall be transparent to internetwork architecture.

E. An operator interface connected to a controller shall allow the operator to interface with each internetwork controller as if directly connected. Controller information such as data, status, and control algorithms shall be viewable and editable from each internetwork controller.

F. Inputs, outputs, and control variables used to integrate control strategies across multiple controllers shall be readable by each controller on the internetwork. Program and test all cross-controller links required to execute control strategies specified in Section 230993. An authorized operator shall be able to edit cross-controller links by typing a standard object address or by using a point-and-click interface.

G. Workstations, Building Control Panels, and Controllers with real-time clocks shall use the BACnet Time Synchronization service. System shall automatically synchronize system clocks daily from an operator-designated device via the internetwork. The system shall automatically adjust for daylight saving and standard time as applicable.

H. System shall be expandable to at least twice the required input and output objects with additional controllers, associated devices, and wiring.

2.04 DDC EQUIPMENT

A. The Operator Workstation or server shall conform to the BACnet Operator Workstation (B-OWS) or BACnet Advanced Workstation (B-AWS) device profile as specified in ASHRAE/ANSI 135 BACnet Annex L.

B. Operator Interface. Web server shall reside on high-speed network with building controllers. Each standard browser connected to server shall be able to access all system information.

C. Communication. Web server or workstation and controllers shall communicate using BACnet protocol. Web server or workstation and control network backbone shall communicate using ISO 8802-3 (Ethernet) Data Link/Physical layer protocol and BACnet/IP addressing as specified in ANSI/ASHRAE 135, BACnet Annex J.

D. Operator Workstation: Industry-standard hardware shall meet or exceed DDC system manufacturer's recommended specifications and shall meet response times specified elsewhere in this document.

1. Motherboard: With 8 integrated USB 2.0 ports, integrated PCIE 10/100/1000 network adapter
2. Processor: Intel® Core™ i7
3. The hard disk shall have sufficient memory to store: All required operator workstation software. A DDC database at least twice the size of the delivered system database. Three years of trend data based on the points specified to be trended at their specified trend intervals. Minimum size: 500GB.
4. Random-Access Memory: 8 GB
5. 320W 90% Efficient Power Supply, Energy Star 5.0 compliant
6. Graphics: card as recommended by BAS supplier for optimum performance.
7. Monitor: 17.3 inch High Definition LED Display (1600 X 900) with anti-glare
8. Keyboard: QWERTY, 105 keys in ergonomic shape.
9. 16x DVD-RW drive
10. Mouse: Three button, optical.
11. APC BR1000G Back-UPS Pro 1000 VA 120V Power-Saving UPS System
12. Operating System: Windows 10 with high-speed Internet access.
13. Provide additional hardware (communication ports, video drivers, network interface cards, cabling, etc.) to facilitate all control functions and software requirements specified for the DDC system.
14. Serial, parallel, and network communication ports and cables as required for proper DDC system operation
15. Printer: Black-and-white, laser-jet type as follows: Print Head: 1200 x 1200 dpi resolution. Paper Handling: Minimum of 250 sheet trays. Print Speed: Minimum of 120 characters per second.
16. Application Software:

    a. I/O capability from operator station.
    b. System security for each operator via software password and access levels.
    c. Automatic system diagnostics; monitor system and report failures.
    d. Database creation and support.
    e. Automatic and manual database save and restore.
    f. Dynamic color graphic displays with up to 10 screen displays at once.
    g. Custom graphics generation and graphics library of HVAC equipment and symbols.
    h. Alarm processing, messages, and reactions.
    i. Trend logs retrievable in spreadsheets and database programs.
    j. Alarm and event processing.
    k. Object and property status and control.

l. Automatic restart of field equipment on restoration of power.
m. Data collection, reports, and logs. Include standard reports for the following:

1) Current values of all objects.
2) Current alarm summary.
3) Disabled objects.
4) Alarm lockout objects.
5) Logs.

n. Custom report development.
o. Utility and weather reports.
p. Workstation application editors for controllers and schedules.
q. Maintenance management.

17. Custom Application Software:

a. English language oriented.
b. Full-screen character editor/programming environment.
c. Allow development of independently executing program modules with debugging/simulation capability.
d. Support conditional statements.
e. Support floating-point arithmetic with mathematic functions.
f. Contains predefined time variables.

E. Control Units: Modular, comprising processor board with programmable, nonvolatile, random-access memory; local operator access and display panel; integral interface equipment; and backup power source.

1. Units monitor or control each I/O point; process information; execute commands from other control units, devices, and operator stations; and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.
d. Software applications, scheduling, and alarm processing.
e. Testing and developing control algorithms without disrupting field hardware and controlled environment.

3. Standard Application Programs:

a. Electric Control Programs: Demand limiting, duty cycling, automatic time scheduling, start/stop time optimization, night setback/setup, on-off control with differential sequencing, staggered start, antishort cycling, PID control, DDC with fine tuning, and trend logging.
b. HVAC Control Programs: Optimal run time, supply-air reset, and enthalpy switchover.
c. Chiller Control Programs: Control function of condenser-water reset, chilled-water reset, and equipment sequencing.
d. Programming Application Features: Include trend point; alarm processing and messaging; weekly, monthly, and annual scheduling; energy calculations; run-time totalization; and security access.
e. Remote communications.

f. Maintenance management.
g. Units of Measure: Inch-pound and SI (metric).

4. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
5. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
6. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

F. Local Control Units: Modular, comprising processor board with electronically programmable, nonvolatile, read-only memory; and backup power source.

1. Units monitor or control each I/O point, process information, and download from or upload to operator workstation or diagnostic terminal unit.
2. Stand-alone mode control functions operate regardless of network status. Functions include the following:

a. Global communications.
b. Discrete/digital, analog, and pulse I/O.
c. Monitoring, controlling, or addressing data points.

3. Local operator interface provides for download from or upload to operator workstation or diagnostic terminal unit.
4. ASHRAE 135 Compliance: Control units shall use ASHRAE 135 protocol and communicate using ISO 8802-3 (Ethernet) datalink/physical layer protocol.
5. LonWorks Compliance: Control units shall use LonTalk protocol and communicate using EIA/CEA 709.1 datalink/physical layer protocol.

G. I/O Interface: Hardwired inputs and outputs may tie into system through controllers. Protect points so that shorting will cause no damage to controllers.

1. Binary Inputs: Allow monitoring of on-off signals without external power.
2. Pulse Accumulation Inputs: Accept up to 10 pulses per second.
3. Analog Inputs: Allow monitoring of low-voltage (0- to 10-V dc), current (4 to 20 mA), or resistance signals.
4. Binary Outputs: Provide on-off or pulsed low-voltage signal, selectable for normally open or normally closed operation.
5. Analog Outputs: Provide modulating signal, either low voltage (0- to 10-V dc) or current (4 to 20 mA).
6. Tri-State Outputs: Provide two coordinated binary outputs for control of three-point, floating-type electronic actuators.
7. Universal I/Os: Provide software selectable binary or analog outputs.

H. Power Supplies: Transformers with Class 2 current-limiting type or overcurrent protection; limit connected loads to 80 percent of rated capacity. DC power supply shall match output current and voltage requirements and be full-wave rectifier type with the following:

1. Output ripple of 5.0 mV maximum peak to peak.
2. Combined 1 percent line and load regulation with 100-mic.sec. response time for 50 percent load changes.
3. Built-in overvoltage and overcurrent protection and be able to withstand 150 percent overload for at least 3 seconds without failure.

I. Power Line Filtering: Internal or external transient voltage and surge suppression for workstations or controllers with the following:

1. Minimum dielectric strength of 1000 V.
2. Maximum response time of 10 nanoseconds.
3. Minimum transverse-mode noise attenuation of 65 dB.
4. Minimum common-mode noise attenuation of 150 dB at 40 to 100 Hz.

2.05 UNITARY CONTROLLERS

A. Unitized, capable of stand-alone operation with sufficient memory to support its operating system, database, and programming requirements, and with sufficient I/O capacity for the application.

1. Configuration: Local keypad and display; diagnostic LEDs for power, communication, and processor; wiring termination to terminal strip or card connected with ribbon cable; memory with bios; and 72-hour battery backup.
2. Operating System: Manage I/O communication to allow distributed controllers to share real and virtual object information and allow central monitoring and alarms. Perform scheduling with real-time clock. Perform automatic system diagnostics; monitor system and report failures.
3. ASHRAE 135 Compliance: Communicate using read (execute and initiate) and write (execute and initiate) property services defined in ASHRAE 135. Reside on network using MS/TP datalink/physical layer protocol and have service communication port for connection to diagnostic terminal unit.
4. LonWorks Compliance: Communicate using EIA/CEA 709.1 datalink/physical layer protocol using LonTalk protocol.
5. Enclosure: Dustproof rated for operation at 32 to 120 deg F.

2.06 WHOLE BUILDING METERING

A. Provide an Obvius AcquiSuite (or approved equal) data acquisition server.

1. Obvius' AcquiSuite is an intelligent, flexible data acquisition server allowing users to collect energy data from meters and environmental sensors. The AcquiSuite is designed to connect to IP-based applications such as software dashboards and kiosks, enterprise energy management applications, as well as demand response and smart grid programs. The AcquiSuite server lets you connect thousands of energy points, benchmark energy usage and reduce energy costs.
2. The AcquiSuite collects and logs data from connected (wired or wireless) devices based on user selected intervals. Data from downstream devices are time stamped and stored locally in non-volatile memory until the next scheduled upload or manual download. Using an integrated modem or Ethernet (LAN) connection you can push or pull data via HTTP, XML, FTP or any custom protocol utilizing our AcquiSuite Module to build your own application, including integrated cellular communication options.
3. No software is required – easily access information through any web browser. The AcquiSuite has eight integrated flex I/O inputs. Each field selectable input can measure resistive, analog (4/20mA / 0-10V) and standard pulse / KYZ pulse output devices. This simplifies installation for basic projects monitoring electric, gas or water meters. There are several additional features including alarming, SNMP Traps, network configuration, wireless diagnostics, security provisions, alarm relays and backlit LCD. Our integrated meter driver library is designed to speed up installation and lower integration costs

through “plug-and-play” connectivity. Optional GSM/GPRS cellular version available for wireless internet connectivity.

4. The AcquiSuite is compatible with nearly any front-end software platform allowing customers to use a variety of reporting tools; whether it’s a local server or an enterprise wide reporting suite. Obvius offers a free utility for automated .CSV file downloads or an affordable hosted solution for $195.00 annually (unlimited data storage).
   a. Include 3 years of hosted data.
5. The AcquiSuite BACnet Server makes all configured and collected data points automatically available as BACnet objects without any register mapping. Once a device is connected to the AcquiSuite, it shall be made available as a virtual BACnet Device Object. Similarly, each data point provided shall be automatically available as a pre-scaled BACnet object with the appropriate engineering units already assigned. Provide the Obvius HD Pulse Module and Flex I/O, to allow virtually any utility pulse meter, sensor or any other simple communications device to be presented as a BACnet object.

B. Electric Meter: Connect to the main switchboard (built-in meter), coordinate with Division 26.

C. LP Gas Meter: Provide a positive-displacement type gas meter where; measurement accuracy shall not affected by changes in specific gravity, changing pressures or fluctuating flows.
1. Rotatable cubic foot Index
2. Indoor/Outdoor, 100% sealed Index
3. Pulse Output
4. ANSI 150 Flange
5. Standards: EN12480, ISO9951, NMi, ANSI.

2.07 SENSING DEVICES

A. Where feasible, provide the same sensor type throughout the project. Avoid using transmitters unless absolutely necessary.

B. Thermistors: Precision thermistors may be used in applications below 200 degrees F. Sensor accuracy over the application range shall be 0.36 degree F or less between 32 to 150 degrees F. Stability error of the thermistor over five years shall not exceed 0.25 degree F cumulative. A/D conversion resolution error shall be kept to 0.1 degree F. Total error for a thermistor circuit shall not exceed 0.5 degree F.

C. Resistance Temperature Detectors (RTDs): Provide RTD sensors with platinum elements compatible with the digital controllers. Encapsulate sensors in epoxy, series 300 stainless steel, anodized aluminum, or copper. Temperature sensor accuracy shall be 0.1 percent (1 ohm) of expected ohms (1000 ohms) at 32 degrees F. Temperature sensor stability error over five years shall not exceed 0.25 degree F cumulative. Direct connection of RTDs to digital controllers without transmitters is preferred. When RTDs are connected directly, lead resistance error shall be less than 0.25 degrees F. The total error for a RTD circuit shall not exceed 0.5 degree F.

D. Temperature Sensor Details

1. Room Type: Provide the sensing element components within a decorative protective cover suitable for surrounding decor.

   a. Provide room temperature sensors with:

      1) Timed override button
      2) Local adjustment capability (programmable range).

a) Offices
b) Conference Rooms
c) Meeting Rooms

3) Guards: Locking; heavy-duty, transparent plastic; mounted on separate base.

2. Duct Probe Type: Ensure the probe is long enough to properly sense the air stream temperature.
3. Duct Averaging Type: Continuous averaging sensors shall be one foot in length for each 4 square feet of duct cross-sectional area, and a minimum length of 6 ft.
4. Pipe Immersion Type: Provide minimum three-inch immersion. Provide each sensor with a corresponding pipe-mounted sensor well, unless indicated otherwise. Sensor wells shall be stainless steel when used in steel piping, and brass when used in copper piping. Provide the sensor well with a heat-sensitive transfer agent between the sensor and the well interior.
5. Outside Air Type: Provide the sensing element on the building's north side with a protective weather shade that positions the sensor approximately 3 inches off the wall surface, does not inhibit free air flow across the sensing element, and protects the sensor from snow, ice, and rain.

E. Transmitters: Provide transmitters with 4 to 20 mA or 0 to 10 VDC linear output scaled to the sensed input. Transmitters shall be matched to the respective sensor, factory calibrated, and sealed. Size transmitters for an output near 50 percent of its full-scale range at normal operating conditions. The total transmitter error shall not exceed 0.1 percent at any point across the measured span. Supply voltage shall be 12 to 24 volts AC or DC. Transmitters shall have non-interactive offset and span adjustments. For temperature sensing, transmitter drift shall not exceed 0.03 degrees F a year.

F. Relative Humidity Transmitters: Provide transmitters with an accuracy equal to plus or minus 3 percent from 0 to 90% scale, and less than one percent drift per year. Sensing elements shall be the polymer type. Vaisala Model HMD50U or equal.

G. Current Transducers: Provide current transducers to monitor motor amperage, unless current switches are shown on design drawings or point tables.

H. Input Switches

1. Timed Local Overrides: Provide buttons or switches to override the DDC occupancy schedule programming for each major building zone during unoccupied periods, and to return HVAC equipment to the occupied mode. This requirement is waived for zones clearly intended for 24 hour continuous operation.
2. Freeze Protection Thermostats: Provide special purpose thermostats with flexible capillary elements 20 feet minimum length for coil face areas up to 40 square feet. Provide longer elements for larger coils at 1-foot of element for every 4 square feet of coil face area, or provide additional thermostats. Provide switch contacts rated for the respective motor starter's control circuit voltage. Include auxiliary contacts for the switch's status condition. A freezing condition at any 18-inch increment along the sensing element's length shall activate the switch. The thermostat shall be equipped with a manual push-button reset switch so that when tripped, the thermostat requires manual resetting before the HVAC equipment can restart.

I. Pressure Transmitters/Transducers:

1. Manufacturers:

a. BEC Controls Corporation.
b. General Eastern Instruments.
c. MAMAC Systems, Inc.
d. ROTRONIC Instrument Corp.
e. TCS/Basys Controls.
f. Vaisala.
g. Kele

2. Duct Differential Pressure Transmitters: Kele M30/40 and T30/40 Series, or approved equal; reliable, stable, low-air pressure transmitters with 4-20 mA outputs.
3. Duct pressure high-limit: Kele Model 1900-5-MR manual reset pressure switch is designed to monitor duct static and shut down the blower when excess pressure occurs. The switch must be manually reset before the system can start again. Switch contacts are SPDT with solder-type connections. The Model 1900-5-MR measures static pressure only, not differential pressure.
4. Air Differential Pressure Switches, Kele 1900 Series, are designed to monitor the differential pressure of air in HVAC applications. These automatic reset switches are available in ranges from 0.07" to 20" W.C. and shall have SPDT screw-type electrical connections.
5. Filter pressure drop: Kele Model A-602 air filter kit includes two static pressure tips and aluminum tubing and fittings, and it allows the a Kele 1900 Series to monitor filter pressure drop.
6. Static-Pressure Transmitter: Non-directional sensor with suitable range for expected input, and temperature compensated. Accuracy: 2 percent of full scale with repeatability of 0.5 percent. Output: 4 to 20 mA. Building Static-Pressure Range: 0- to 0.25-inch wg. Duct Static-Pressure Range: 0- to 5-inch wg.
7. Water Pressure Transducers: Stainless-steel diaphragm construction, suitable for service; minimum 150-psig operating pressure; linear output 4 to 20 mA.

J. Hydronic Remote Differential Pressure Transmitters: Bell & Gossett ST Series; Setra, or approved equal. Transmitter shall provide an isolated linear 4-20 mA dc output. The unit shall be accurate to ± 0.07% of full span, and shall withstand over ranges up to a static pressure of 2300 psi with negligible change in output. It shall have stainless steel wetted parts with 1/4" NPT process connection. Unit shall be protected against radio frequency interference and shall have a water tight (NEMA Type 6/6P) electrical enclosure with ½" NPT conduit connection.

K. Air Flow Measurement Devices (AMD)
1. Provide one AMD for each measurement location provided on the plans, schedules and/or control diagrams to determine the average airflow rate and temperature at each measurement location. The AMD shall be UL/cUL 873 Listed as an assembly.
2. EBTRON, Inc. Model HTx104-PE is basis of design. Airflow measurement devices shall use the principle of thermal dispersion and provide one self-heated bead-in-glass thermistor and one zero power bead-in-glass thermistor at each sensing node.
3. Each AMD shall be provided with a microprocessor-based transmitter and one or more sensor probes. Devices that have electronic signal processing components on or in the sensor probe are not acceptable.
4. Airflow measurement shall be field configurable to determine the average Actual or Standard mass airflow rate.
5. Actual airflow rate calculations shall have the capability of being corrected by the transmitter for altitudes other than sea level.
6. Temperature measurement shall be field configurable with velocity weighted average as the default, or manual selection of arithmetic average temperature.

7. Sensor Probes

   a. Sensor probes shall be constructed of gold anodized, 6063 aluminum alloy tube.
   b. Sensor probe mounting brackets shall be constructed of 304 stainless steel.
   c. Probe internal wiring between the connecting cable and sensor nodes shall be Kynar coated copper.
   d. Probe internal wiring connections shall consist of solder joints and spot welds.
   e. Internal wiring connections shall be sealed and protected from the elements. They shall be capable of direct exposure to water without affecting instrument operation.
   f. Each sensor probe shall be provided with an integral, FEP jacket, plenum rated CMP/CL2P, UL/cUL Listed cable rated for exposures from -67 °F to 392 °F (-55 °C to 200 °C) and continuous and direct UV exposure.
   g. Each sensor probe shall contain one or more independently wired sensing nodes.
   h. Sensor node airflow and temperature calibration data shall be stored in a serial memory chip in the cable connecting plug and not require matching or adjustments to the transmitter in the field.
   i. Each sensor node shall be provided with two bead-in-glass, hermetically sealed thermistors potted in a marine grade waterproof epoxy with sensor housings constructed of glass-filled polypropylene. Upon request, the manufacture shall provide a written independent laboratory test result of 100% survival rate in a 30 day saltwater and acid vapor test.
   j. Each thermistor shall be individually calibrated at a minimum of 3 temperatures to NIST-traceable temperature standards.
   k. Each sensor node shall be individually calibrated at 16 measurement points to airflow standards directly calibrated at NIST to the NIST Laser Doppler Anemometer (LDA) primary velocity standard and have an accuracy of ±2% of reading over the entire calibrated airflow range of 0 to 5,000 FPM (25.4 m/s)..
   l. Upon request the manufacture shall submit for AMD approval a copy of the actual NIST report of calibration used for the reference standard used.
   m. The accuracy shall include the combined uncertainty of the sensor nodes and transmitter.
   n. Devices whose overall accuracy is based on individual accuracy specifications of the sensor probes and transmitter shall demonstrate compliance with this requirement over the entire operating range.
   o. The installed airflow accuracy shall be:
   p. Ducts and Plenums - ±3% of reading when install in accordance with the manufactures recommended placement guidelines.

8. Transmitter

   a. A remotely located microprocessor-based transmitter shall be provided for each measurement location.
   b. All printed circuit board interconnects, edge fingers, and test points shall be gold plated.
   c. All printed circuit boards shall be electro-less nickel immersion gold plated.
   d. All integrated circuitry shall be temperature rated as ‘industrial-grade’. Submissions containing ‘commercial-grade’ integrated circuitry are not acceptable.
   e. The transmitter shall be capable of determining the airflow rate and temperature average of all connected sensor nodes in an array for a single location.
   f. Separate integration buffers shall be provided for display airflow output, airflow signal output (analog and network).
   g. The transmitter shall be capable of providing a high and/or low airflow alarm output with user-defined setpoint and % of setpoint tolerance. Alarm shall be capable of being manually or automatically reset and low-limit cutoff value may be selected to disable the alarm. An alarm delay function shall also be field defined.

h. The transmitter shall be capable of identifying an AMD malfunction via the system status alarm and ignore any sensor node that is in a fault condition.
i. The transmitter shall be capable of field configuration, diagnostics and include Field Output Adjustment Wizard that allows for a one or two point field adjustment to factory calibration for installations that require adjustment.
j. The transmitter shall be provided with a 16-character, alpha-numeric, LCD display.
k. The airflow rate, temperature, hi and/or low airflow set point alarm and system status alarm shall be visible on the display.
l. The transmitter shall be provided two field selectable (0-5/0-10 VDC or 4-20mA), scalable, isolated and over-current protected analog output signals.
m. Analog output signals shall provide the total airflow rate and be field configurable to output a system status alarm
n. The network communications RS-485 (field selectable BACnet MS/TP or Modbus RTU) shall provide: the average airflow rate, temperature, low and/or high airflow set point alarm, system status alarm, individual sensor node airflow rates, and individual sensor node temperatures.
o. The transmitter shall have an on-off power switch. Isolation transformers shall not be required.
p. The transmitter shall be powered by 24 VAC (22.8 to 26.4 under load) @11 V-A max. and use a power supply that is over-current and over-voltage protected.
q. The transmitter shall use “watch-dog” timer circuit to ensure automatic reset after power disruption, transients and brown-outs.
r. Each transmitter shall have an operating temperature range of -20° F to 160° F (-28.9° C to 71.1° C) and humidity range of 0 to 100% RH.

2.08 GAS DETECTION

A. CO/NO2 Gas Detector – Transmitters, Basis of Design: Brasch Model GSE.

1. The detector shall be an ETL listed unit containing a control board and sensor board that conforms completely to the UL 61010B-1 standard.
2. The NEMA 1 enclosure shall be constructed of heavy polycarbonate plastic, which consists of two pieces, cover and chassis. The cover shall close flush with the sides of the box and shall require a special tool to open it. The sensor module shall be protected from damage inside the enclosure and the cover shall contain screened openings to allow proper sensing. The openings shall conform to the UL 61010B-1 standard.
3. Input voltage: 24V. BAS contractor shall provide 24V power wiring.
4. The detector shall contain an electro-chemical carbon monoxide (CO) sensor with temperature compensation circuits and an electro-chemical nitrogen dioxide (NO2) sensor.
5. The enclosure shall be provided with four, ½” pre-punched openings for connection of field conduit. The detector shall include factory-installed wiring that exits the enclosure and allows for installation without the detector being opened.
6. The detector shall be protected against static discharge, excessive electrical noise, and tested for safety in accordance with the UL 61010B-1 standard.
7. The detector shall have a 0.5” minimum height, liquid crystal display (LCD) that will continually display the current nitrogen dioxide (NO2) and carbon monoxide (CO) level, in parts per million. The detector shall have a green “power” LED, a yellow “sensor-active” LED, a red “low-alert” LED, a red “high-alert” LED and a red “alarm” LED.
8. Overcurrent Protection: Provide power supply fuses of the time-lag type.
9. Switches and Controls:

a. The detector shall provide a 4–20 ma signal in direct relationship to gas concentrations. The signal types can be selected at time of order or changed in the field. This signal shall be compatible with the BAS system.

b. An external push button on the front of the enclosure shall be provided to silence the 106 dB internal alarm.
c. The alarm circuit shall become active again, once the detector is no longer at alarm levels.
d. Output relays providing a normally closed set of contacts for the low-alert and for the alarm shall be provided. These relays shall provide a fail-safe that will automatically activate ventilation equipment upon power loss to the sensor. The low-alert and high-alert relays shall be capable of being configured in the field for fan control. These relays shall be suitable for the connection of 24 VAC, 24 VA inductive circuits.
e. Switches shall be provided for field adjustment of the gas detection level for the low-alert, and of the on/off time delay for the low-alert and high-alert. Selectable time delays shall range from 0 to 7 minutes, in 1 minute increments.
f. Selectable CO detection levels shall range from 20 to 55 ppm.
g. Selectable NO2 detection levels shall range from 0.3 to 4.0 ppm.

10. Auto Technology, Vehicle Corridor: CO and NO2 Combination sensing. The detector shall have separate proportional outputs for CO and NO2 levels.

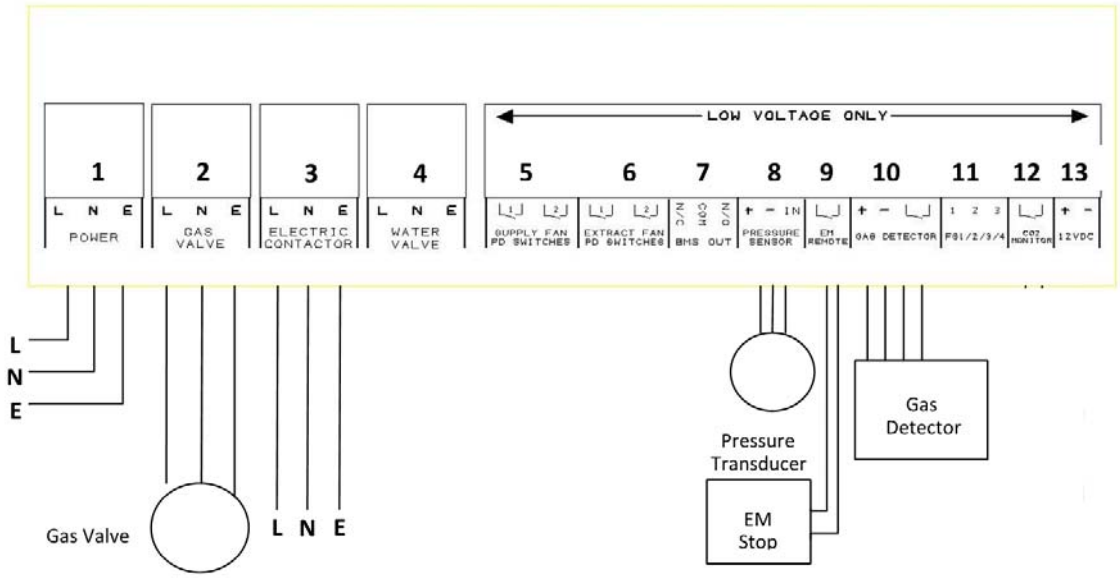
B. Carbon-Dioxide (CO2) Sensor:

1. Manufacturers: Vaisala GMW21 and GMD20 Series, Honeywell Model C7232, MSA Airox Model 711271, GE-Telaire.
2. Analog and a relay output, use non-dispersive infrared (NDIR) technology, and feature a unique corrosion-free sensing chamber for accurate, stable CO2 sensing.
3. Gold-plated sensor for long-term calibration stability
4. Automatic Background Calibration (ABC) algorithm based on long-term evaluation to reduce required maintenance. Manufacturer recommended calibration interval shall not be less than five years.
5. Configuration as indicated: Wall mount with LCD to provide sensor readings and status information or Duct mount as indicated.

2.09 SCIENCE LABORATORY UTILITY CONTROL

A. Scope Of Work:

1. Provide a laboratory safety utility controller for the Science Lab.
2. Division 23: Provide the utility controller panel, gas solenoid valve & wiring, remote emergency stop button & wiring, gas detector & wiring; gas pressure transducer & wiring.
3. Division 26: Power wiring to the controller; electrical power wiring from electrical-contactor, fire alarm interface.



B. Basis of Design: American Gas Safety “Merlin 1000S+”, or approved equal by ISIMET.

C. In the Science Lab, provide a Utility Controller with fascia panel mounted switches to activate remote solenoids and relays to control natural gas and electrical convenience outlets or other indicated services or devices. Utility Controller shall comply with Underwriter’s Laboratory UL61010-1 3rd Edition Standards. Controller shall have integrated printed circuit board and Microprocessor with adaptable programming features. Controller shall utilize and operate a pressure transducer to perform a pressure drop test on the gas line before allowing gas to be supplied. Controller shall continuously check incoming gas supply pressure throughout operation. Controller shall provide line voltage signals for output circuits. Controller shall provide inputs for remote EPO’s and Gas Sensors. The Controller shall be equipped with an Authority Key Lock that restricts activation of output signals to the instructor or educator. Controller shall be provided with a fascia mounted EPO button. Output signals will require Key Lock authority for re-set.

D. Each Controller shall be provided with a UL approved pressure transducer to be installed on the natural gas pipe, either via the solenoid valve or via a reducing fitting located as close to the solenoid valve as is permissible on the downstream side.

E. In the Science Lab where shown on Drawings, provide a UL approved solenoid for gas services Solenoid shall be normally closed and fail closed on loss of power.

F. Provide a wall mounted Remote Panic Button. Locate as shown on the plans. Integrate assembly with low voltage input on Controller.

G. Provide an AGS Merlin Fuel Gas Sensor in order to detect raw fuel gas within the classroom. Integrate Fuel Gas Sensor with the Controller.

H. System Configuration

1. Utility Controller shall be factory configured to the standard configurations and shall be capable of field adjustments to meet specific project modification requirements. Configurations are limited to DIP switch adjustments on rear of fascia panel without the requirement of additional equipment.

2. Time-Out Function: Controller shall be pre-set to shut down after either 2hrs, 4hrs 8hrs or have this function disabled. This configuration shall be adjusted via the DIP switches on the reverse side of the fascia panel.
3. Panic Alarm Re-Set: The Controller shall only re-set from panic alarm after engagement of the authority key on fascia panel and after local panic alarm has been re-set.
4. Fire Alarm Re-set: The Utility Controller shall be configured so that continued fire alarm signal to Controller shall prevent re-set.
5. The lab hood exhaust fan shall be integrated with Controller via the BMS output. Provide control wiring from Controller contacts to BMS and configure the Controller via the DIP switches on the reverse side of the fascia panel.

2.10 OUTPUT HARDWARE

A. Motorized control dampers, unless otherwise specified elsewhere, shall be as follows:

1. Submittals shall include leakage, maximum airflow and maximum pressure ratings based on AMCA Publication 500. Dampers shall meet the leakage requirements of the International Energy Conservation Code by leaking less than 3 cfm/sq. ft. at 1" of static pressure and shall be AMCA licensed as Class 1A. Dampers shall be Ruskin model CD60, or approved equal.
2. Control dampers shall be the parallel or opposed blade type as follows: Outdoor and/or return air mixing dampers shall be parallel blade, arranged to direct airstreams toward each other. Other modulating dampers shall be the opposed blade type. Two-position shutoff dampers may be parallel or opposed blade type with blade and side seals.
3. Frame: 5 inches x minimum 16 gage roll formed, galvanized steel hat-shaped channel, reinforced at corners. Structurally equivalent to 13 gage U-channel. Damper blades shall not exceed 8 inches in width or 48 inches in length. Blades shall be suitable for medium velocity performance 2000 fpm. Blades shall be not less than 16-gauge.
4. Bearings shall be corrosion resistant, permanently lubricated stainless steel sleeve type turning in an extruded hole in the damper frame.
5. All blade edges, top, and bottom of the frame shall be provided with replaceable butyl rubber or neoprene seals. Side seals shall be spring-loaded stainless steel.
6. Individual damper sections shall not be larger than 48 in. x 60 in. Provide a minimum of one damper actuator per section.
7. Modulating dampers shall provide a linear flow characteristic where possible.
8. Dampers shall have exposed linkages. Dampers over 48” in applications where sectioning is not applicable shall be supplied with a jackshaft to provide sufficient force throughout the intended operating range.

B. Electronic damper/valve actuation shall be provided.

1. Manufactured, brand labeled or distributed by BELIMO, or approved equal.
2. Size for torque required for damper seal at load conditions.
3. Coupling: V-bolt dual nut clamp with a V-shaped, toothed cradle.
4. Mounting: Actuators shall be capable of being mechanically and electrically paralleled to increase torque if required.
5. Overload protected electronically throughout rotation.
6. Fail-Safe Operation: Mechanical, spring-return mechanism.
7. Manual Positioning. Operators shall be able to manually position each actuator when the actuator is not powered. Non-spring-return actuators shall have an external manual gear release. Spring-return actuators with more than 7 N·m (60 in.-lb) torque capacity shall have a manual crank.
8. Proportional Actuators shall be fully programmable through an EEPROM without the use of actuator mounted switches.

9. Proportional actuators shall have an external, built-in switch to allow the reversing of direction of rotation.
10. Proportional actuators shall accept a 0 to 10 VDC or 0 to 20 mA control signal and provide a 2 to 10 VDC or 4 to 20 mA operating range. An actuator capable of accepting a pulse width modulating control signal and providing full proportional operation of the damper is acceptable. All actuators shall provide a 2 to 10 VDC position feedback signal.
11. Temperature Rating: -22 to +122ºF -30 to +50ºC [-58 to +122ºF -50 to +50ºC]
12. Housing: Minimum requirement NEMA type 2 mounted in any orientation. .
13. Agency Listings: ISO 9001, cULus, CE or CSA
14. The manufacturer shall warrant all components for a period of 5 years from the date of production, with the first two years unconditional.

C. Control Valves: Control valves shall be two-way or three-way type for two-position or modulating service as shown.

1. Close-off (differential) Pressure Rating: Valve actuator and trim shall be furnished to provide the following minimum close-off pressure ratings:

a. Two-way: 150% of total system (pump) head.
b. Three-way: 300% of pressure differential between ports A and B at design flow or 100% of total system (pump) head.

2. Water Valves: Body and trim style and materials shall be in accordance with manufacturer's recommendations for design conditions and service shown, with equal percentage ports for modulating service.

a. Sizing Criteria:

1) Two-position service: Line size.
2) Two-way modulating service: Pressure drop shall be equal to twice the pressure drop through heat exchanger (load), 50% of the pressure difference between supply/return mains, or 5 psi, whichever is greater.
3) Three-way modulating service: Pressure drop equal to twice the pressure drop through the coil exchanger (load), 5 psi maximum.

b. Valves ½ in. through 2 in. shall be bronze body or cast brass ANSI Class 250, spring-loaded, PTFE packing, quick opening for two-position service. Two-way valves to have replaceable composition disc or stainless steel ball.
c. Valves 2½ in. and larger shall be cast iron ANSI Class 125 with guided plug and PTFE packing.
d. Water valves shall fail normally open or closed, as specified.

D. Output Switches: Control Relays; Field installed and DDC panel relays shall be double pole, double throw, UL864 listed, with contacts rated for the intended application, indicator light, and dust proof enclosure. The indicator light shall be lit when the coil is energized and off when coil is not energized. Relays shall be the socket type, plug into a fixed base, and replaceable without tools or removing wiring. Encapsulated "PAM" type relays may be used for terminal control applications.

2.11 STATUS SENSORS

A. Status Inputs for Electric Motors: Veris Hawkeye 908 Series, or approved equal; split-core adjustable current sensors designed to provide accurate, reliable and maintenance-free fan and

pump status indication. Comply with ISA 50.00.01, current-sensing split-core transformers with self-powered transmitter, adjustable and suitable for 175 percent of rated motor current.

B. Current Switches: Self-powered, solid-state with adjustable trip current, selected to match current and system output requirements.

C. Electronic Valve/Damper Position Indicator: Visual scale indicating percent of travel and 2- to 10-V dc, feedback signal.

D. Water-Flow Switches: Bellows-actuated mercury or snap-acting type with pilot-duty rating, stainless-steel or bronze paddle, with appropriate range and differential adjustment, in NEMA 250, Type 1 enclosure.

2.12 ELECTRICAL POWER AND DISTRIBUTION

A. Transformers: Transformers shall conform to UL 506. For control power other than terminal level equipment, provide a fuse or circuit breaker on the secondary side of each transformer.

B. Surge and Transient Protection

1. Provide each digital controller with surge and transient power protection. Surge and transient protection shall consist of the following devices, installed externally to the controllers.
2. Power Line Surge Protection: Provide surge suppressors on the incoming power at each controller or grouped terminal controllers. Surge suppressors shall be rated in accordance with UL 1449, have a fault indicating light, and conform to the following:

    a. The device shall be a transient voltage surge suppressor, hard-wire type individual equipment protector for 120 VAC/1 phase/2 wire plus ground.
    b. The device shall react within 5 nanoseconds and automatically reset.
    c. The voltage protection threshold, line to neutral, shall be no more than 211 volts.
    d. The device shall have an independent secondary stage equal to or greater than the primary stage joule rating.
    e. The primary suppression system components shall be pure silicon avalanche diodes.
    f. The secondary suppression system components shall be silicon avalanche diodes or metal oxide varistors.
    g. The device shall have an indication light to indicate the protection components are functioning.
    h. All system functions of the transient suppression system shall be individually fused and not short circuit the AC power line at any time.
    i. The device shall have an EMI/RFI noise filter with a minimum attenuation of 13 dB at 10 kHz to 300 MHz.
    j. The device shall comply with IEEE C62.41.1 and IEEE C62.41.2, Class "B" requirements and be tested according to IEEE C62.45.
    k. The device shall be capable of operating between -20 degrees F and 122 degrees F.

3. Telephone and Communication Line Surge Protection: Provide surge and transient protection for DDC controllers and DDC network related devices connected to phone and network communication lines. The device shall provide continuous, non-interrupting protection, and shall automatically reset after safely eliminating transient surges. The protection shall react within 5 nanoseconds using only solid-state silicon avalanche

technology. The device shall be installed at the distance recommended by its manufacturer.

4. Controller Input/output Protection: Provide controller inputs and outputs with surge protection via optical isolation, metal oxide varistors (MOV), or silicon avalanche devices. Fuses are not permitted for surge protection.

C. Wiring: Provide complete electrical wiring for the DDC System, coordinate line of demarcation with Division 26. Unless indicated otherwise, provide all normally visible or otherwise exposed wiring in conduit. Where conduit is required, control circuit wiring shall not run in the same conduit as power wiring over 100 volts. Circuits operating at more than 100 volts shall be in accordance with Division 26. Run all circuits over 100 volts in conduit, metallic tubing, covered metal raceways, or armored cable. Use plenum-rated cable for circuits under 100 volts in enclosed spaces. Examples of these spaces include HVAC plenums, within walls, attics, or above suspended ceilings.

D. Power Wiring: The following requirements are for field-installed wiring:

1. Wiring for 24 V circuits shall be insulated copper 18 AWG minimum and rated for 300 VAC service.
2. Wiring for 120 V circuits shall be insulated copper 14 AWG minimum and rated for 600 VAC service.

E. Analog Signal Wiring: Field-installed analog signal wiring shall be 18 AWG single or multiple twisted pair. Each cable shall be 100 percent shielded and have a 20 AWG drain wire. Each wire shall have insulation rated for 300 VAC service. Cables shall have an overall aluminum-polyester or tinned-copper cable-shield tape.

PART 3 - EXECUTION

3.01 EXAMINATION

A. The project plans shall be thoroughly examined for control device and equipment locations. Any discrepancies, conflicts, or omissions shall be reported to the architect/engineer for resolution before rough-in work is started.

B. The contractor shall inspect the site to verify that equipment may be installed as shown. Any discrepancies, conflicts, or omissions shall be reported to the engineer for resolution before rough-in work is started. Verify that duct-, pipe-, and equipment-mounted devices and wiring are installed before proceeding with installation.

C. The contractor shall examine the drawings and specifications for other parts of the work. If head room or space conditions appear inadequate—or if any discrepancies occur between the plans and the contractor's work of others—the contractor shall report these discrepancies to the engineer and shall obtain written instructions for any changes necessary to accommodate the contractor's work with the work of others. Any changes in the work covered by this specification made necessary by the failure or neglect of the contractor to report such discrepancies shall be made by—and the expense of—this contractor.

3.02 INSTALLATION

A. Provide software in control units and operator workstation(s). Implement all features of programs to specified requirements and as appropriate to sequence of operation. Connect and configure equipment and software to achieve sequence of operation specified.

B. 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.

C. Provide equipment, piping, and wiring/raceway parallel to building lines (i.e., horizontal, vertical, and parallel to walls) wherever possible.

D. Provide sufficient slack and flexible connections to allow for vibration of piping and equipment.

E. 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.

F. 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.

G. 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.

H. Provide guards on wall room sensors:

1. Open walkway / corridor hallway areas; except Main Lobby and student Café.
2. Small Engines
3. Marine Tech
4. Fire EMS
5. Auto Collision
6. Auto tech
7. Welding
8. Carpentry
9. Machine Tool
10. Vestibules with overhead doors

I. 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.

J. 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.

K. Gas Monitor/Transmitters: Verify location of transmitter with room layout and details before installation. Do not exceed the manufactures' recommended maximum surveillance radius. Provide proper quantity as required. Mounting height shall be at manufacturer recommended height for the gas being sensed.

L. Energy Meters: Locate energy meters as indicated. Connect each meter output to the DDC system, to measure both instantaneous and accumulated energy usage.

M. Provide automatic dampers according to Section 233113 "Ductwork."

N. Provide damper motors on outside of duct in warm areas, not in locations exposed to outdoor temperatures.

O. Provide labels and nameplates to identify control components according to Section 230553 "Identification for HVAC Piping and Equipment."

P. 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.

Q. Provide steam and condensate instrument wells, valves, and other accessories according to Section 232216 Steam and Condensate Piping Specialties."

R. Provide refrigerant instrument wells, valves, and other accessories according to Section 232300 "Refrigerant Piping."

S. Provide duct volume-control dampers according to Section 233113 "Ductwork"

3.03 WIRING

A. All control and interlock wiring shall comply with national and local electrical codes, and Division 26 of this specification. Where the requirements of this section differ from Division 26, the requirements of this section shall take precedence.

B. Division 26 is providing line-voltage junction boxes throughout for control power. BAS contractor shall provide transformers and low-voltage wiring.

C. NEC Class 1 (line voltage) wiring shall be UL listed in approved raceway according to NEC and Division 26 requirements. Low-voltage wiring shall meet NEC Class 2 requirements. Low-voltage power circuits shall be sub-fused when required to meet Class 2 current limit.

D. Where NEC Class 2 (current-limited) wires are in concealed and accessible locations, including ceiling return air plenums, approved cables not in raceway may be used provided that cables are UL listed for the intended application.

E. Do not install Class 2 wiring in raceways containing Class 1 wiring. Boxes and panels containing high-voltage wiring and equipment may not be used for low-voltage wiring except for the purpose of interfacing the two (e.g. relays and transformers).

F. Where Class 2 wiring is run exposed, wiring is to be run parallel along a surface or perpendicular to it and neatly tied at 10 ft intervals.

G. Where plenum cables are used without raceway, they shall be supported from or anchored to structural members. Cables shall not be supported by or anchored to ductwork, electrical raceways, piping, or ceiling suspension systems.

H. All wire-to-device connections shall be made at a terminal block or terminal strip. All wire-to-wire connections shall be at a terminal block.

I. All wiring within enclosures shall be neatly bundled and anchored to permit access and prevent restriction to devices and terminals.

J. Maximum allowable voltage for control wiring shall be 120 V. If only higher voltages are available, the contractor shall provide step-down transformers.

K. All wiring shall be installed as continuous lengths, with no splices permitted between termination points.

L. Install plenum wiring in sleeves where it passes through walls and floors. Maintain fire rating at all penetrations.

M. Size of raceway and size and type of wire type shall be the responsibility of the contractor in keeping with the manufacturer’s recommendations and NEC requirements, except as noted elsewhere.

N. Include one pull string in each raceway 1 inch or larger.

O. Use color-coded conductors throughout with conductors of different colors.

P. Control and status relays are to be located in designated enclosures only. These enclosures include packaged equipment control panel enclosures unless they also contain Class 1 starters.

Q. Conceal all raceways except within mechanical, electrical, or service rooms.

R. Secure raceways with raceway clamps fastened to the structure and spaced according to code requirements. Raceways and pull boxes may not be hung on flexible duct strap or tie rods. Raceways may not be run on or attached to ductwork.

S. Adhere to this specification's Division 26 requirements where raceway crosses building expansion joints.

T. Install insulated bushings on all raceway ends and openings to enclosures. Seal top end of vertical raceways.

U. The contractor shall terminate all control and/or interlock wiring and shall maintain updated (as-built) wiring diagrams with terminations identified at the job site.

V. Flexible metal raceways and liquid-tight flexible metal raceways shall not exceed 1 m (3 ft) in length and shall be supported at each end. Flexible metal raceway less than ½ in. electrical trade size shall not be used. In areas exposed to moisture, including chiller and boiler rooms, liquid-tight, flexible metal raceways shall be used.

W. Raceway must be rigidly installed, adequately supported, properly reamed at both ends, and left clean and free of obstructions. Raceway sections shall be joined with couplings (according to code). Terminations must be made with fittings at boxes, and ends not terminating in boxes shall have bushings installed.

3.04 COMMUNICATION WIRING

A. The contractor shall adhere to the items listed in the "Wiring" article in Part 3 of the specification. All cabling shall be installed in a neat and workmanlike manner. Follow manufacturer's installation recommendations for all communication cabling

B. Do not install communication wiring in raceways and enclosures containing Class 1 or other Class 2 wiring.

C. Maximum pulling, tension, and bend radius for the cable installation, as specified by the cable manufacturer, shall not be exceeded during installation.

D. Contractor shall verify the integrity of the entire network following cable installation. Use appropriate test measures for each particular cable.

E. When a cable enters or exits a building, a lightning arrestor must be installed between the lines and ground. The lighting arrestor shall be installed according to manufacturer’s instructions.

F. All runs of communication wiring shall be unspliced length when that length is commercially available.

G. All communication wiring shall be labeled to indicate origination and destination data.

H. Grounding of coaxial cable shall be in accordance with NEC regulations article on "Communications Circuits, Cable, and Protector Grounding."

I. BACnet MS/TP communications wiring shall be installed in accordance with ASHRAE/ANSI Standard 135. This includes but is not limited to:

1. The network shall use shielded, twisted-pair cable with characteristic impedance between 100 and 120 ohms. Distributed capacitance between conductors shall be less than 100 pF per meter (30 pF per foot.)
2. The maximum length of an MS/TP segment is 1200 meters (4000 ft) with AWG 18 cable. The use of greater distances and/or different wire gauges shall comply with the electrical specifications of EIA-485.
3. The maximum number of nodes per segment shall be 32, as specified in the EIA 485 standard. Additional nodes may be accommodated by the use of repeaters.
4. An MS/TP EIA-485 network shall have no T connections.

J. Fiber Optic Cable: Maximum pulling tensions as specified by the cable manufacturer shall not be exceeded during installation. Post-installation residual cable tension shall be within cable manufacturer's specifications. All cabling and associated components shall be installed in accordance with manufacturers' instructions. Minimum cable and unjacketed fiber bend radii, as specified by cable manufacturer, shall be maintained.

3.05 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. Report results in writing.

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper unit operation. Remove and replace malfunctioning units and retest.
2. Test and adjust controls and safeties.
3. Test calibration of controllers by disconnecting input sensors and stimulating operation with compatible signal generator.
4. Test each point through its full operating range to verify that safety and operating control set points are as required.
5. Test each control loop to verify stable mode of operation and compliance with sequence of operation. Adjust PID actions.
6. Test each system for compliance with sequence of operation.
7. Test software and hardware interlocks.

B. DDC Verification:

1. Verify that instruments are installed before calibration, testing, and loop or leak checks.
2. Check instruments for proper location and accessibility.
3. Check instrument installation for direction of flow, elevation, orientation, insertion depth, and other applicable considerations.
4. Check instrument tubing for proper fittings, slope, material, and support.
5. Check installation of air supply for each instrument.
6. Check flow instruments. Inspect tag number and line and bore size, and verify that inlet side is identified and that meters are installed correctly.
7. Check pressure instruments, piping slope, installation of valve manifold, and self-contained pressure regulators.
8. Check temperature instruments and material and length of sensing elements.
9. Check control valves. Verify that they are in correct direction.
10. Check air-operated dampers. Verify that pressure gages are provided and that proper blade alignment, either parallel or opposed, has been provided.
11. Check DDC system as follows:

    a. Verify that DDC controller power supply is from emergency power supply, if applicable.
    b. Verify that wires at control panels are tagged with their service designation and approved tagging system.
    c. Verify that spare I/O capacity has been provided.
    d. Verify that DDC controllers are protected from power supply surges.

C. Replace damaged or malfunctioning controls and equipment and repeat testing procedures.

3.06 ADJUSTING

A. Calibrating and Adjusting:

1. Calibrate instruments.
2. Make three-point calibration test for both linearity and accuracy for each analog instrument.

3. Calibrate equipment and procedures using manufacturer's written recommendations and instruction manuals. Use test equipment with accuracy at least double that of instrument being calibrated.
4. Control System Inputs and Outputs:

    a. Check analog inputs at 0, 50, and 100 percent of span.
    b. Check analog outputs using milliampere meter at 0, 50, and 100 percent output.
    c. Check digital inputs using jumper wire.
    d. Check digital outputs using ohmmeter to test for contact making or breaking.
    e. Check resistance temperature inputs at 0, 50, and 100 percent of span using a precision-resistant source.

5. Flow:

    a. Set differential pressure flow transmitters for 0 and 100 percent values with 3-point calibration accomplished at 50, 90, and 100 percent of span.
    b. Manually operate flow switches to verify that they make or break contact.

6. Pressure:

    a. Calibrate pressure transmitters at 0, 50, and 100 percent of span.
    b. Calibrate pressure switches to make or break contacts, with adjustable differential set at minimum.

7. Temperature:

    a. Calibrate resistance temperature transmitters at 0, 50, and 100 percent of span using a precision-resistance source.
    b. Calibrate temperature switches to make or break contacts.

8. Stroke and adjust control valves and dampers without positioners, following the manufacturer's recommended procedure, so that valve or damper is 100 percent open and closed.
9. Stroke and adjust control valves and dampers with positioners, following manufacturer's recommended procedure, so that valve and damper is 0, 50, and 100 percent closed.
10. Provide diagnostic and test instruments for calibration and adjustment of system.
11. Provide written description of procedures and equipment for calibrating each type of instrument. Submit procedures review and approval before initiating startup procedures.

B. Adjust initial temperature and humidity set points.

C. Laboratory Safety Device System

1. Prior to placing the Utility Controller System into service, perform ALL Start-Up procedures and checklists as stated in Manufacturer’s Operations and Maintenance Procedure
2. Verify that all components and devices comply with manufacturer’s requirements and recommendations and that all devices and installations conform to Drawings and specification requirements.
3. Upon completion of ALL Start-Up tests, place the system into service. Complete all warranty registration documents. Submit originals with other project related closeout and O & M documentation. Review all operating procedures with a representative of the owner. Provide all System Authority Keys to the owner’s representative.

D. 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 three visits to Project during other than normal occupancy hours for this purpose.

3.07 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 16 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

3.08 TEST AND BALANCE SUPPORT

A. The controls contractor shall coordinate with and provide on-site support to the test and balance (TAB) personnel This support shall include:

1. On-site operation and manipulation of control systems during the testing and balancing.
2. Control setpoint adjustments for balancing all relevant mechanical systems.
3. Tuning control loops with setpoints and adjustments determined by TAB personnel.

3.09 CONTROLS SYSTEM OPERATORS MANUALS

A. Provide three electronic and printed copies of a Controls System Operators Manual. The manual shall be specific to the project, written to actual project conditions, and provide a complete and concise depiction of the installed work. Provide information in detail to clearly explain all operation requirements for the control system.

B. Provide with each manual: CDs of the project's control system drawings, control programs, data bases, graphics, and all items listed below. Include gateway back-up data and configuration tools where applicable. Provide CDs in jewel case with printed and dated project-specific labels on both the CD and the case. For text and drawings, use Adobe Acrobat or MS Office file types. When approved by the Owner, AutoCAD and Visio files are allowed. Give files descriptive English names and organize in folders.

C. Provide printed manuals in sturdy 3-ring binders with a title sheet on the outside of each binder indicating the project title, project location, contract number, and the controls contractor name, address, and telephone number. Each binder shall include a table of contents and tabbed dividers, with all material neatly organized. Manuals shall include the following:

1. A copy of the as-built control system (shop) drawings set, with all items specified under the paragraph "Submittals." Indicate all field changes and modifications.
2. A copy of the project's mechanical design drawings, including any official modifications and revisions.
3. A copy of the project's approved Product Data submittals provided under the paragraph "Submittals."
4. A copy of the project's approved Performance Verification Testing Plan and Report.
5. A copy of the project's approved final TAB Report.
6. Printouts of all control system programs, including controller setup pages if used. Include plain-English narratives of application programs, flowcharts, and source code.
7. Printouts of all physical input and output object properties, including tuning values, alarm limits, calibration factors, and set points.
8. A table entitled "AC Power Table" listing the electrical power source for each controller. Include the building electrical panel number, panel location, and circuit breaker number.
9. The DDC manufacturer's hardware and software manuals in both print and CD format with printed project-specific labels. Include installation and technical manuals for all controller hardware, operator manuals for all controllers, programming manuals for all controllers, operator manuals for all workstation software, installation and technical manuals for the workstation and notebook, and programming manuals for the workstation and notebook software.
10. A list of qualified control system service organizations for the work provided under this contract. Include their addresses and telephone numbers.
11. A written statement entitled "Software Upgrades" stating software and firmware patches and updates will be provided upon request at no additional cost to the Owner for a minimum of two years from contract acceptance. Include a table of all DDC system software and firmware provided under this contract, listing the original release dates, version numbers, part numbers, and serial numbers.

D. Provide a sample output of a quarterly summary report of energy usage from the data acquisition server

3.10 CLEANING

A. The contractor shall clean up all debris resulting from his/her activities daily. The contractor shall remove all cartons, containers, crates, etc., under his/her control as soon as their contents have been removed. Waste shall be collected and placed in a designated location.

B. At the completion of work in any area, the contractor shall clean all work, equipment, etc., keeping it free from dust, dirt, and debris, etc.

C. At the completion of work, all equipment furnished under this section shall be checked for paint damage, and any factory-finished paint that has been damaged shall be required to match the adjacent areas. Any cabinet or enclosure that has been deformed shall be replaced with new material and repainted to match the adjacent areas.

END OF SECTION

SECTION 23 09 01

VARIABLE FREQUENCY DRIVES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section 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

1.03 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

1.04 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.

1.05 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

2.01 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

2.02 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]** [**ModBus RTU][Johnson Controls Metasys N2][LonWorks][Siemens Apogee P1]** 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. The 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

3.01 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.

3.02 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.

3.03 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.

3.04 IDENTIFICATION

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

3.05 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.

3.06 CONNECTIONS

A. Conduit installation requirements are specified in other Division 26 Sections. Drawings indicate general arrangement of conduit, fittings, and specialties.

B. Ground equipment according to Division 26 Section "Grounding and Bonding."

3.07 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.

3.08 ADJUSTING

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

3.09 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

SECTION 23 09 93

SEQUENCE OF OPERATIONS FOR HVAC CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 23 Section “Common Work Results for Mechanical”
2. Section 23 09 00 – “Direct Digital Control (DDC) System”
3. Division 23 Sections – Equipment with built in DDC controllers
4. Division 23 Section “Testing, Adjusting, and Balancing”
5. Division 26

C. Refer to Division 1 Section “Alternates”.

1.02 GENERAL

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. The system is BAS controlled using electric actuation.

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. These sequences are intended to be performance based. Provide components and software to meet sequences and system intent, regardless if the information is shown in the points-lists, sequences, or drawings. Implementations that provide the same functional result using different underlying detailed logic will be acceptable.

C. Review the chiller, boiler, or heat pump manufacturer’s instructions, modify/provide proper sequencing per manufacturer’s requirements.

D. Unless otherwise indicated, control loops shall be enabled and disabled based on the status of the system being controlled to prevent windup. When a control loop is enabled or re-enabled, it and all its constituents (such as the proportional and integral terms) shall be set initially to a Neutral value. A control loop in Neutral shall correspond to a condition that applies the minimum control effect, i.e., valves/dampers closed, VFDs at minimum speed, etc.

E. The term “proven” (i.e., “proven on”/ “proven off”) shall mean that the equipment’s DI status point (where provided, e.g. current switch, DP switch, or VFD status) matches the state set by the equipment’s DO command point.

F. The term “software point” shall mean an analog variable, and “software switch” shall mean a digital (binary) variable, that are not associated with real I/O points. They shall be read/write capable (e.g., BACnet analog variable and binary variable).

G. 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.

H. To avoid abrupt changes in equipment operation, the output of every control loop shall be capable of being limited by a user adjustable maximum rate of change, with a default of 25% per minute.

I. Setpoints, timers, deadbands, PID gains, etc., listed in sequences shall be adjustable by the user with appropriate access level whether indicated as adjustable in sequences or not. Software points shall be used for these variables. Fixed scalar numbers shall not be embedded in programs except for physical constants and conversion factors.

J. Values for all points, including real (hardware) points used in control sequences shall be capable of being overridden by the user with appropriate access level (e.g., for testing and commissioning). If hardware design prevents this for hardware points, they shall be equated to a software point and the software point shall be used in all sequences.

K. 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

L. Provide Sequenced starting of HVAC equipment, whether or not specifically mentioned in each Sequence of Operation: At initial start-up; for automatic starting on emergency power, or after power blackout.

M. Setback Controls:

1. Heating systems shall be equipped with controls configured to automatically restart and temporarily operate the system as required to maintain zone temperatures above an adjustable heating setpoint at least 10°F below the occupied heating setpoint.
2. Cooling systems shall be equipped with controls configured to automatically restart and temporarily operate the mechanical cooling system as required to maintain zone temperatures below an adjustable cooling setpoint at least 5°F above the occupied cooling setpoint or to prevent high space humidity levels.
3. Optimum Start Controls. Individual heating and cooling systems with setback controls shall have optimum start controls. The control algorithm shall, as a minimum, be a function of the difference between space temperature and occupied setpoint, the outdoor temperature, and the amount of time prior to scheduled occupancy.

N. 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.

O. Variable Frequency Drives

1. To avoid operator confusion, the speed command point (and speed feedback point, if used) for VFDs should be configured so that a speed of 0% corresponds to 0 Hz and 100% corresponds to maximum speed set in the VFD, not necessarily 60 Hz. The maximum speed may be limited below 60 Hz to protect equipment or it may be above 60 Hz for direct drive equipment. Many times drives are configured such that a 0% speed signal corresponds to the minimum speed programmed into the VFD, but that causes the speed AO value and the actual speed to deviate from one another.
2. For each piece of equipment, the minimum speed shall be stored in a single software point. This value shall be written to the VFD's minimum speed setpoint via the drive's network interface; in the case of a hard-wired VFD interface, the minimum speed shall be the lowest speed command sent to the drive by the BAS.
3. Current VFD status and operating conditions shall be monitored through its communications interface port. The interface shall monitor the following software points: Motor RPM, motor amps, motor runtime, VFD status, "In fault condition", and "In bypass".
4. System Dampers:

    a. Damper control typically consists of a requirement to open a damper (such as an outdoor air damper) before the motor is to operate in any mode (drive or bypass). This means that a "start" or "run" command can come from the BAS, an operator at the VFD provides a local "start" command at the VFD keypad, or the command can come from the serial communication connection.
    b. After a run command is received, but before the VFD actually runs the motor, the VFD shall close a relay contact to actuate the damper. When the damper is fully open, an end switch from the damper will close and then the VFD will be allowed to operate the motor. The damper end-switches shall be mounted such that they can be adjusted during start-up so the open indication is only provided when the damper is in the fully open position.
    c. Ensure that the VFD has an input that when activated, will stop the motor in any VFD operating mode as well as bypass.

P. Alarms

1. All alarms shall include a Time/Date Stamp using the standalone control module time and date.
2. Each alarm can be configured in terms of criticality (Critical/Not Critical), operator acknowledgement (Requires Acknowledgement/Does Not Require Acknowledgement), and conditions required for an alarm to clear automatically (Requires Acknowledgement of a Return to Normal/Does Not Require Acknowledgement of a Return to Normal).
3. An operator shall be able to sort alarms based on level, time/date, and current status.
4. Alarms should be reported with the following information:

    a. Date and time of the alarm
    b. Level of the alarm
    c. Description of the alarm
    d. Equipment tags for the units in alarm
    e. Possible causes of the alarm, if provided by the fault detection routines
    f. The source that serves the equipment in alarm

5. There shall be 5 levels of alarm: See Points List.
6. The BAS contractor shall review the alarm levels and criticality with the Owner. Include at least four (4) hours of time for assisting the owner in setting up the system and programming alarm levels and responses (i.e. text message or other notifications).

7. Hierarchical Alarm Suppression: For each piece of equipment or space controlled by the BAS, define its relationship (if any) to other equipment in terms of “source,” “load,” or “system.”

    a. Source: A component is a “source” if it provides resources to a downstream component, such as a chiller providing chilled water to an AHU.
    b. Load: A component is a “load” if it receives resources from an upstream component, such as an AHU that receives chilled water from a chiller.
    c. The same component may be both a load (receiving resources from an upstream source) and a source (providing resources to a downstream load).
    d. System: A set of components is a “system” if they share a load in common (i.e., collectively act as a source to downstream equipment, such as a set of chillers in a lead/lag relationship serving air handlers).

        1) If a single component acts as a source for downstream loads (e.g., an AHU as a source for its VAV boxes), then that single source component shall be defined as a “system” of one element.
        2) For equipment with associated pumps (chillers, boilers, heat pumps):

            a) If the pumps are in a one-to-one relationship with equipment they serve, the pumps shall be treated as part of the system to which they are associated (i.e., they are not considered loads) since a pump failure will necessarily disable its associated equipment.
            b) If the pumps are headered to the equipment they serve, then the pumps may be treated as a system, which is a load relative to the upstream equipment (e.g., chillers) and a source relative to downstream equipment (e.g., air handlers).

    e. For each system as defined above, there shall be a SystemOK flag, which is either true or false.
    f. SystemOK shall be true when all of the following are true:

        1) The system is proven on.
        2) The system is achieving its temperature and/or pressure setpoint(s) for at least five minutes
        3) The system is ready and able to serve its load

    g. SystemOK shall be false while the system is starting up (i.e., before reaching setpoint) or when enough of the system’s components are unavailable (in alarm, disabled, or turned off) to disrupt the ability of the system to serve its load. This threshold shall be defined by the design engineer for each system.

        1) By default, Level 1 through Level 3 component alarms (indicating equipment failure) shall inhibit SystemOK. Level 4 and Level 5 component alarms (maintenance and energy efficiency alarms) shall not affect SystemOK.
        2) The operator shall have the ability to individually determine which component alarms may or may not inhibit SystemOK.

    h. The BAS shall selectively suppress (i.e., fail to announce; alarms may still be logged to a database) alarms for load components if SystemOK is false for the source system that serves that load.

        1) If SystemOK is false for a cooling water system (i.e., chiller, heat pump, or associated pump) then only high temperature alarms from the loads shall be suppressed.

2) If SystemOK is false for a heating water system (i.e., boiler or associated pump) then only low temperature alarms from the loads shall be suppressed.
3) If SystemOK is false for an airside system (air handler, VAV box, etc.), then all alarms from the loads shall be suppressed.

i. This hierarchical suppression shall cascade through multiple levels of load-source relationship, such that alarms at downstream loads shall also be suppressed.
j. The following types of alarms will never be suppressed by this logic:

1) Life/safety and Level 1 alarms
2) Failure-to-start alarms (i.e., equipment is commanded on, but status point shows equipment to be off)
3) Failure-to-stop/hand alarms (i.e., equipment is commanded off, but status point shows equipment to be on)

Q. Time-Based Suppression Block: This block is used to suppress reset requests and alarms after a change in setpoint. This includes automatic changes in setpoint, e.g., due to a change in occupancy sensor status, as well as changes made by occupants. This block shall calculate a time delay period after any change in setpoint based on the difference between the controlled variable (e.g., zone temperature) at the time of the change and the new setpoint. The default time delay period shall be:

1. For thermal zone temperature alarms: 10 minutes per °F of difference, but no longer than 120 minutes
2. For thermal zone temperature cooling requests: 5 minutes per °F of difference, but no longer than 30 minutes
3. For thermal zone heating requests: 5 minutes per °F of difference, but no longer than 30 minutes

R. Normal positions for controlled devices:

1. Unless noted, the following valves and dampers shall fail closed:

a. Outside air dampers
b. Exhaust air closure dampers
c. Cooling coil valves for coils located indoors shall close to the coil.
d. Domestic hot water heat source.

2. Unless noted, the following valves and dampers shall fail open:

a. Heating coils.
b. Cooling coil valves for coils located outdoors shall open to the coil.

1.03 GRAPHICAL USER INTERFACE

A. All points, trends, and alarms shown in the points list or described in the sequence shall be shown on the graphics.

B. BACnet Points – Available BACnet data shall be integrated and displayed:

1. Heat Pumps (Alternate #1)
2. Boiler Controller
3. Chiller

4. DOAS
5. AHU
6. MUA
7. Pumps
8. Destratification Fans

C. All setpoints including setpoints internal to control algorithms shall be adjustable from all BAS operator interfaces. All commands shall be overrideable from all BAS operator interfaces. All control points shall be adjustable or overrideable from the same graphic page that displays the points.

D. All points required by the sequence of operation including, but not limited to, the points listed in the sequences of operation below, as well as all of the points' associated values, shall be connected to the BAS and available to the BAS operators on all operator workstations and all operator interface devices as part of a graphical display that depicts the mechanical system controlled.

E. Provide runtimes of all pumps, air handlers, and fans at the BAS.

F. For Maine Advanced Buildings points.

PART 2 - SEQUENCES OF OPERATION

2.01 MAINE ADVANCED BUILDINGS

A. Whole Building Metering

1. Provide the building with measurement equipment including measurement devices capable or measuring whole-building electric and heating hot water usage in one-hour intervals. Refer to Section 230900-2.06 for the data acquisition server and meter specs.
2. Collect and collate the signals from the measurement devices and translate them into usage data to be displayed on the user interface. Display energy usage for current day, previous day, and same day of previous year; monthly data and cumulative energy usage for previous 12 months.
3. Program the data acquisition server to generate a quarterly summary report of energy usage.
4. Provide 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).

B. Fault Detection & Diagnostics (FDD): Provide storage in the BAS for a minimum of six (6) months of faults.

2.02 PEAK DEMAND LIMITING (PDL)

A. 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.

2.03 PUMPS

A. Typical for all pumps.

1. The BAS system shall use DI status wired to each VFD or pump controller to confirm the pumps are in the desired state (i.e. ON or OFF).
2. Generate an alarm if status deviates from BAS start/stop control.
3. Pumps shall be provided with automatic lead lag control and run-time equalization.

2.04 CHILLER PLANT - CH-1 Base Bid (HP-1-6 Alternate #1)

A. Provide a run signal to start the pumps on a call for cooling (or heating for heat pumps).

B. Chiller or heat pump can start upon proof of water flows.

C. When enabled, the chiller/heat pumps operate through their own factory controllers, subject to its own internal safeties and controls.

D. Provide a 3-way valve to control the HCR water temperature. When changing from heating mode to cooling mode, the 3-way valve shall be controlled to slowly (over 4 hour period) drop the water temperature.

E. Chiller Freeze Protection

1. Evaporator heater is provided by 23 64 26.
2. System shall have 25% propylene glycol.
3. During cold temperatures (below 20F), start the chiller pump at 33% (adj.) GPM to keep the water moving to the chiller on the roof. The 3-way valve shall be closed to the system.

F. Primary pumps (P-CH1/P-CH2/P-CH3) and well water pumps:

1. Provide constant primary flow to the chiller
2. For the heat pumps, the GPM (source and load) shall stage to match the heat pumps that are operating. Isolation valves shall open to allow the heat pumps to run. Pump flows shall modulate as heat pump isolation valves open and close. Note: The heat pumps will be piped with pressure compensating balancing valves.
3. Isolation valves shall be 2-way or 3-way as indicated.

G. Geothermal: BAS system shall monitor water temperatures to and from the borefield, as well as borefield pressure. This data shall be logged and accessible for a minimum of 1 year for troubleshooting purposes. See Sheet G-1.0 and specification 237000.

2.05 BOILER PLANT CONTROL – CONDENSING BOILER PLANT

A. BAS shall enable the boiler plant. Manual enable, or, boiler plant shall be enabled upon a call for heating for more than 5 minutes.

B. Heating Primary Loop Control

1. Input Device: Supply and return header temperature sensors.
2. Boiler plant shall be controlled by a Boiler Plant Controller specified in Section 23 52 16. Each boiler shall run subject to its own internal safeties and controls.
3. Provide 160°F primary hot water to meet DHW heater demand. When the DHW demand is satisfied, boilers shall be controlled to provide 140°F hot water.

C. Heating Injection into CH/HWS loop (P-H1, P-H2) – See "Heating/Cooling-Water Supply Temperature Reset" paragraph hereinafter.

D. Alternate #1 geothermal has smaller boilers – with hydraulic separator and primary pumps. These pumps shall be integrated with the boiler controller.

E. Combustion air: Direct piped; combustion air damper control not required.

2.06 DHW HEATER

A. Integrate with the solar controller furnished by Section 23 56 13. Provide supplementary controls as needed for a complete and functioning system.

B. Control DHW Heating Pumps (P-D1, P-D2):

1. Input Device: the DHW Controller specified in Section 23 56 13.
2. Output Device: BAS software
3. Action: Energize pump on a call for DHW heating. Maintain tank storage temperature, 140°F.

C. Solar loop temperature

1. Input Device: Solar Controller
2. Output Device: BAS Software, start command.
3. Action: Provide control of UH-2 in the solar water circuit. If water temperature exceeds high limit (temperature as determined by the solar manufacturer specified in Section 23 56 13), a motorized diverter 3-way valve shall open to UH-2 and the UH-2 fan shall be energized.

2.07 HEATING/COOLING DISTRIBUTION LOOP

A. Two Pipe Changeover

1. Input Device: BAS software
2. Output Device: BAS system command
3. Action

a. The school staff shall have a BAS switch to seasonally switch between heating and cooling mode.

1) Cooling to heating: October 15 +/-
2) Heating to cooling: May 15 +/-
3) Chart below indicates monthly average temperatures for Knox County Regional Airport:

	Annual (d)	Jan (e)	Feb (f)	Mar (g)	Apr (h)	May (i)	Jun (j)	Jul (k)	Aug (l)	Sep (m)	Oct (n)	Nov (o)	Dec (p)
Tavg	**44.8**	**22.1**	**24.9**	**32.3**	**41.7**	**50.8**	**59.6**	**65.2**	**64.7**	**57.9**	**47.5**	**39.5**	**29.6**

b. Changeover shall be automatic, upon toggling the switch. Provide a deadband between chilled water mode and hot water mode of at least 15°F ambient outdoor dry bulb air temperature.
c. The controls shall require the system to operate in one mode for at least 4 hours before changing over to the other mode.

B. Heating/Cooling-Water Supply Temperature Reset:

1. Input Device: Outside air temperature value from BAS software
2. Input Devices: Supply and main return temperature sensors.
3. Input Device: Geo heat pumps - The return water temperature to the heat pumps shall be used as the control point. Use this signal and offset the temperature by the rise of the heat pumps at the flow rate (~7F in heating, ~11F in cooling).
4. Output Device: BAS software, supply loop temperature setting.
5. Output Device: BAS DO pump enable
6. Output Device: BAS AO to heating injection pump VFD speed.
7. Action, cooling: The chiller/HP controller shall receive an AO signal from the BAS system. This AO shall be used to reset chilled water temperature setpoint.
8. Action, heating – gas boilers: Modulate the heating injection pump speed (P-H1, P-H2) from 40% to 100% to satisfy temperature setpoint.
9. Action, heating – heat pump, the controller shall receive an AO signal from the BAS system. This AO shall be used to reset hot water temperature setpoint.

    a. The Alternate #1 heat pumps are not sized for the full heating load. During extreme cold weather, supplementary boiler heating will be needed. The boiler heating shall come on as a 2nd stage when the heat pumps cannot maintain the setpoint. Modulate the heating injection pump speed.

10. Action, reset: Provide controls so that the heating and cooling supply temperatures are no more than 30°F apart at the changeover point. Reset heating-water supply temperature in straight-line relationship with outdoor-air temperature for the following conditions:

    a. 120°F heating water when outdoor-air temperature is 0°F.
    b. 80°F heating water when outdoor-air temperature is 60°F.
    c. Chilled water resets from 45°F to 50°F.

C. Enable: Secondary System Circulating Pumps (P-HC1 / HC2 / HC3):

1. Input Device: BAS software
2. Output Device: BAS DO start command to pump VFD.
3. Action: Energize pump
4. Action: The smart pump VFD's shall modulate as required to maintain pressure setpoint.

D. Secondary System Minimum Flow Control: Provide 3-way valves as indicated at terminal units.

2.08 DEDICATED OUTSIDE AIR SYSTEMS (DOAS & AHU)

A. The BAS contractor shall coordinate and interface with the DOAS & AHU unit controllers specified in Section 237200 “Air-To-Air Energy Recovery Equipment”. The BAS contractor shall provide supplemental controls, wiring, and other items as required for proper unit function.

B. Coordination of Sequences: Ensure that all coil controls have common inputs and do not overlap in function. Provide a deadband between heating and cooling stages.

C. Start and Stop Supply Fan:

1. Initiate: Occupied Time Schedule:

    a. Input Device: BAS system time schedule. Occupied mode shall be determined by a user defined occupancy schedule.
    b. Output Device: Run command to unit.
    c. Action: Energize unit controller.
    d. Provided an optimal start sequence: This sequence shall use the BAS to determine the length of time required to bring each zone from night setback temperature to the occupied setpoint temperature. The system shall wait as long as possible before starting, so that the temperature in each zone reaches occupied setpoint just in time for occupancy. This optimal starting time shall be determined using the difference between actual zone temperature and occupied setpoint. The BAS shall compare the difference with the historical performance of how quickly the zone has been able to warm up or cool down.

2. Initiate: Unoccupied Time Schedule

    a. Input Device: Time schedule
    b. Output Device: Stop command to unit controller.
    c. Action: Unit shutdown.
    d. Provide an optimal stop sequence: At the end of the occupied period, the system is shut off and the temperature is allowed to drift away from occupied setpoint. Optimal stop shall use the BAS to determine how early heating and cooling can be shut off for each zone, so that the indoor temperature drifts 1F from occupied setpoint for the last hour of the day.

3. Supply Fan VFD Control - DOAS: Normal mode is constant airflow. The airflow setting shall be adjustable through the BAS.
4. Supply Fan VFD Control - AHU: VAV using duct pressure sensing.

    a. Input Device: Static-pressure transmitter sensing supply-duct static pressure. Locate the sensor in a position such that the controller setpoint is no greater than 1/3 the total design fan static pressure.
    b. Output Device: 0-10VDC BAS system analog output to DOAS/AHU unit terminal block (units have factory provided VFD’s).
    c. Action: Supply 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. Static pressure setpoint shall be reset based on the zone requiring the most pressure; i.e., the setpoint is reset lower until one zone damper is nearly wide open. Controls shall provide the following:

        1) Monitor zone damper positions or other indicator of need for static pressure
        2) Automatically detect those zones that may be excessively driving the reset logic and generate a Level 5 alarm to the BAS.

3) Readily allow operator removal of zone(s) from the reset algorithm

D. Exhaust Fan VFD: The exhaust fan shall track the outside air damper using the unit controller as specified in Section 237200.

E. Outside Air & Recirculated Air:

1. The recirculated air damper will operate inverse of the outdoor air damper. The outdoor air damper will open to a Minimum Outdoor Air Position (Min OA) when in occupied mode.
2. The units will have an airflow monitor, furnished with the unit – See 237200.
3. AHU: Minimum outside air shall be maintained using the airflow monitor furnished with the unit. The BAS shall control the outside air dampers to maintain the minimum outside airflow setpoint.
4. DOAS units are normally 100% outside air during occupied mode.

F. Economizer: Control by DOAS/AHU unit controller – see 237200.

G. Energy Recovery Wheel Sequence: Control by DOAS/AHU unit controller – see 237200.

H. Coil Valve Control: The BAS shall be programmed for “cooling mode” or “heating mode”. The system is 2-pipe changeover, the AHU/DOAS units have separate chilled water and hot water coils.

1. Input Device: Discharge temperature sensor provided by BAS contactor.
2. The units shall have separate coils and control valves. The heating valve or cooling valve shall be active, depending on the plant heating or cooling mode.
   a. Heating Output Device: Modulating normally open 3-way control valve, provided by the BAS contractor. Chilled water valve closed.
   b. Cooling Output Device: Modulating normally closed control valve (2-way or 3-way as scheduled), provided by the BAS contractor. Heating valve closed.
3. Action - AHU: Modulate coils to maintain a 55°F supply air temperature. Provide outside air temperature reset of the supply temperature.
4. Action - DOAS: The heating and cooling coils shall modulate to maintain space temperature and humidity setpoints as sensed by wall sensors.
5. Action – DOAS Dehumidification: The cooling coils shall modulate to maintain space humidity setpoints. Since this is a 2-pipe changeover system, hot water reheat will not be available. If the space temperature drops 3°F below setpoint, the dehumidification sequence shall temporarily stop.

I. System safeties, as described below, prevent operation of the DOAS/AHU unit whenever a safety device is activated. Whenever a safety device is activated the unit shall be in STOP mode.

1. Enable: Freeze Protection:

   a. Input Device: Discharge air temperature sensor
   b. Output Device: BAS software
   c. Action: Alarm the BAS and shutdown the unit if the supply air drops below 37°F.

2. Enable: Air System Smoke Detectors (systems over 2,000 CFM)

   a. Input Device: Duct-mounted smoke detectors (furnished by Division 26) shall be provided in accordance with NFPA 90A. Installation in ductwork and connection to BAS shall be under Division 23.

b. Output Device: BAS system alarm.
c. Output Device: Fire alarm - Detector wired to the fire alarm system by Div. 26.
d. Action: Allow start if duct is free of products of combustion. Activated when products of combustion are detected in air stream. Smoke detector signals alarm, unit shall go to STOP mode when products of combustion are detected in airstream. Restarting the u shall require manual reset at the smoke detector.

2.09 MAKEUP AIR SYSTEMS (MUA)

A. The BAS contractor shall coordinate and interface with the MUA unit controllers specified in Section 23 74 23 “PACKAGED, DIRECT-FIRED, OUTDOOR, HEATING-ONLY MAKEUP-AIR UNITS”. The BAS contractor shall provide supplemental controls, wiring, and other items as required for proper unit function.

B. Start and Stop Supply Fan:

1. Initiate:

a. Input Device: Interlock with associated exhaust system.
b. Output Device: Run command to unit.
c. Action: Energize unit controller.

2. Supply Fan VFD Control: Normal mode is constant airflow. The airflow setting shall be adjustable through the BAS.

C. Automatic motorized inlet air damper furnished by section 237423.

D. Interface with heating controls.

E. Provide and air measuring device (AMD) in the supply air duct. Locate in the vertical straight duct riser below the roof.

F. System safeties, as described below, prevent operation of the DOAS/AHU unit whenever a safety device is activated. Whenever a safety device is activated the unit shall be in STOP mode.

1. Enable: Freeze Protection:

a. Input Device: Discharge air temperature sensor
b. Output Device: BAS software
c. Action: Alarm the BAS and shutdown the unit if the supply air drops below 37°F.

2. Enable: Air System Smoke Detectors (systems over 2,000 CFM)

a. Input Device: Duct-mounted smoke detectors (furnished by Division 26) shall be provided in accordance with NFPA 90A. Installation in ductwork and connection to BAS shall be under Division 23.
b. Output Device: BAS system alarm.
c. Output Device: Fire alarm - Detector wired to the fire alarm system by Div. 26.
d. Action: Allow start if duct is free of products of combustion. Activated when products of combustion are detected in air stream. Smoke detector signals alarm, unit shall go to STOP mode when products of combustion are detected in airstream. Restarting the unit shall require manual reset at the smoke detector.

2.10 TERMINAL UNITS

A. The unit shall use an optimal start algorithm for morning start-up. This algorithm shall minimize the unoccupied warm-up or cool-down period while still achieving comfort conditions by the start of scheduled occupied period.

B. Each zone shall have separate occupied and unoccupied heating and cooling setpoints.

C. The software shall prevent:

1. The heating setpoint from exceeding the cooling setpoint minus 1°F (i.e., the minimum difference between heating and cooling setpoints shall be 1°F).
2. The unoccupied heating setpoint from exceeding the occupied heating setpoint; and
3. The unoccupied cooling setpoint from being less than the occupied cooling setpoint.

D. Zone Unoccupied Override:

1. A timed local override control shall allow an occupant to override the schedule and place the unit into an occupied mode for an adjustable period of time (2 hours maximum allowed – per Maine Advanced Buildings). At the expiration of this time, control of the unit shall automatically return to the schedule. The adjustment shall be capable of being limited in software. These shall be absolute limits imposed by programming, which are in addition to the range limits (e.g., ±4°F) of the thermostat adjustment device.

    a. As a default, the active occupied cooling setpoint shall be limited between 73°F and 80°F.
    b. As a default, the active occupied heating setpoint shall be limited between 60°F and 71°F.

2. The active heating and cooling setpoints shall be independently adjustable, respecting the limits and anti-overlap logic described above. If zone thermostat provides only a single setpoint adjustment, then the adjustment shall move both the active heating and cooling setpoints upwards or downwards by the same amount, within the limits described above.
3. The adjustment shall only affect occupied setpoints in Occupied Mode, and shall have no impact on setpoints in all other modes.
4. At the onset of demand limiting, the local setpoint adjustment value shall be frozen. Further adjustment of the setpoint by local controls shall be suspended for the duration of the demand limit event.

E. Control Loops

1. Two separate control loops shall operate to maintain space temperature at setpoint, the Cooling Loop and the Heating Loop.

    a. The Heating Loop shall be enabled whenever the space temperature is below the current zone heating setpoint temperature, and disabled when space temperature is above the current zone heating setpoint temperature and the Loop output is zero for 30 seconds. The Loop may remain active at all times if provisions are made to minimize integral windup.
    b. The Cooling Loop shall be enabled whenever the space temperature is above the current zone cooling setpoint temperature, and disabled when space temperature is below the current zone cooling setpoint temperature and the Loop output is zero for 30 seconds. The Loop may remain active at all times if provisions are made to minimize integral windup.

2. The Cooling Loop shall maintain the space temperature at the active cooling setpoint. The output of the loop shall be a software point ranging from 0% (no cooling) to 100% (full cooling).
3. The Heating Loop shall maintain the space temperature at the active heating setpoint. The output of the loop shall be a software point ranging from 0% (no heating) to 100% (full heating).
4. Loops shall use P + I or other technology with similar performance. P and I gains shall be adjustable by the operator.
5. Zone State

    a. Heating: when the output of the space heating control loop is nonzero and the output of the cooling loop is equal to zero.
    b. Cooling: when the output of the space cooling control loop is nonzero and the output of the heating loop is equal to zero.
    c. Deadband: when not in either Heating or Cooling.

6. Zone temperature alarms

    a. High temperature alarm

        1) If the zone is 3°F above cooling setpoint for 10 minutes, generate Level 3 alarm.
        2) If the zone is 5°F above cooling setpoint for 10 minutes, generate Level 2 alarm.

    b. Low temperature alarm

        1) If the zone is 3°F below heating setpoint for 10 minutes, generate Level 3 alarm.
        2) If the zone is 5°F below heating setpoint for 10 minutes, generate Level 2 alarm.

    c. Suppress zone temperature alarms as follows:

        1) After zone setpoint is changed.
        2) Zone alarms are not suppressed in Setup, Setback, or Unoccupied Modes so that you detect heating or cooling equipment or control failures that could result in excessive pull down or pick up loads and even freezing of pipes if left undetected.

    d. For zones with CO2 sensors:

        1) CO2 sensors: If the CO2 concentration is less than 300 ppm, or the zone is in Unoccupied Mode for more than 2 hours and zone CO2 concentration exceeds 600 ppm, generate a Level 3 alarm. The alarm text shall identify the sensor and indicate that it may be out of calibration.
        2) If the CO2 concentration exceeds setpoint plus 10% for more than 10 minutes generate a Level 3 alarm.

F. Unit Heaters - Hydronic

1. Enable:

    a. Input Device: BAS software
    b. Output Device: BAS software

c. Action: Enable unit heaters whenever the boiler plant is in heating mode.

2. Room Temperature:

a. Input Device: Electronic temperature sensor.
b. Output Device: BAS system binary output.
c. Output Device: Normally-open 2-position, 2-way control valve. Note: See unit heater schedule, some unit heaters will have 3-way valves, open/close.
d. Action: Open control valve and cycle fan to maintain space temperature (occupied & unoccupied). Minimum run time: 1 minute. Space temperature setpoint: 65°F.

G. Duct Heating Coils, Hydronic:

1. Room Temperature:

a. Input Device: Electronic temperature sensor.
b. Output Device: Two way control valves with 0-10VDC modulating actuators
c. Action: Modulate valve to maintain temperature.

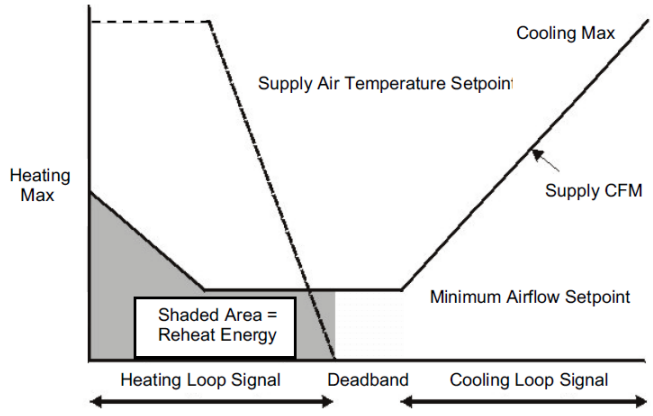
H. Air Terminal Units: Each pressure-independent VAV box shall include have a discharge air sensor to monitor DA temperature.

1. Unoccupied Mode

a. When the central air handling unit is off, the BAS shall command the VAV supply air damper closed.
b. When the central air handling unit is off, the BAS shall command the hot water valve closed.
c. If the room temperature falls below 60°F (adjustable), the BAS shall generate an alarm.

2. Occupied Mode

a. The BAS shall schedule the VAV to occupied mode. The central air handling unit must be running before the VAV will operate in the occupied mode.
b. Provide “dual maximum” control for maximum efficiency. In addition to a minimum airflow setpoint and a cooling maximum airflow setpoint, there is also a heating maximum airflow setpoint; hence the name "dual maximum".



c. When the zone is in the cooling mode, the cooling loop output is mapped to the airflow setpoint from the cooling maximum to the minimum airflow setpoints. The hot water valve is closed.
d. When the zone is in the deadband mode, the airflow setpoint shall be the minimum airflow setpoint. The hot water valve is closed.
e. When the zone is in the heating mode, the heating loop shall maintain space temperature at the heating setpoint as follows:

1) From 0%-50% loop signal, the heating loop output shall reset the discharge temperature from supply air temperature setpoint (e.g., 55°F) to 90°F. Note the upper temperature is limited to prevent stratification during heating.
2) From 50%-100% loop signal, the heating loop output shall reset the zone airflow setpoint from the minimum airflow setpoint to the maximum heating airflow setpoint. The supply air discharge temperature remains at 90°F.
3) The hot water valve shall be modulated using a PI control loop to maintain the discharge temperature at setpoint. Note that directly controlling the hot water valve from the zone temperature PI loop is not acceptable since it will not allow supply air temperature to be under control and limited in temperature to prevent stratification.
4) The VAV damper shall be modulated to maintain the measured airflow at setpoint.

f. CO2 Demand Control Ventilation (variable occupancy spaces including Classrooms, Conference Rooms, Café, and other spaces as shown on the plans):

1) When the zone CO2 sensor is below setpoint, the system will have the terminal damper at minimum position and modulate the damper based on its PID temperature control algorithm to maintain desired zone temperature set-points. CO2 setpoints (adjustable):
   a) Classrooms: 940
   b) Science Classrooms: 895
   c) Computer Labs, Production: 965
   d) Café: 1,400
   e) Conference: 1,200
   f) Unassigned: 940
2) If the CO2 level at the zone exceeds its set point the system will begin to modulate the damper using a PID control loop. When the CO2 level set point is reached the box will stop modulation and begin back toward minimum position.
3) If while modulating-open the damper, the space temperature limit is reached the system will engage reheat, modulating the 2-way control valve to maintain setpoint.
4) If the maximum damper position is reached and the CO2 set point is still not satisfied the associated AHU will modulate its OA damper using a PID loop to bring the zone CO2 level below set point.

I. Radiant Floor systems shall be controlled thru the BAS. BAS contractor shall provide space sensors, and other control components, Section 23 83 16 will furnish the zone valve power heads (part of manifolds).

1. Enable:

a. Input Device: BAS software
b. Output Device: BAS software

c. Action: Enable radiant floor heating whenever the seasonal changeover of the heat/cool plant is in heating mode. During cooling mode, control valves shall be closed. Also, disable radiant heating whenever OA temperature is 55°F (adj.) or higher.

2. Space Heating:

a. Input Device: Provide wall temperature sensor
b. Output Devices: HW control valve control.
c. Action: Open valve to provide heating.
d. Radiant heating systems configured with a setback heating setpoint at least 4°F below the occupied heating setpoint.

2.11 EXHAUST FANS

A. Heat Relief – Mechanical & Electrical Rooms

1. The fan shall be enabled after the motorized damper statuses (exhaust fan and intake) have proven.
2. The unit shall be continuously enabled to maintain a zone temperature cooling setpoint of 80°F (adj.). Stage 1 of cooling shall be to open dampers. If temperature rises an additional 3°F, the fan shall be energized.
3. The motorized dampers (as scheduled) shall open anytime the unit runs and shall close anytime the unit stops. The motorized dampers shall close 30 sec (adj.) after the fan stops.
4. Alarms

a. High Zone Temp: If the zone temperature is greater than the cooling setpoint by a user definable amount (adj.).
b. Damper Failure: Commanded open, but the status is closed.

B. BAS ON/OFF Schedule

1. The fan shall be enabled after the motorized damper (as scheduled) status has proven. Fans shall be energized based on occupancy schedule. Fans schedules shall be coordinated with associated air system occupancy schedule.
2. PF-1 Destratification Fans: If the local smoke detector activates, the fan(s) shall turn OFF.
3. Mixing Room Fans (part of packaged mixing room) – per NFPA 33: “The ventilation system shall be in operation at all times”.

C. Switch Controlled

1. Wood & Metal Dust Collectors: On/off buttons to start the dust collectors (see specification 23 34 24).
2. Lab Hood EF: On/off switch built in to the fume hood. Coordinate with section 115300.
3. Local wall switch provided by Division 26.

a. EF-W
b. Exhaust Bench (H-B)
c. EF-V

4. Fume Arms: Fan control switch mounted on hood (see specification 23 34 24).
5. Vehicle Exhaust: Micro switch for fan control (see specification 23 34 24).

D. Interlock: Wire to equipment control circuit to open MOD (as scheduled) and start the fan. Where dampers operate in conjunction with fan operation, the damper open signal shall precede the fan start signal by 10-23 seconds. The damper close signal shall be delayed 10-23 seconds after the fan stop signal.

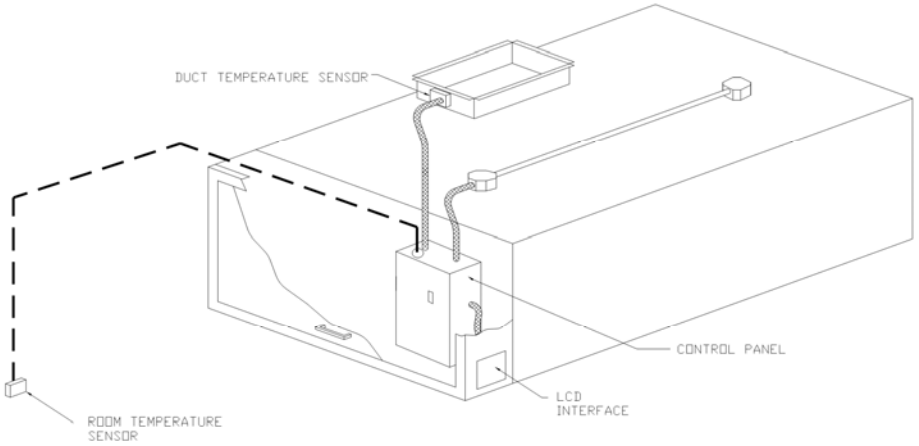
2.12 DESTRATIFICATION FANS

A. Start –stop via BAS.

B. Integrate BACnet controls. Fan speed control by the smart sense controller specified in 233423.

2.13 KITCHEN EXHAUST

A. Provide interface with the Basis of Design kitchen hood DCV system (furnished by kitchen supplier – See 114000). The Demand Control Ventilation System (DCV) is designed to automatically reduce exhaust and supply airflow quantities, while ensuring hood performance is maintained. The DCV uses Variable Frequency Drives (VFD) and temperature sensors in the exhaust ducts to modulate the fans speed during cooking operation and maximize energy savings. The LCD screen interface provides fan control, system configuration, and diagnostic information.



TYPICAL HOOD CONTROL PANEL INSTALLATION

1. The DCV system furnished with the hoods includes:

   a. Smart Controller
   b. LCD Screen Interface
   c. Duct Temperature Sensor
   d. Variable Frequency Drive

2. The system includes a LCD screen interface for fans and hood lights control, gas valve reset, programmable schedule, Max Air Override function, Preparation Time mode, Cool Down mode, and diagnostics including VFD status. The LCD screen shows descriptive plain text explaining the functions or values. The LCD screen interface will be installed on the face of the hood, on the face of the utility cabinet or on the face of a wall mounted control enclosure.

3. The smart controller will constantly monitor the exhaust air temperature through the riser mounted temperature sensor and modulate the fan speeds accordingly.
4. A room temperature sensor will also be provided for field installation in the kitchen space in order to start the fans based on the fixed temperature differential between the room and the exhaust air in the duct rather than fixed set-points.
5. A Preparation Time Mode is available for morning operation: dedicated make-up air will be locked out only allowing the use of transfer air during this mode. Exhaust fan(s) will run at low CFM while maintaining a balanced kitchen pressure.
6. A Cool-down Mode is designed for equipment cool-down period at the end of the daily cooking operations: similarly to Preparation Time mode, dedicated make-up air will be locked out only allowing the use of transfer air during this mode. Exhaust fans will run at low CFM while maintaining a balanced kitchen pressure.
7. Fan maximum/ minimum speeds will be adjustable for proper kitchen balance. Fan direction change is also available from the smart controller configuration menu without need for rewiring.
8. Duct Temperature Sensors shall be mounted in the exhaust hood risers. Temperature probe will be constructed of Stainless Steel. System will be factory pre-set to modulate fan speed within a range of 45°F for 600°F and 700°F cooking applications and a range of 5°F for 400°F cooking applications. Set-points are fully adjustable through the touch screen interface based on application needs.
9. The Max Air Override will have an adjustable timeout value.
10. The panels include color coded wiring with as-built wiring diagrams and spare terminals controlled by the fire system micro switch. The panel is factory pre-wired to shut supply fans down in a fire condition.

B. Provide a BACnet interface to the DCV controller.

BACNET

BACNET IP or BACNET MS/TP compatibility can be implemented in this package through a Protocessor, which is a BTL listed embedded Gateway configured to give a Building Management System (BMS) access to monitor and/or control a list of BACNET objects. The Protocessor is mounted and factory pre-wired inside the Electrical Control Panel. Field connections to the Building Management System are shown to the right.

The Protocessor is pre-configured at the factory to use the field protocol of the Building Management System in the specific jobsite. BACNET objects can only be accessed through the specified port and protocol.

1. Field Ethernet Connection for BACNET IP
2. Field RS485 Connection for BACNET MS/TP

Figure 25 - BACNET Wiring Reference

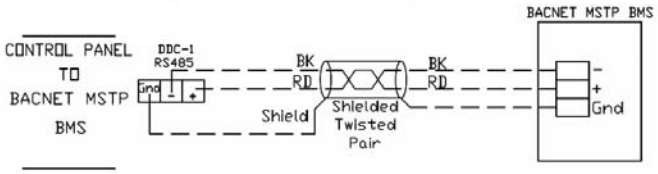
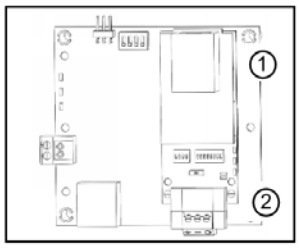


Figure 26 - BACNET Connections



2.14 GAS DETECTION

A. All points shall be displayed thru the BAS.

B. See Section 230900 for gas detectors.

C. Science Laboratory Safety Device System: Provide low voltage integration wiring from each controller to connection point on BAS. The controller (see 230900) provides a NO, COM and NC relay output for BAS integration, the relay will change state in “Alarm” or “Gas On”.

1. Wire the gas shutoff valve.
2. Alarm upon high gas level.

D. Vehicle Gas Detection (CO or CO/NO2) – Auto Tech, Corridor 100G, and Demonstration-Crit Area 197.

1. Mount sensors at 5 feet AFF.
2. Normal Operation: If the monitored gas concentration level is below the field adjustable Low Alert setting, the detector will be in the Normal Operation mode. In this mode the front panel display will indicate the ambient gas concentration. The detector output control relays will be in the inactive state and only the power and active sensor front panel lamps will be illuminated.
3. Low Alert Operation:

    a. If the monitored gas concentration level for a sensor reaches the Low Alert setting, the detector will flash the Low Alert indicator lamp and activate a delay timer. The duration of the delay is field adjustable from 0 to 7 minutes.
    b. If the concentration level remains at or above the Low Alert setting for the duration of the delay period, the Low Alert relay contacts will close.
    c. Overhead doors (typ for 2: Vestibule 100H and 100E): Wire to OH door control circuit to start the adjacent fan. After the door is closed, the fan shall remain on for 10 minutes (adj).

        1) In addition, the low alert level shall be used to start both fans.
        2) Note: The inner door of each vestibule shall be the control point.

    d. Once the monitored gas concentration level drops below the Low Alert setting, the panel will activate another delay timer. If the concentration level remains below the Low Alert setting for the duration of the delay period, the panel will revert to the Normal Operation state.
    e. Alert Levels

        1) CO Low alert: 35 PPM.
        2) NO2 Low alert: 1.0 PPM

4. High Alert Operation: If the detector is in a Low Alert status and the monitored gas concentration reaches a factory set High Alert level, the detector will actuate its High Alert relay contacts and front panel lamp.

    a. Auto Tech and Auto Collision: If not already running, DOAS, EF’s and MUA in the space shall be energized.

5. Once the concentration is no longer at or above the High Alert setting, the detector will return to the Low Alert Operation mode. If the Low Alert relay is actuated, High Alert Operation will be immediate. If the detector is processing a Low Alert delay period, it will enter the High Alert Operation mode upon its completion.

    a. CO High alert: 100 PPM.
    b. NO2 High alert: 5.0 PPM.

6. Alarm Mode Operation: If the monitored gas concentration remains at or above the factory set High Alert level longer than 15 minutes, a set of Alarm relay contacts will close and an internal buzzer will sound. This set of contacts shall be used to alarm the BAS. The buzzer will stay on and the contacts will remain closed until the monitored gas concentration falls below the factory set High Alert level. The internal buzzer may be silenced by pressing a front panel mounted push-button switch.

2.15 DHW RECIRCULATION

A. Domestic Hot Water Recirculation Pumps:

1. Operate the pumps only when the DHW temperature in the return line near the DHW heater falls below 110°F. Pump cycling shall be controlled by a return line aquastat (furnished with TMV package, see spec 221119) set at 110°F with a 5°F deadband.
2. Pump shall be OFF at night. Turn on ½ hour prior to occupy time.

2.16 DUCTLESS SPLIT AIR CONDITIONING UNITS

A. AC unit shall operate by manufacturer-supplied controls to maintain setpoint.

B. Provide a temp sensor to control the unit, compatible with the thermostat interface specified in Section 238130.

2.17 MISCELLANEOUS POINTS

A. Systems: See points list.

B. Monitoring

1. Input Device: contact closure or relay from equipment
2. Output Device: BAS Software
3. Action: Alarm

END OF SECTION

SECTION 23 11 23

FACILITY FUEL GAS PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

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"

1.02 SUMMARY

A. This Section includes fuel gas piping, specialties, and accessories within the building.

1.03 PROJECT CONDITIONS

A. LP Gas System Pressure: Coordinate with gas supplier.

1.04 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 shown on the structural plans.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data

1.06 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 58 “LP Gas Code”.
2. Maine Fuel Board Rules

E. FM Standard: Provide components listed in FM's "Fire Protection Approval Guide" if specified to be FM approved.

1.07 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.

1.08 COORDINATION

A. LP Gas: Make arrangements with local supplier for gas service to the Owner’s distribution system. Provide service to the building as required by the propane supplier. The installation of the gas service shall comply with the published supplier standards. Pay all charges; include charges in the base bid.

PART 2 - PRODUCTS

2.01 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. Meters:

    a. American Meter Co.
    b. Badger Meter, Inc.; Utility Products Div.
    c. Equimeter, Inc.
    d. National Meter.
    e. Schlumberger Industries; Gas Div.

4. 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.

2.02 PIPING MATERIALS

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

2.03 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. PE Pipe: ASTM D 2513, SDR 11.

1. PE Fittings: ASTM D 2683, socket-fusion type or ASTM D 3261, butt-fusion type with dimensions matching PE pipe.
2. PE Transition Fittings: Factory-fabricated fittings with PE pipe complying with ASTM D 2513, SDR 11; and steel pipe complying with ASTM A 53/A 53M, black steel, Schedule 40, Type E or S, Grade B.
3. Anodeless Service-Line Risers: Factory fabricated and leak tested.

    a. Underground Portion: PE pipe complying with ASTM D 2513, SDR 11 inlet.
    b. Casing: Steel pipe complying with ASTM A 53/A 53M, Schedule 40, black steel, Type E or S, Grade B, with corrosion-protective coating covering. Vent casing aboveground.
    c. Aboveground Portion: PE transition fitting.
    d. Outlet shall be threaded or flanged or suitable for welded connection.
    e. Tracer wire connection.
    f. Ultraviolet shield.
    g. Stake supports with factory finish to match steel pipe casing or carrier pipe.

C. Corrugated, Stainless-Steel Tubing: Comply with ANSI/IAS LC 1.

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

    a. OmegaFlex, Inc.
    b. Parker Hannifin Corporation; Parflex Division.
    c. Titeflex.
    d. Tru-Flex Metal Hose Corp.

2. Tubing: ASTM A 240/A 240M, corrugated, Series 300 stainless steel.
3. Coating: PE with flame retardant. 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. Flame-Spread Index: 25 or less. Smoke-Developed Index: 50 or less.
4. Fittings: Copper-alloy mechanical fittings with ends made to fit and listed for use with corrugated stainless-steel tubing and capable of metal-to-metal seal without gaskets. Include brazing socket or threaded ends complying with ASME B1.20.1.
5. Striker Plates: Steel, designed to protect tubing from penetrations.

6. Manifolds: Malleable iron or steel with factory-applied protective coating. Threaded connections shall comply with ASME B1.20.1 for pipe inlet and corrugated tubing outlets.
7. Operating-Pressure Rating: 5 psig.

D. Transition Fittings: Type, material, and end connections to match piping being joined.

E. Common Joining Materials: Refer to Division 23 Section "Common Work Results for HVAC" for joining materials not in this Section.

2.04 SPECIALTY VALVES

A. Valves, NPS 2 and Smaller: Threaded ends according to ASME B1.20.1 for pipe threads.

B. Valves, NPS 2-1/2 and Larger: Flanged ends according to ASME B16.5 for steel flanges.

C. Appliance Connector Valves: ANSI Z21.15 and IAS listed.

D. 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.

E. Gas Valves, NPS 2 and Smaller: ASME B16.33 and IAS-listed bronze body and 125-psig pressure rating. Tamperproof Feature: Include design for locking.

F. Plug Valves, NPS 2-1/2 and Larger: ASME B16.38 and MSS SP-78 cast-iron, lubricated plug valves, with 125-psig pressure rating. Tamperproof Feature: Include design for locking.

G. General-Duty Valves, NPS 2-1/2 and Larger: ASME B16.38, cast-iron body, suitable for fuel gas service, with "WOG" indicated on valve body, and 125-psig pressure rating.

1. Gate Valves: MSS SP-70, OS&Y type with solid wedge.
2. Butterfly Valves: MSS SP-67, lug type with lever handle.

2.05 PIPING SPECIALTIES

A. Appliance Flexible Connectors:

1. Indoor, Fixed-Appliance Flexible Connectors: Comply with ANSI Z21.24.
2. Indoor, Movable-Appliance Flexible Connectors: Comply with ANSI Z21.69.
3. Outdoor, Appliance Flexible Connectors: Comply with ANSI Z21.75.
4. Corrugated stainless-steel tubing with polymer coating.
5. Operating-Pressure Rating: 0.5 psig.
6. End Fittings: Zinc-coated steel.
7. Threaded Ends: Comply with ASME B1.20.1.
8. Maximum Length: 72 inches

B. Y-Pattern Strainers:

1. Body: ASTM A 126, Class B, cast iron with bolted cover and bottom drain connection.
2. End Connections: Threaded ends for NPS 2 and smaller; flanged ends for NPS 2-1/2 and larger.

3. Strainer Screen: 40-mesh startup strainer, and perforated stainless-steel basket with 50 percent free area.
4. CWP Rating: 125 psig.

C. Weatherproof Vent Cap: Cast- or malleable-iron increaser fitting with corrosion-resistant wire screen, with free area at least equal to cross-sectional area of connecting pipe and threaded-end connection.

D. 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.

2.06 PRESSURE REGULATORS

A. Provide service, line, and appliance pressure regulators as indicated and as required by code. 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. Provide for each hookup.

D. Pressure Regulator Vents: Factory- or field-installed, corrosion-resistant screen in opening if not connected to vent piping.

2.07 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.

2.08 LABELING AND IDENTIFYING

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

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine roughing-in for gas piping system to verify actual locations of piping connections before equipment installation.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EARTHWORK

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

3.03 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.

3.04 LP STORAGE CONTAINER INSTALLATION

A. Arrange to have owner to fill storage container to at least 80 percent capacity with propane.

B. Install piping connections with swing joints or flexible connectors to allow for storage container settlement and for thermal expansion and contraction.

C. Ground containers according to NFPA 780. Grounding is specified in Division 26.

D. Set storage container on concrete ballast base large enough to offset buoyancy of empty storage container immersed in water.

E. Install tie-down straps over container anchored in ballast base and repair damaged coating.

F. Backfill with a minimum coverage for underground or mounded storage containers according to NFPA 58.

G. Backfill with pea gravel as required in Division 31.

H. Provide cathodic protection for storage container.

3.05 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. Commercial Cooking Appliances. Commercial cooking appliances shall be connected in accordance with the connector manufacturer's installation instructions using a listed appliance connector complying with ANSI Z21.69, Connectors for Moveable Gas Appliances.

E. Gas Service Piping at Meters and Regulators: Steel pipe, steel welding fittings, and welded joints.

F. Underground Fuel Gas Piping, outdoors: Provide underground, PE, natural-gas piping according to ASTM D 2774. Install underground piping buried at least 36 inches below finished grade.

3.06 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.

G. Kitchen Fire Suppression: Install the gas line shutoff valve (furnished with each hood fire suppression system).

H. Science Lab Safety: Install the gas line shutoff valve (furnished with by 230900).

3.07 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, overpressure protection devices, and valves on gas trains 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.

3.08 PIPING JOINT CONSTRUCTION

A. Ream ends of pipes and tubes and remove burrs.

B. Remove scale, slag, dirt, and debris from inside and outside of pipe and fittings before assembly.

C. Threaded Joints:

1. Thread pipe with tapered pipe threads complying with ASME B1.20.1.
2. Cut threads full and clean using sharp dies.
3. Ream threaded pipe ends to remove burrs and restore full inside diameter of pipe.
4. Apply appropriate tape or thread compound to external pipe threads unless dry seal threading is specified.
5. Damaged Threads: Do not use pipe or pipe fittings with threads that are corroded or damaged. Do not use pipe sections that have cracked or open welds.

D. Welded Joints:

1. Construct joints according to AWS D10.12/D10.12M, using qualified processes and welding operators.
2. Bevel plain ends of steel pipe.
3. Patch factory-applied protective coating as recommended by manufacturer at field welds and where damage to coating occurs during construction.

E. PE Piping Heat-Fusion Joints: Clean and dry joining surfaces by wiping with clean cloth or paper towels. Join according to ASTM D 2657.

1. Plain-End Pipe and Fittings: Use butt fusion.
2. Plain-End Pipe and Socket Fittings: Use socket fusion.

3.09 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 ¾ 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 appliances using gas with shutoff valves and unions. Provide valve upstream from and within 72 inches of each appliance. Provide union downstream from valve.

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.

E. Provide gas hookups to food service equipment, coordinate with Section 114000. Flexible gas hookup hoses are furnished by 114000.

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. Piping will be painted by Section 09 90 00, including exposed piping, valves, regulators, and piping specialties, except components with factory-applied paint or protective coating. Paint in accordance with NFPA 58.

B. 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 54/58 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

SECTION 23 21 13

HYDRONIC HVAC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 7 Section for materials and methods for sealing pipe penetrations.
2. Division 23 Section "Common Work Results for Mechanical"
3. Division 23 Section "Hangers and Supports" for pipe supports.
4. Division 23 Section "Thermometers and Pressure Gages"
5. Division 23 Section "Mechanical Identification" for labeling and identifying.
6. Division 23 Section "Hydronic Pumps" for pumps, motors, and accessories.
7. Division 23 controls section for temperature-control valves and sensors.

1.02 SUMMARY

A. This Section includes piping and specialties for hydronic HVAC piping.

1.03 ACTION SUBMITTALS

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

1. Piping
2. Hydronic specialties
3. Chemical treatment.

B. Delegated-Design Submittal:

1. Design calculations and detailed fabrication and assembly of pipe anchors and alignment guides, hangers and supports for multiple pipes, expansion joints and loops, and attachments of the same to the building structure.
2. Locations of pipe anchors and alignment guides and expansion joints and loops.

1.04 INFORMATIONAL SUBMITTALS

A. Water Analysis: Submit a copy of the water analysis to illustrate water quality available at Project site.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For air-control devices, hydronic specialties, and special-duty valves to include in emergency, operation, and maintenance manuals.

1.06 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.

E. HVAC Water-Treatment Service Provider Qualifications: An experienced HVAC water-treatment service provider capable of analyzing water qualities, installing water-treatment equipment, and applying water treatment as specified in this Section.

1.07 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.

C. Coordinate pipe sleeve installations and penetrations with other trades.

D. Coordinate pipe fitting pressure classes with products specified in related Sections.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. 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. Caleffi
i. Nexus

2. Hydronic Pressure-Reducing Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT Bell & Gossett
e. Spence Engineering Company, Inc.
f. Caleffi
g. Watts Industries, Inc.

3. Safety Valves:

a. Amtrol, Inc.
b. Armstrong Pumps, Inc.
c. Conbraco Industries, Inc.
d. ITT McDonnell & Miller.
e. Kunkle Valve Division.
f. Spence Engineering Company, Inc.
g. Caleffi
h. Watts Industries Inc.

4. Expansion Tanks, Air Separators, and Hydronic Specialties:

a. Amtrol, Inc.
b. Woods
c. ITT Bell & Gossett
d. Taco, Inc.
e. Caleffi
f. Watts Industries Inc.
g. Wessels
h. Patterson
i. Thrush

5. Air Vents and Vacuum Breakers:

a. Armstrong International, Inc.
b. Barnes & Jones, Inc.
c. ITT Hoffman
d. Caleffi
e. Spirax Sarco, Inc.

2.02 PIPING MATERIALS

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

2.03 COPPER TUBE AND FITTINGS

A. Drawn-Temper Copper Tubing: ASTM B 88, Type L.

B. DWV Copper Tubing: ASTM B 306, Type DWV.

C. Wrought-Copper Fittings: ASME B16.22.

D. Wrought-Copper Unions: ASME B16.22.

E. Solder Filler Metals: ASTM B 32, 95-5 tin antimony.

F. Brazing Filler Metals: AWS A5.8, Classification BAg-1 (silver).

2.04 STEEL PIPE AND FITTINGS

A. Steel Pipe, NPS 2 and Smaller: ASTM A-53, Type S (seamless) or Type F (furnace-butt welded), Grade B, Schedule 40 and 80, black steel, plain ends.

B. Steel Pipe, NPS 2-1/2 and larger: ASTM A-53, Type E (electric-resistance welded), Grade B, Schedule 40 and 80, black steel, plain ends.

C. Malleable-Iron Threaded Fittings: ASME B16.3, Classes 150 and 300.

D. Malleable-Iron Unions: ASME B16.39; Classes 150, 250, and 300.

E. Cast-Iron Pipe Flanges and Flanged Fittings: ASME B16.1, Classes 25, 125, and 250; raised ground face, and bolt holes spot faced.

F. Wrought-Steel Fittings: ASTM A-234/A 234M, wall thickness to match adjoining pipe.

G. Wrought Cast- and Forged-Steel Flanges and Flanged Fittings: ASME B16.5, including bolts, nuts, and gaskets of the following material group, end connections, and facings: Material Group: 1.1. End Connections: Butt-welding. Facings: Raised face.

H. Mechanically formed copper or steel tee connections are not acceptable.

I. Welded Branch and Tap Connections: Forged steel weldolets, or branchlets and threadolets may be used for branch connections up to one pipe size smaller than the main. Forged steel half-couplings, ANSI B16.11 may be used for drain, vent and gage connections.

J. Welding Materials: Comply with Section II, Part C, of the ASME Boiler and Pressure Vessel Code for welding materials appropriate for wall thickness and for chemical analysis of pipe being welded.

K. Gasket Material: Thickness, material, and type suitable for fluid to be handled; and design temperatures and pressures.

2.05 AQUATHERM PIPING

A. Pipe shall be Aquatherm or Nupi Niron. Hot water supply piping shall contain a fiber layer (faser) to restrict thermal expansion. Pipe systems shall carry a 10-year warranty for property damage liability coverage of up to $15 million per damage event. This warranty shall cover the

pipes, the fittings, and any incidental damage caused by material failure. The policy shall also provide 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. 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, and ASTM F 2389 or CSA B137.11.

D. Piping in plenum returns: Thee 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 25/50 flame/smoke development rating.

E. Piping 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. When installed in systems with pumps in excess of 7.5 HP, piping shall be protected from excessive heat generated by operating the pump at shut-off conditions. Where the possibility exists that the pump will operate with no flow, the protection method shall be a temperature relief valve or comparable level of protection, set to a maximum temperature of 185°F.

G. 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).

H. Where up to 1 inch of standard insulation is indicated in Section 23 07 00, a factory installed, thermal and vapor barrier insulation shall be provided. Where more than 1 inch of standard insulation is indicated in Section 23 07 00, additional overlap of factory installed, thermal and vapor barrier insulation shall be provided to ensure equivalent thermal resistance. The thick wall, self-insulating fittings shall not require an additional vapor barrier for the piping system to meet this performance level. The thermal barrier shall be 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.

2.06 PEX PIPE AND FITTINGS

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. Watts Radiant
4. Viega

B. PEX-a (Engle-method Crosslinked Polyethylene) Piping: ASTM 876 with oxygen-diffusion barrier that meets DIN 4726. Performance Requirements: 200°F at 80 psi, 180°F at 100 psi. Provide fittings from the same manufacturer of the piping.

C. PEX-a Fittings, Elbows and Tees (½ inch through 2 inch nominal pipe size): ASTM F1960 cold-expansion fitting manufactured from the following material types:

1. UNS No. C69300 Lead-free (LF) Brass
2. 20% glass-filled polysulfone as specified in ASTM D6394
3. Unreinforced polysulfone (group 01, class 1, grade 2) as specified in ASTM D6394
4. Polyphenylsulfone (group 03, class 1, grade 2) as specified in ASTM D6394
5. Blend of polyphenylsulfone (55-80%) and unreinforced polysulfone (rem.) as specified in ASTM D6394
6. Reinforcing cold-expansion rings shall be manufactured from the same source as PEX-a piping manufacturer and marked “F1960”.

D. PEX-a Fittings (2½ inch through 4 inch nominal pipe size): SDR9 compression type fitting consisting of a double O-ring insert with a compression sleeve tightened around the pipe and insert.

E. Plastic-to-Metal Transition Fittings: 2” and below: Threaded Brass to PEX-a Transition: one-piece brass fitting with male or female threaded adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. Brass Sweat to PEX-a Transition: one-piece brass fitting with sweat adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring. 2-1/2” and larger: Dezincification-resistant (DZR) Brass to PEX-a Transition: male NPT thread and PEX compression fitting.

F. Plastic-to-Metal Transition Unions: Threaded Brass to PEX-a Union: one-piece brass fitting with male or female threaded adapter and F1960 cold-expansion end, with PEX-a reinforcing cold-expansion ring.

2.07 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. Aquatherm Climatherm: 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.
4. Comply with MSS SP-110.

B. Butterfly Valves

1. Basis of Design: Center Line Series 200; Lug Type, cast iron, drilled and tapped lug body, ductile iron disc, 416SS shaft, bronze bushing, EPDM seat.
2. Valve bodies shall have extended necks to provide for 2-1/4" insulation as needed.
3. Comply with MSS SP-67.
4. Compatible with ANSI 125/150 flanges. Dead-end capacity to 200 psi.
5. Operators: 6” and smaller: handle with infinite adjustment; 8” and larger: gear w/balance-stop hand wheel. Valves located 7 feet or higher: provide gear/chain wheel.
6. Approved Manufacturers: Watts, Hammond, Nibco, Milwaukee, or approved equal.

C. 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. Comply with the following standards for design, workmanship, material and testing: Bronze Valves: MSS SP – 80; Cast Iron Valves: MSS SP – 71.
2. Construct valves of pressure casting free of any impregnating materials. Construct disc and hanger as one piece. Support hanger pins by removable side plug.
3. 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.
4. 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.
5. Flanged Ends 2-1/2" and Larger: Class 125, iron body, bronze mounted, horizontal swing, cast-iron disc: Hammond IR1124, Nibco F918-B, Stockham G931, Milwaukee F2974 or approved equal.

D. Pressure-Reducing Valves: Diaphragm-operated, bronze or brass body with low inlet pressure check valve, inlet strainer removable without system shutdown, and non-corrosive valve seat and stem. Select valve size, capacity, and operating pressure to suit system. Valve shall be factory set at operating pressure and have capability for field adjustment.

E. ASME Safety Relief Valves: Bell & Gossett A-434D, or equal; diaphragm-operated, bronze or brass body with brass and rubber, wetted, internal working parts; shall suit system pressure and heat capacity and shall comply with the ASME Boiler and Pressure Vessel Code, Section IV. The fluid shall not discharge into the spring chamber. The valve shall have a low blow-down differential. The valve seat and all moving parts exposed to the fluid shall be of non-ferrous material.

2.08 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. Automatic Flow Control Valve (AFCV)
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. Shutoff Valves (2½" and larger) shall be lug pattern butterfly valves, Nexus Model BV:

1. A minimum of 225 psi WP, 250° F.
2. 125# Class lug pattern cast or ductile iron body.
3. EPDM cartridge seat, 416 stainless steel one-piece shaft, and 304 stainless steel disc.
4. Top and bottom shaft bushings.
5. Provide an infinite position chrome plated steel top plate for balancing purposes.
6. Epoxy coated body.

G. Automatic Flow Control Valves shall be non-clogging design, Nexus Model UM:

1. The flow cartridge's non-clogging service design shall include no metal-to-metal contact, no segmented ports, and incorporate a flow nozzle and a metering disc controlled by a pressure compensating spring.
2. The flow cartridge shall be a single assembly, constructed with stainless steel moving parts and be accessible without removing the valve from the piping (½" thru 2½" brass valves).
3. The flow cartridge shall be 100% factory flow tested and calibrated to maintain an accuracy of ±5%; the accuracy shall be 100% maintained over the operating pressure range.

4. The flow cartridge shall carry a limited lifetime material warranty.
5. Valves (2½" and smaller) shall be a forged brass Y-pattern body with ball valve, (2) pressure/temperature ports, a tag indicating the model, flow rate and PSID range, blowout proof stem with dual FKM O-ring seals, interchangeable union end with FKM O-ring seal, hard chrome plated brass ball with Teflon seats, and rated at 600 psi WP, 325° F.
6. Valves (2½" +) shall be a wafer style or 125# / 150# Class flanged cast iron body with (2) pressure/temperature ports, a tag indicating the model, flow rate and PSID range; able to incorporate a drain and/or vent as required; and rated at 175 psi WP, 250° F.

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

I. 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.

J. Combination Strainer/Butterfly Valves (2½" and larger) used for supply side shutoff and strainer requirements shall be cast or gray iron construction, Nexus Model SXFV:

1. A minimum rating of 175 psi WP, 250° F.
2. 125# Class flanges (mates to 150# Class flanges) and lug pattern butterfly valve.
3. Multiple ¼" tapped accessory ports across the filter screen.
4. A flanged end cap with a ¾" port for a blowdown/drain valve standard thru 8" size.
5. A ¾" port for thermometer well.
6. A 304 stainless steel screen, with perforations 0.045" thru 3", and 0.125" thru 8".

K. 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.

L. Y-Strainers (2½" and larger) shall be 125# Class flanged cast or ductile iron body, Nexus Model SXF:

1. Multiple ¼" tapped accessory ports across the filter screen.
2. A flanged end cap with a ¾" port for a blowdown valve standard thru 8" size.
3. A ¾" port for thermometer well.
4. A 304 stainless steel screen, with perforations 0.045" thru 3", and 0.125" thru 8".

M. 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.

N. 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.

O. 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. The (2½") hose shall have stainless steel outer braid and carbon steel Sch. 40 fittings, and designed for a working pressure of 400 psi, 70º 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
7. Chilled water systems: Provide extended pressure and temperature test plugs, manual air vents and handles. Extended handles shall not break the vapor barrier when operated.

2.09 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.

C. Chiller flexible connection: Provide the Flex-Hose Co.'s Flexzorber EED or equal, double sphere flanged (EPDM).
1. The molded spherical body must be manufactured with multiple plies of nylon tire cord fabric. The nylon tire cord fabric body must be reinforced with a spring steel wire.
2. Provide an ozone-resistant EPDM elastomer bonded to the nylon cord (to avoid exposure to atmosphere or media).
3. Provide floating/rotatable zinc-coated plate steel flanges and must have drilled bolt holes in accordance with ANSI 150# standard.
4. The 150 PSIG pressure of the molded body must have a minimum 4:1 safety factor (burst to operating pressure) at 70°F. Design pressure is based on a maximum operating temperature of 250° F.

D. Expansion Tanks: Taco Model CA, or approved equal. Construction: Welded steel, designed, tested and stamped in accordance with ASME (BPV code sec VIII, div 1); supplied with National Board Form U-1, rated for working pressure of (125/150 psi), with flexible heavy duty butyl rubber bladder. Bladder shall be able to accept the full volume of the expansion tank and shall be removable and replaceable. Bladder shall be NSF 61 rated for potable water service and shall be manufactured with FDA approved materials.

E. Expansion tank isolation valves: Provide valve lockouts: shall meet OSHA requirements to ensure ball valves are locked securely and effectively; for use on 1/4-turn valves to prevent tampering; polypropylene material resists chemicals, solvents, cracking & rust; provide padlock locking mechanism. Seton, Brady, or approved equal.

F. Air and Dirt Separator

1. Provide air and dirt removal devices of the size and type as shown on the plans. Air and dirt separation devices shall be Taco 4900 Series or approved equal by Spirovent or Bell & Gossett.
2. Air and dirt removal device shall be constructed of steel designed and fabricated per Section VIII Division 1 of the ASME Boiler and Pressure Vessel Code with a maximum working pressure rating of 125 psi at 270°F.
3. Each air & dirt separator shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. Air vent shall be furnished with a closeable port to prevent vent clogging during system fill. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and the removal of floating impurities from the air / system fluid interface within the separator. A blowdown valve shall be provided by the unit manufacturer on the bottom of each air and dirt separator to allow cleaning as required.
4. The air & dirt separator shall employ the use of high surface area, stainless steel pall rings to achieve optimal separation of air & dirt from the system fluid. Screens made of 304-stainless steel are provided on the inlet and outlet of each separator to isolate the internals from the system. Units installed in open systems shall be provided with a removable top head for removal and cleaning of the internal coalescence media.
5. The supplier of the air & dirt separator shall furnish to the design engineer the results of independent air & dirt testing of a representative unit from the suppliers' standard product offering. Suppliers not providing these independent performance test results will not be accepted.

G. Multi-Purpose Tank - Air Separator, Buffer Tank, Hydraulic Decoupler

1. 1. Manufacturers:

    a. Taco, Inc; MPT Series
    b. Spirotherm
    c. Caleffi
    d. B&G

2. The Multi-Purpose Tank shall be constructed of steel. It shall be designed, fabricated and stamped per ASME Section VIII Division 1 with a maximum working pressure of 125 psi at 270°F. Manufacturer shall be holder of ASME U stamp.
3. The pressure vessel shall consist of four system connections that are arranged on the tank in a manner that hydraulically decouples the central plant from the secondary distribution system.
4. Provide with flanged connections. Both inlet and outlet to be in the same horizontal and vertical planes.
5. Provide four 3/4" system connections sensing ports installed to allow for pressure and temperature monitoring of the plant.

6. The air removal device shall be equipped with a brass conical shaped air venting chamber designed to minimize system fluid from fouling the venting assembly. The air vent shall be able to be closed to allow flushing and purging of dirt via side port without dirt passing through vent on initial system fill.
7. A brass flushing cock shall be located on the side of each separator to facilitate system fast-fill and removal of the floating impurities from the air system interface within the separator.
8. A 2” full port blow down valve shall be provided by the unit manufacturer on the bottom of each unit to allow blow down and cleaning.
9. Provide 1-1/2” Armaflex factory insulation.
10. Provide internal pall rings.
11. Provide a base-ring support and concrete pad.

H. Y-Pattern Strainers: Strainers shall be Y-type with removable basket. Body shall have cast-in arrows to indicate direction of flow. Strainer screens shall have finished ends fitted to machined screen chamber surfaces to preclude bypass flow. Strainer element material shall be AISI Type 304 corrosion-resistant steel. Provide fine-mesh start-up strainers. Strainers in sizes 3-inch and smaller shall have screwed ends; Hammond 3010, or approved equal. Body material shall be cast bronze conforming to ASTM B584-C84400. Strainer bodies fitted with screwed screen retainers shall have straight threads and shall be gasketed with nonferrous metal. Strainer screens shall have perforations not to exceed 1/32”. In sizes 4 and larger, strainers shall have flanged ends; Hammond 3030, or approved equal. Body material shall be cast iron conforming to ASTM A126 Class B. Strainer bodies fitted with bolted-on screen retainers shall have offset blowdown holes. Strainer screens shall have perforations not to exceed 1/16” (4” size); 1/8" (5” size and larger).

2.10 WATER TREATMENT FOR CLOSED LOOP HYDRONIC SYSTEMS

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

1. Sentinel
2. Anderson Chemical Company.
3. Aqua-Chem, Inc.
4. Barclay Water Management, Inc.
5. General Electric Company; GE Water & Process Technologies.
6. H-O-H Water Technology, Inc.
7. Metro Group, Inc. (The); Metropolitan Refining Div.
8. Nalco; an Ecolab company.
9. Watcon, Inc.

B. Performance Requirements

1. Supply water for both the hot/chilled water and geothermal water circuits shall be analyzed and treated by a professional water treatment specialist who is familiar with the operating conditions and materials of construction specified.
2. Water quality for hydronic systems shall minimize corrosion, scale buildup, and biological growth for optimum efficiency of hydronic equipment without creating a hazard to operating personnel or the environment.
3. Base HVAC water treatment on quality of water available at Project site, hydronic system equipment material characteristics and functional performance characteristics, operating personnel capabilities, and requirements and guidelines of authorities having jurisdiction.

4. Cycles of concentration shall be controlled such that recirculated water quality is maintained within the following parameters:

    a. pH Greater than 7 and less than 8.5
    b. Total Dissolved Solids (TDS) Less than 1,000 ppm
    c. Hardness as CaCO3 30 to 100 ppm
    d. Alkalinity as CaCO3 30 to 500 ppm
    e. Chlorides Less than 200 ppm
    f. Sulfates Less than 200 ppm
    g. Iron: Less than 0.2 ppm
    h. Iron fouling: Less than 0.5 ppm of Oxygen

C. Bypass Chemical Feeder: Neptune Model DBF, J. L. Wingert Company, or approved equal; welded steel construction; 5-gallon capacity; with inlet, outlet, and drain valves.

1. The feeder shell shall be constructed of 10 gauge steel minimum. Tank heads shall be a minimum 9 gauge steel. The bypass feeder shall be rated at 300 psi and to 200°F.
2. The tank shall have a wide mouth, 3-1/2" opening so that chemical addition can be performed without the need of a funnel. The bypass feeder shall have a continuous threaded closure requiring 2-1/2 turns to close and seal.
3. The cap shall be constructed of cast iron with an epoxy-coated underside to prevent corrosion and shall use a square ring gasket seal.

D. Chemicals: Specially formulated, based on analysis of makeup water, to prevent accumulation of scale and corrosion in piping and connected equipment.

2.11 GLYCOL

A. DuPont Dowfrost HD or approved equal; the propylene glycol fluid to be used in such a system shall meet the following requirements: The fluid shall be industrially inhibited propylene glycol (phosphate-based). The fluid shall be easily analyzed for glycol concentration and inhibitor level, and easily re-inhibited using inhibitors readily available from the fluid manufacturer. The fluid shall pass ASTM D1384 (less than 0.5 mils penetration per year for all system metals). The fluid shall be dyed bright yellow to aid in leak detection

B. Glycol Feeders: Provide completely, preassembled packages; Glycol Feed System, JL Wingert or Neptune G50 Series, or approved equal.

1. The pump shall be a bronze rotary gear pump with a capacity as scheduled. Pump shall be mounted below the tank.
2. The tank shall be constructed of polyethylene and be provided with a four-leg carbon steel stand with four bolt pads. The tank stand shall have upper and lower steel support banding to insure tank stability. Tank stand shall be painted with a two-coat system consisting of an oxide primer and alkyd enamel finish.
3. Piping – Pump suction piping shall be piped using PVC fittings and tubing.
4. A PVC ball valve and a cast iron "Y" strainer shall be provided in the pump suction piping.
5. Pump discharge manifold shall be piped using Schedule 40 brass fittings suitable for chilled or hot water service. A pressure switch, ball valve, brass check valve and brass relief valve shall be mounted on the pump discharge assembly manifold. Piping shall be supported at both the top and bottom of the tank frame. The brass relief valve shall be piped back to the tank using PVC tubing and fittings. A pressure gauge shall be mounted in the discharge piping.

6. Panel – A 115 volt control panel with NEMA 4X enclosure consisting of the following shall be provided:

    a. H-O-A selector switch with running light and magnetic starter for feed pump.
    b. In AUTO, the pump is operated by the skid-mounted differential (adjustable) pressure switch and interlocked to a low level float switch mounted in the side of the tank.
    c. Pressure Switch: Cut-In Range as scheduled
    d. Level switch also energizes a low level remote dry contact.
    e. Panel shall also be equipped with an 8' power cord with grounded plug. Panel shall be mounted to the tank frame and positioned at eye level for ease of operation. Panels mounted on tank lids or mounted below the tank are unacceptable.
    f. All electrical components (pressure switch, level switch, and pump) shall be wired in conduit to control panel. Loose, exposed, unprotected wire is unacceptable.

PART 3 - EXECUTION

3.01 HYDRONIC PIPING APPLICATIONS – ABOVE GROUND

A. Hot/chilled Water, NPS 3 and Smaller: Type L drawn-temper copper tubing with soldered joints, or Schedule 40 steel pipe with threaded joints; or PEX-a piping.

B. Hot/chilled Water, NPS 4 and Larger: Schedule 40 steel pipe with welded or welded and flanged joints; Aquatherm or Nupi Niron

C. Makeup water piping, downstream of backflow preventer: Aquatherm or Nupi Niron, PEX, or Type L, drawn-temper copper tubing; PEX-a piping.

D. Above Ground Well Water: Aquatherm, Nupi Niron, or piping specified in 237000.

E. Drain Lines: ¾" minimum diameter; PVC or DWV Copper Tubing: ASTM B 306, Type DWV.

3.02 HYDRONIC PIPING APPLICATIONS – BELOW GROUND

A. Hydronic piping within slabs, use PEX, no joints permitted below slab.

B. Geothermal Piping and Glycol: See Section 237000.

3.03 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.

3.04 VALVE APPLICATIONS

A. Hydronic Valve Applications: Shutoff Duty: Ball and butterfly valves. Throttling Duty: Globe, ball, and butterfly 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 calibrated balancing valves in the return water line of terminal units, as indicated, and ass required to facilitate system balancing.

D. Install check valves at each pump discharge and elsewhere as required to control flow direction.

E. Install pressure-reducing valves on hot-water generators and elsewhere as required to regulate system pressure.

3.05 HYDRONIC PIPING INSTALLATIONS

A. Refer to Division 23 Section "Common Work Results for Mechanical" for basic piping installation requirements.

B. The drawings show the general arrangement of pipe and equipment but do not show all required fittings and offsets that may be necessary to connect pipes to equipment and to coordinate with other trades. Provide all necessary fittings, offsets and pipe runs at no additional cost. Coordinate with other trades for space available and relative location of HVAC equipment and accessories to be connected on ceiling grid. Pipe location on the drawings shall be altered by contractor where necessary to avoid interferences and clearance difficulties.

C. Install groups of pipes parallel to each other, spaced to permit applying insulation and servicing of valves.

D. Refer to Division 23 Section "Common Work Results for Mechanical" for joint construction requirements for soldered and brazed joints in copper tubing; threaded, welded, and flanged joints in steel piping; and solvent-welded joints for PVC and CPVC piping.

E. 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.

F. PEX Piping

1. Install PEX-a tubing according to manufacturer’s recommendations.
2. PEX-a Piping Hanger Spacing: Install hangers for PEX-a piping with the following maximum spacing: 1 inch and below: Maximum span, 32 inches. 1¼ inch and above:

Maximum span, 48 inches. 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. 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.

3. Pipe Joint Construction: PEX-a Connections: Install per manufacturer's recommendations. Use manufacturer-recommended cold-expansion tool for F1960 connections.

G. 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.

H. Install piping at a uniform grade of 0.2 percent upward in direction of flow. Pipe size at connections to equipment shall be distribution main size, not connection size. Reduce pipe sizes using eccentric reducer fitting installed with level side up. 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.

I. Provide dielectric fittings as specified in Section 23 05 00. Install unions or flanges in piping, adjacent to valves, at final connections of equipment, and elsewhere as indicated.

J. Install strainers on supply side of each control valve, pressure-reducing valve, solenoid valve, and elsewhere as indicated or recommended by component manufacturer to have strainer protection. Provide valved drain and hose connection on strainer blow down connection. Install with provisions for service clearance. Remove and clean strainer after 24 hours of operation and after 30 days of operation.

K. Install safety valves on hot-water generators and elsewhere as required by the ASME Boiler and Pressure Vessel Code. Install safety-valve discharge piping, without valves, to floor. Comply with the ASME Boiler and Pressure Vessel Code, Section VIII, Division 1, for installation requirements. Check the settings and operation of each safety valve, including valves furnished by heater manufacturer. Record settings.

3.06 HANGERS AND SUPPORTS

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

3.07 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.

B. Air separator and expansion tank to be installed on the suction side of the system pumps. Expansion tank to be tied into system piping in close proximity to air separator and system fill line. Install piping to compression tank with a 2 percent upward slope toward tank.

C. Install expansion tanks on concrete pad. Vent and purge air from hydronic system, and ensure tank is properly charged with air to suit system design requirements. Do not install drain valve.

D. Hydraulic Separators: The primary loop shall be purged of air with the secondary terminal loop shutoff valves closed. The primary loop shall be cleaned of debris by starting the primary pumps and continuously circulating water in the primary loop. The system shall be cleaned by frequently cleaning the start-up screens in the primary pump suction diffusers until the screens do not collect any more debris. Once the suction diffuser start-up screens are clean then the shutoff valves to the secondary terminal loops can be opened. The secondary terminal loops shall be purged of air by opening the manual air vents on the terminal units. When the secondary terminal unit piping is purged of air then the circulators can be started.

E. Brazed Plate Heat Exchanger: Install piped with counter flow direction. Install 20-mesh strainers (confirm mesh rating, provide per manufacturers requirement's) with manual blow downs on heat exchanger inlet connections. Install exchanger to allow removal and maintenance.

3.08 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 tappings, 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. Control valves shall be installed so that they are accessible and serviceable and so that actuators may be services and removed without interference from structure or other pipes and/or equipment.

E. 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.

3.09 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.

3.10 CHEMICAL TREATMENT

A. Perform an analysis of makeup water to determine type and quantities of chemical treatment needed to keep system free of scale, corrosion, and fouling, and to sustain the water characteristics described in Part 2.

B. Provide bypass chemical feeders in each hydronic system where indicated.

1. Install in upright position with top of funnel not more than 48 inches above the floor.
2. Install feeder in minimum NPS 3/4 bypass line, from main with full-size, full-port, ball valve in the main between bypass connections.
3. Install NPS 3/4 pipe from chemical feeder drain to nearest equipment drain and include a full-size, full-port, ball valve.

C. Initial flushing:

D. 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 per 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 as approved by the commissioning agent.

E. During the flushing 30 mesh (max.) Y-strainers (or acceptable equivalent) shall be in place in the system piping and examined periodically as necessary to remove collected residue. The flushing process shall take no less than 6 hours or until the strainers when examined after each flushing are clean.

F. Fill system with fresh water and add liquid alkaline compound with emulsifying agents and detergents to remove grease and petroleum products from piping. Circulate solution for a minimum of 24 hours, drain, clean strainer screens, and refill with fresh water. Circulate systems at normal temperature to remove adherent organic soil, hydrocarbons, flux, pipe mill varnish, pipe joint compounds, iron oxide, and like deleterious substances not removed by flushing, without chemical or mechanical damage to any system component. Removal of tightly adherent mill scale is not required. Keep isolated equipment which is "clean" and where dead-end debris accumulation cannot occur. Sectionalize system if possible, to circulate at velocities not less than 6 feet per second. Circulate each section for not less than four hours. Blow-down all strainers, or remove and clean as frequently as necessary. Drain and prepare for final flushing.

G. Detergent and acid concentrations shall be used in strict accordance with the respective chemical manufacturers instructions. After flushing with the detergent and/or dilute acid concentrations the system loop shall be purged with clean water for at least one hour to ensure that all residual cleaning chemicals have been flushed out.

H. Final Flushing: Return systems to conditions required by initial flushing after all cleaning solution has been displaced by clean make-up. Flush all dead ends and isolated clean equipment. Gently operate all valves to dislodge any debris in valve body by throttling velocity. Flush for not less than one hour.

I. Close and fill system as soon as possible after final flushing to minimize corrosion. Add initial chemical treatment and maintain water quality in ranges noted above for the first year of operation.

J. Fill systems that glycol solutions to the concentrations indicated in the equipment schedules.

3.11 FIELD QUALITY CONTROL

A. Prepare hydronic piping according to ASME B31.9 and as follows:

1. Leave joints, including welds, uninsulated and exposed for examination during test.
2. Provide temporary restraints for expansion joints that cannot sustain reactions due to test pressure. If temporary restraints are impractical, isolate expansion joints from testing.
3. Flush hydronic piping systems with clean water; then remove and clean or replace strainer screens.
4. Isolate equipment from piping. If a valve is used to isolate equipment, its closure shall be capable of sealing against test pressure without damage to valve. Install blinds in flanged joints to isolate equipment.
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 hydronic piping:

1. Use ambient temperature water as a testing medium unless there is risk of damage due to freezing. Another liquid that is safe for workers and compatible with piping may be used.
2. While filling system, use vents installed at high points of system to release air. Use drains installed at low points for complete draining of test liquid.
3. Isolate expansion tanks and determine that hydronic system is full of water.
4. Subject piping system to hydrostatic test pressure that is not less than 1.5 times the system's working pressure. Test pressure shall not exceed maximum pressure for any vessel, pump, valve, or other component in system under test. Verify that stress due to pressure at bottom of vertical runs does not exceed 90 percent of specified minimum yield strength or 1.7 times the "SE" value in Appendix A in ASME B31.9, "Building Services Piping."
5. After hydrostatic test pressure has been applied for at least 10 minutes, examine piping, joints, and connections for leakage. Eliminate leaks by tightening, repairing, or replacing components, and repeat hydrostatic test until there are no leaks.
6. Prepare written report of testing.

C. Perform the following before operating the system:

1. Open manual valves fully.
2. Inspect pumps for proper rotation.
3. Set makeup pressure-reducing valves for required system pressure.
4. Inspect air vents at high points of system and determine if all are installed and operating freely (automatic type), or bleed air completely (manual type).
5. Set temperature controls so all coils are calling for full flow.
6. Inspect and set operating temperatures of hydronic equipment to specified values.
7. Verify lubrication of motors and bearings.

END OF SECTION

SECTION 232123

HYDRONIC PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following: Division 23 Section "Common Work Results for HVAC"

1.02 SUMMARY

A. This Section includes hydronic pumps and accessories.

1.03 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.

1.04 CLOSEOUT SUBMITTALS

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

1.05 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.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Manufacturer's Preparation for Shipping: Clean flanges and exposed machined metal surfaces and treat with anticorrosion compound after assembly and testing. Protect flanges, pipe openings, and nozzles with wooden flange covers or with screwed-in plugs.

B. Store pumps in dry location.

C. Retain protective covers for flanges and protective coatings during storage.

D. Protect bearings and couplings against damage from sand, grit, and other foreign matter.

E. Comply with pump manufacturer's written rigging instructions.

1.07 COORDINATION

A. Coordinate electrical power with Division 26.

B. Concrete Bases: Refer to Section 230500.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Taco
2. Armstrong
3. Bell & Gossett ITT
4. PACO
5. Grundfos
6. Patterson
7. Wilo

2.02 VARIABLE SPEED WET ROTOR CIRCULATOR PUMPS – GRUNDFOS MAGNA3

A. Pump shall be a Grundfos Magna3 or approved equal; in-line wet rotor design. Oil lubricated pumps and shaft coupled pumps shall not be accepted. The pump shall be a standard product of a single pump manufacturer. The pump, motor, and variable speed drive shall be an integral product designed and built by the same manufacturer.

B. The enclosure shall be marked “Enclosure Type 2.”

C. The pump shall be certified and listed by a Nationally Recognized Test Laboratory (NRTL) for U.S. and Canada to comply with UL778 and UL 60730-1A.

D. Ratings

1. Maximum Pressure: 175 PSIG
2. Minimum Media Temperature: 14 °F
3. Maximum Media Temperature: 230 °F
4. Maximum Continuous Media Temperature: 203 °F
5. Maximum Sound Pressure Level: 43dB(A)
6. Voltage: 1x115V +/-10% or 1x208-230V +/-10% as required.
7. Maximum Energy Efficiency Index: 0.20

E. Pump Construction

1. Pump housing: Cast Iron: EN-JGL-250 with Cataphorese surface treatment
2. Stainless Steel: 304 Stainless
3. Impellers: Composite PES 30% GF
4. Rotor Can: PPS reinforced with Carbon Fiber(Fortran MT9141L PPS-GF40)
5. Rotor Cladding: 316 Stainless Steel
6. Stator Housing: Aluminum
7. Shaft: 316L Stainless Steel
8. Thrust Bearing: Axial: Carbon Graphite, Radial: ceramic Alumina Hilox 961
9. O-Rings: EPDM
10. Bearing Plate: 304 Stainless Steel
11. Neck Ring: 304 Stainless Steel
12. Control Box: Polycarbonate

F. Motor

1. Motor shall be 4-pole permanent-magnet (PM motor) and tested with the pump as one unit by the same manufacturer. Conventional asynchronous squirrel-cage motors shall not be acceptable.
2. Each motor shall be of the integrated Variable Speed Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.
3. The stator housing shall be made of pressure die cast aluminum.
4. The motor shall be cooled by the pumped fluid
5. The power electronics shall be cooled to the ambient air.
6. The Motor shall be self-ventilating.
7. Minimum insulation class for the motor shall be Class F.
8. The integrated VFD control shall utilize an energy optimization algorithm to minimize energy consumption by reducing the factory-set setpoint and adjust to system characteristics. This shall be accomplished without the need of any external sensors or input.

G. The pump shall have the following control mode and operating modes:

1. AUTO*ADAPT* – During operation, the pump automatically reduces the factory-set setpoint and adjusts it to the actual system characteristic. Manual setting of the setpoint is not possible.
2. FLOW*LIMIT* - It shall be possible for the user to select a maximum flow that the pump shall not exceed in order to eliminate the need for additional throttling valves. The pump shall operate per selected control mode but will limit speed to not exceed the user specified flow limit
3. FLOW*ADAPT* – The pump shall operate in the AUTOADAPT control mode with FLOWLIMIT enabled.
4. Proportional Pressure – The head delivered shall be reduced from a manual setpoint linearly in accordance with decrease in flow demand in the system
5. Constant Pressure – A manual set, constant head is maintained, irrespective of flow up to the maximum speed of the pump.
6. Constant Curve – The pump runs as an uncontrolled pump by the means of a set of pump curves. The pump curve adjustable between maximum and minimum from the control panel or through a wireless remote control.
7. Constant Temperature – the pump shall adjust speed to maintain a constant media temperature in the flow pipe in which the pump is installed.
8. Constant Differential Temperature - the pump shall adjust speed to maintain a constant temperature drop between the flow pipe in which the pump is installed and a user installed temperature sensor.
9. Alternating Operation – Two single head pumps or two heads of a dual head pump shall communicate wirelessly to one another. In alternating operation, only one pump shall

operating at a time. The operation shall alternate based on time or energy to ensure even run time of both pumps. If a pump stops due to fault the other pump shall take over automatically.

10. Back-Up Operation – Two single head pumps or two heads of a dual head pump shall communicate wirelessly to one another. In Back-Up operation one pump shall operate continuously. If the duty pumps stops due to fault the back-up pump shall take over automatically.
11. Cascade Operation - Two single head pumps or two heads of a dual head pump shall communicate wirelessly to one another. Two pumps shall operate together in constant pressure control. The pump controller shall determine when to operate a single pump or both pumps to meet demands. While both pumps operate they shall run at the same speed.

H. Interface and Communication

1. The pump shall have an integrated operator interface consisting of:

    a. Minimum 2.4" (measured diagonally) color TFT display
    b. 7 push buttons for navigation of menu
    c. Push Buttons must be able to operate at minimum 25,000 times
    d. Push Buttons must be isolated from the main supply by reinforced insulation according to UL60730
    e. LEDs to signal pump status for quick indication

2. The pump shall have a sensor integrated directly into the pump housing with 4 lines consisting of Ground, Supply, and two signals for Differential Pressure and Media Temperature.

    a. Sensor Supply shall be 4.8V DC +/- 2% at 20mA referenced to Ground. The supply must be able to withstand a permanent short circuit.
    b. The electrical values for the signal shall be 4.8V DC +/-2% referenced to ground.

3. The pump module shall have one analog input configurable for either 4-20mA or 0-10VDC input signal configurable for external Temperature or Pressure sensor, or Setpoint influence. Sensor input shall have three wires for Ground, Supply, and Signal. The Supply for external analog input shall be 24V DC +/-10% at 22mA reference to Ground. The supply must be able to withstand a permanent short circuit. Connection can be made to a screw terminal capable of wire sizes up to AWG16.
4. The pump shall have 3 Digital Inputs galvanically isolated from the main supply by a reinforced insulation according to UL60730.

    a. Start/Stop –Used to start or start the pump. The pump shall be enabled when connected to common ground by an external potential free short circuit. An open circuit to this input shall disable the pump. Connection can be made to a screw terminal capable of wire sizes up to AWG16.
    b. Minimum – used to force the pump to run at minimum load (curve). When connected to common ground by an external potential free short circuit the pump must run at minimum load. Connection can be made to a screw terminal capable of wire sizes up to AWG16.
    c. Maximum - used to force the pump to run at maximum load (curve). When connected to common ground by an external potential free short circuit the pump must run at maximum load. Connection can be made to a screw terminal capable of wire sizes up to AWG16.

5. The pump module shall have two Output Relays. Each relay shall be configurable for Alarm, Reading, or Operating indication. Each relay must have three screw terminals see

above. Output relays contacts shall be rated for maximum 250VAC at 2A and minimum 5VDC at 20mA. Each must have galvanic isolation from the internal supply by reinforced insulation according to UL60730.

6. Provide a BACnet add-on module for integration into the BAS
7. The pump module shall have wireless connectivity for two pumps to communicate with one another or for the pump to communicate to a mobile device with additional hardware.

    a. Communication range shall at minimum within 30ft of the pump without walls or barriers.
    b. Two identical pumps shall be capable of wireless communication with one another to operate as a two pump system in:

        1) Duty/Standby
        2) Alternating Mode, pumps alternate operation every 24 hours
        3) Cascade operation with both pumps running simultaneously in constant differential pressure mode.

2.03 WET ROTOR CIRCULATORS - GRUNDFOS

A. Description

1. Furnish and install variable speed pumps as per plans and pump schedule.
2. The pump shall be a standard product of a single pump manufacturer. The pump and motor shall be designed and built by the same manufacturer.
3. The wet rotor circulator pump shall be certified and listed by UL (1Z28 Water circulating pump) and/or CSA (Water Circulating Pump) and/or ETL Water Circulating Pump) for conformance to U.S. and Canadian Standards to operate at maximum 230°F and minimum 35°F water.
4. The sound pressure level of the pump shall be lower than 38dB(A)
5. The pumps shall be capable of operating continuously at 203°F.

B. Pumps

1. The pumps shall be of the quiet wet rotor in-line design.
2. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region.
3. The pump housing shall be of the in-line type and have a stainless steel neck ring to minimize recirculation and increase pump efficiency.
4. The impellers shall be of the radial type with curved blades. The impeller shall be secured to the shaft by a split cone and nut.
5. The suction and discharge flanges shall be tapped and drilled to allow gauge installation on the pump.
6. Pump Construction.

    a. Pump housing: Cast iron EN-JL-1040 (35B-40B) or SS 1.4408 (CF8M)
    b. Impellers: 304 Stainless Steel or Composite PES 30% GF
    c. Rotor can: 304 Stainless Steel
    d. Rotor cladding: 316 Stainless Steel
    e. Shaft: 303 Stainless Steel
    f. Thrust Bearing: Tungsten Carbide
    g. Axial thrust bearing: Carbon MY106
    h. Journal: Tungsten Carbide
    i. O-rings: EPDM
    j. Bearing plate: 304 Stainless Steel

C. Integrated Variable Frequency Drive Motors

1. Each motor shall be 4- or 8-pole, synchronous, permanent-magnet (PM motor) and tested with the pump as one unit by the same manufacturer. Conventional asynchronous squirrel-cage motors shall not be acceptable.
2. The circulator shall be supplied with an integrated VFD and shall not be used with any external VFDs. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.
3. The stator housing shall be made of pressure die cast aluminum. The stator housing shall have 3 drain holes to enable condensed water to escape.
4. The motor shall be cooled by the pumped fluid.
5. Motor shall be self-ventilating. The stator housing shall have nickel plated brass inspection screw.
6. Minimum insulation class for the motors shall be Class F.
7. The integrated VFD control shall utilize an energy optimization algorithm to minimize energy consumption by reducing the factory-set setpoint and adjust to actual system characteristics. This shall be accomplished without the need of any external sensors or input.
8. Operating Mode:

    a. AutoADAPT – During operation, the pump automatically reduces the factory-set setpoint and adjusts it to the actual system characteristic. This setting ensures minimum energy consumption and noise level from valves, which reduces operating costs and increases comfort. Manual setting of the setpoint is not possible.
    b. Automatic Night-Time duty – The pump shall change automatically between normal duty and night-time duty. Changeover between normal and night-time duty shall take place as a result of flow-pipe temperature measured by an internal integrated temperature sensor. The changeover shall take place when the temperature sensor registers a flow-pipe drop of more than 10-15°C within approximately 2 hours. The required temperature drop shall be a minimum of 0.1°C per minute.

D. Terminal Box

1. The terminal box shall be made of black composite material. Enclosure class shall be IP44. Aluminum terminal boxes shall not be acceptable.
2. The terminal box shall be able to connect directly to the mains without the need of an external contactor.
3. The terminal box shall be suitable to accept add-on modules.

2.04 VARIABLE SPEED PACKAGED PUMPING SYSTEM

A. Furnish and install a pre-fabricated and tested variable speed packaged pumping system for hydronic HVAC applications. Basis of Design: Grundfos Hydro (Integrated VFD/Motor)

B. The packaged pump system shall be a standard product of a single pump manufacturer. The entire pump system including pumps and pump logic controller, shall be designed, built, and tested by the same manufacturer.

1. All pumps shall be ANSI NSF 61 / NSF372 Listed for drinking water and low lead requirements.
2. The pumps shall be of the in-line vertical multi-stage design.

3. The head-capacity curve shall have a steady rise in head from maximum to minimum flow within the preferred operating region. The shut-off head shall be a minimum of 20% higher than the head at the best efficiency point.

C. The complete packaged water booster pump system shall be certified and listed by UL (Category QCZJ – Packaged Pumping Systems) for conformance to U.S. and Canadian Standards.

D. The complete packaged pumping system shall be NSF61 / NSF372 Listed for drinking water and low lead requirements.

E. The packaged pump system shall be ASHRAE 90.1 – 2010 compliant without the need of a remote mounted sensor. The control logic used to simulate a remote mounted sensor shall be proportional pressure control with squared or linear adaptation. An actual flow rate or calculated flow rate based on performance curves (5^{th} order polynomial) loaded into the controller; shall be used to adjust setpoint pressure in proportional pressure control.

F. Large In-line Vertical Multi-Stage Pumps (Nominal flows from 130 to 500 GPM) shall have the following features:

1. The pump impellers shall be secured directly to the smooth pump shaft by means of a split cone and nut design.
2. The suction/discharge base shall have ANSI Class 125 or Class 250 flange connections in a slip ring (rotating flange) design as indicated in the drawings or pump schedule.
3. Pump Construction.

    a. Suction/discharge base, pump head; Ductile Iron (ASTM 65-45-12)
    b. Shaft couplings, flange rings: Ductile Iron (ASTM 65-45-12)
    c. Shaft: 431 Stainless Steel
    d. Motor Stool: Cast Iron (ASTM Class 30)
    e. Impellers, diffuser chambers, outer sleeve: 304 Stainless Steel
    f. Impeller wear rings: 304 Stainless Steel
    g. Intermediate Bearing Journals: Silicon Carbide
    h. Intermediate Chamber Bearings: Leadless Tin Bronze
    i. Chamber Bushings: Graphite Filled PTFE
    j. O-rings: EPDM

4. The shaft seal shall be a balanced O-ring cartridge type with the following features:

    a. Collar, Drivers, Spring: 316 Stainless Steel
    b. Shaft Sleeve, Gland Plate: 316 Stainless Steel
    c. Stationary Ring: Silicon Carbide
    d. Rotating Ring: Silicon Carbide
    e. O-rings: EPDM
    f. The Silicon Carbide shall be imbedded with graphite.

5. Shaft seal replacement shall be possible without removal of any pump components other than the coupling guard, motor couplings, motor and seal cover. The entire cartridge shaft seal shall be removable as a one piece component.

G. Integrated Variable Frequency Drive Motors

1. Each motor shall be of the Integrated Variable Frequency Drive design consisting of a motor and a Variable Frequency Drive (VFD) built and tested as one unit by the same manufacturer.

2. The VFD shall be of the PWM (Pulse Width Modulation) design using current IGBT (Insulated Gate Bipolar Transistor) technology.
3. The VFD shall convert incoming fixed frequency three-phase AC power into a variable frequency and voltage for controlling the speed of motor. The motor current shall closely approximate a sine wave. Motor voltage shall be varied with frequency to maintain desired motor magnetization current suitable for centrifugal pump control and to eliminate the need for motor de-rating.
4. The VFD shall utilize an energy optimization algorithm to minimize energy consumption. The output voltage shall be adjusted in response to the load, independent of speed.
5. The VFD shall automatically reduce the switching frequency and/or the output voltage and frequency to the motor during periods of sustained ambient temperatures that are higher than the normal operating range. The switching frequency shall be reduced before motor speed is reduced.
6. An integral RFI filter shall be standard in the VFD.
7. The VFD shall have a minimum of two skip frequency bands which can be field adjustable.
8. The VFD shall have internal solid-state overload protection designed to trip within the range of 125-150% of rated current.
9. The integrated VFD motor shall include protection against input transients, phase imbalance, loss of AC line phase, over-voltage, under-voltage, VFD over-temperature, and motor over-temperature. Three-phase integrated VFD motors shall be capable of providing full output voltage and frequency with a voltage imbalance of up to 10%.
10. The integrated VFD motor shall have, as a minimum, the following input/output capabilities:

    a. Speed Reference Signal: 0-10 VDC, 4-20mA
    b. Digital remote on/off
    c. Fault Signal Relay (NC or NO)
    d. Fieldbus communication port (RS485)

11. The motor shall be Totally Enclosed Fan Cooled (TEFC) with a standard NEMA C-Face, Class F insulation with a temperature rise no higher than Class B.
12. The cooling design of the motor and VFD shall be such that a Class B motor temperature rise is not exceeded at full rated load and speed at a minimum switching frequency of 9.0 kHz.
13. Motor drive end bearings shall be adequately sized so that the minimum L10 bearing life is 17,500 hours at the minimum allowable continuous flow rate for the pump at full rated speed.

H. Pump System Controller

1. The pump system controller shall be a standard product developed and supported by the pump manufacturer.
2. Provide an installation wizard to make it simple and straightforward to operate the Hydro MPC. The installation wizard guides the operator through a sequence of instructions to ensure that all settings are made in the correct order and that system performance, as well as required protection settings are set up step by step. The wizard shall be designed to help assure a correct installation and commissioning of the pump system.
3. The controller shall be microprocessor based capable of having software changes and updates via personal computer (notebook). The controller user interface shall have a color display with a minimum screen size of 3-1/2” x 4-5/8” for easy viewing of system status parameters and for field programming. The display shall have a back light with contrast adjustment. Password protection of system settings shall be standard.
4. The controller shall provide internal galvanic isolation to all digital and analog inputs as well as all fieldbus connections.
5. The controller shall have the ability to be connected to a battery to maintain power on controller during periods of loss of supply power.

6. The controller shall have built in data logging capability. Logged vales shall be graphically displayed on the controller and able to be exported. A minimum of 3,600 samples per logged value with the following parameters available for logging:

    a. Estimated flow-rate
    b. Speed of pumps
    c. Inlet pressure
    d. Process Value (usually discharge pressure of differential pressure depending on application)
    e. Power consumption
    f. Controlling parameter (process value)

7. The controller shall display the following as status readings from a single display on the controller (this display shall be the default):

    a. Current value of the control parameter, (typically discharge pressure)
    b. Most recent existing alarm (if any)
    c. System status with current operating mode
    d. Status of each pump with current operating mode and rotational speed as a percentage (%)
    e. Estimated flow-rate, (not requiring flow meter connection)

8. The controller shall have as a minimum the following hardware inputs and outputs:

    a. Three analog inputs (4-20mA or 0-10VDC)
    b. Three digital inputs
    c. Two digital outputs
    d. Ethernet connection
    e. Field Service connection to PC for advanced programming and data logging

9. Pump system programming (field adjustable) shall include as a minimum the following:

    a. Sensor Settings (Suction, Discharge, Differential Pressure analog supply/range)
    b. PI Controller (Proportional gain and Integral time) settings
    c. High system pressure indication and shut-down
    d. Low system pressure indication and shut-down

10. The system controller shall be able to accept up to seven programmable set-points via a digital input, (additional input/output module may be required).
11. The system pressure set-point shall be capable of being automatically adjusted by using an external set-point influence. The set-point influence function enables the user to adjust the control parameter (typically pressure) by measuring an additional parameter. (Example: Lower the system pressure set-point based on a flow measurement to compensate for lower friction losses at lower flow rates).
12. The controller shall be capable of receiving a remote analog set-point (4-20mA or 0-10 VDC) as well as a remote system on/off (digital) signal.
13. The controller shall be able to adjust the ramp time of a change in set point on both an increase or decrease change in set point.
14. The pump system controller shall store up to 24 warning and alarms in memory. The time, date and duration of each alarm shall be recorded. A potential-free relay shall be provided for alarm notification to the building management system. The controller shall display the following alarm conditions:

    a. High System Pressure
    b. Low system pressure

c. Low suction pressure (warning and alarm)
d. Individual pump failure
e. VFD trip/failure
f. Loss of sensor signal (4-20 mA)
g. Loss of remote set-point signal (4-20mA)
h. System power loss

15. The pump system controller shall be mounted in a UL Type 3R rated enclosure. A self-certified NEMA enclosure rating shall not be considered equal. The entire control panel shall be UL 508 listed as an assembly. The control panel shall include a main disconnect, circuit breakers for each pump and the control circuit and control relays for alarm functions.
16. Provide control panel options:

    a. Pump Run Lights
    b. System Fault Light
    c. Surge Arrestor
    d. Service Disconnect Switches

17. The controller shall be capable of receiving a redundant sensor input to function as a backup to the primary sensor (typically discharge pressure).
18. The controller shall have a pump "Test Run" feature such that pumps are switched on during periods of inactivity (system is switched to the "off" position but with electricity supply still connected). The inoperative pumps shall be switched on for a period of two to three (3-4) seconds every 24 hours, 48 hours or once per week and at specific time of day (user selectable).
19. The controller shall be capable of changing the number of pumps available to operate or have the ability limit the maximum power consumption by activation of a digital input for purposes of limited generator supplied power.
20. The controller shall be capable of displaying instantaneous power consumption (Watts or kilowatts) and cumulative energy consumption (kilowatt-hours).
21. The controller shall be capable of displaying instantaneous specific energy use (kW/gpm), (optional flow meter must be connected).
22. The actual pump performance curves (5^{th} order polynomial) shall be loaded (software) into the pump system controller. Pump curve data shall be used for the following:

    a. Display and data logging of calculated flow rate (not requiring flow measurement)
    b. Proportional pressure control
    c. Pump outside of duty range protection
    d. Pump cascade control based on pump efficiency

23. The controller shall be capable of displaying an estimated flow-rate on the default status screen.
24. The controller shall have proportional pressure control to compensate for pipe friction loss by decreasing pressure set-point at lower flow-rates and increasing pressure set-point at higher flow-rates by using actual flow rate or calculated flow rate. Proportional pressure control that uses pump speed or power consumption only shall not be considered equal to proportional pressure control that uses actual or calculated flow rate.
25. Provide a BACnet communication expansion card installed inside controller.
26. The controller shall have Ethernet connection with a built in server allowing for connection to a network with read/write access to controller via web browser and internet.
27. The controller shall have a programmable Service Contact Field that can be populated with service contact information including: contact name, address, phone number(s) and website.

I. Sequence Of Operation

1. The system controller shall operate equal capacity variable speed pumps to maintain a differential pressure (system set-point). The system controller shall receive an analog signal (4-20mA) from the factory installed pressure transducer on the discharge manifold, indicating the actual system pressure.
2. Proportional Pressure Function: The proportional pressure function gives the Hydro MPC the ability to increase setpoint pressure at higher flow rates and reduce the setpoint at lower flow rates. The pump curve data loaded into the controller gives the controller the ability to continuously estimate the flow rate so no flow meter is required for the proportional pressure function.
3. Standard Cascade Control (Pumping Efficiency Based): The pump system controller shall adjust pump speed as necessary to maintain system set-point pressure as flow demand increases. Utilizing the pump curve information (5^{th} order polynomial), the pump system controller shall stage on additional pumps when pump hydraulic efficiency will be higher with additional pumps in operation. Exception: When the flow and head are outside the operating pump(s) allowable operating range the controller shall switch on an additional pump thus distributing flow and allowing all pump(s) to operate in allowable operating range. When the system pressure is equal to the system set-point, all pumps in operation shall reach equal operating speeds. The pump system controller shall have field adjustable Proportional Gain and Integral time (PI) settings for system optimization.
4. The system controller shall be capable of switching pumps on and off to satisfy system demand without the use of flow switches, motor current monitors or temperature measuring devices.
5. All pumps in the system shall alternate automatically based on demand, time and fault. If flow demand is continuous (no flow shut-down does not occur), the system controller shall have the capability to alternate the pumps every 24 hours, every 48 hours or once per week. The interval and actual time of the pump change-over shall be field adjustable.

J. System Construction

1. Suction and discharge manifold construction shall be in way that ensures minimal pressure drops, minimize potential for corrosion, and prevents bacteria growth at intersection of piping into the manifold. Manifold construction that includes sharp edge transitions or interconnecting piping protruding into manifold is not acceptable. Manifold construction shall be such that water stagnation cannot exist in manifold during operation to prevent bacteria growth inside manifold.
2. The suction and discharge manifolds material shall be 316 stainless steel.
3. Pump Isolation valves shall be provided on the suction and discharge of each pump. Isolation valve sizes 2 inch and smaller shall be nickel plated brass full port ball valves. Isolation valve sizes 3 inch and larger shall be a full lug style butterfly valve. The valve disk shall be of stainless steel. The valve seat material shall be EPDM and the body shall be cast iron, coated internally and externally with fusion-bonded epoxy.
4. A spring-loaded non-slam type check valve shall be installed on the discharge of each pump. The valve shall be a wafer style type fitted between two flanges. The head loss through the check valve shall not exceed 5 psi at the pump design capacity. Check valves 1-1/2” and smaller shall have a POM composite body and poppet, a stainless steel spring with EPDM or NBR seats. Check valves 2” and larger shall have a body material of stainless steel or epoxy coated iron (fusion bonded) with an EPDM or NBR resilient seat. Spring material shall be stainless steel. Disk shall be of stainless steel or leadless bronze.
5. A pressure transducer shall be factory installed on the discharge manifold (or field installed as specified on plans). Systems with positive inlet gauge pressure shall have a factory installed pressure transducer on the suction manifold for water shortage protection. Pressure transducers shall be made of 316 stainless steel. Transducer accuracy shall be +/- 1.0% full scale with hysteresis and repeatability of no greater than 0.1% full scale. The output signal shall be 4-20 mA with a supply voltage range of 9-32 VDC.

6. A bourdon tube pressure gauge, 2.5 inch diameter, shall be placed on the suction and discharge manifolds. The gauge shall be liquid filled and have copper alloy internal parts in a stainless steel case. Gauge accuracy shall be 2/1/2 %. The gauge shall be capable of a pressure of 30% above its maximum span without requiring recalibration.
7. The base frame shall be constructed of corrosion resistant 304 stainless steel. Rubber vibration dampers shall be fitted between each pumps and base frame to minimize vibration.
8. The control panel shall be mounted on a 304 stainless steel fabricated control cabinet stand attached to the system skid.

2.05 AUTOMATIC CONDENSATE PUMP UNITS

A. Manufacturers:

1. Little Giant
2. Hartell Div.; Milton Roy Co.
3. Marsh Manufacturing, Inc.

B. Description: Little Giant NXTGen or approved equal; packaged units with corrosion-resistant pump, plastic tank with cover, and automatic controls. Include factory- or field-installed check valve and a 72-inch-minimum, electrical power cord with plug.

C. Provide 20 feet of 3/8” tubing.

PART 3 - EXECUTION

3.01 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.

3.02 PUMP INSTALLATION

A. Pumps and equipment shall be provided per manufacturer’s recommendations and according to the standards of the Hydraulics Institute.

B. Provide 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. Provide connector/expansion joints at the pump suction and discharge as indicated.

E. Pumps shall **NOT** be run dry to check rotation.

F. Suspend in-line pumps in accordance with manufacturer’s recommendations.

3.03 AUTOMATIC CONDENSATE PUMP UNITS

A. Provide units for collecting condensate and extend to open drain, floor drain, mop sink, or other approved location.

B. Provide check valve on each condensate pump unit discharge.

C. Connect 3/8" tubing provided with pump unit. Do not extend tubing through smoke or fire-rated walls.

3.04 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Provide piping adjacent to machine to allow service and maintenance.

C. Connect piping to pumps. Provide valves that are the same size as piping connected to pumps.

D. Provide suction and discharge pipe sizes equal to or greater than diameter of pump nozzles. Provide fittings and specialties as detailed on the plans.

E. Provide a single gage with three-input selector valve; locate at pump suction and discharge tappings, also strainer.

F. Provide 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.

3.05 COMMISSIONING

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

B. Pumps with VFD's or packaged controls: The control package manufacturer's factory trained representative shall provide start-up of the packaged pumping system. This start-up shall include verification of proper installation, system initiation, adjustment and fine tuning. Start-up shall not be considered complete until the sequence of operation, including all alarms, has been sufficiently demonstrated to the Owner or Owner's designated representative. This jobsite visit shall occur only after all hook-ups, tie-ins, and terminations have been completed and signed-off on the manufacturer's start-up request form.

C. Check piping connections for tightness.

D. Clean strainers on suction piping.

E. Perform the following startup checks for each pump before starting:

1. Verify bearing lubrication.

2. Verify that pump is free to rotate by hand and that pump for handling hot liquid is free to rotate with pump hot and cold. If pump is bound or drags, do not operate until cause of trouble is determined and corrected.
3. Verify that pump is rotating in the correct direction.

F. Prime pump by opening suction valves and closing drains, and prepare pump for operation. Start motor. Open discharge valve slowly.

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

3.06 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

SECTION 23 31 13

DUCTWORK

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes ducts and accessories.

1.03 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.

1.04 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. Structural Performance: Duct hangers and supports and shall withstand the effects of gravity loads and stresses within limits and under conditions described in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible".

C. Airstream Surfaces: Surfaces in contact with the airstream shall comply with requirements in ASHRAE 62.1. Exception: Sheet metal surfaces and fasteners.

D. SMACNA - Round Industrial Duct Construction Standard.

E. NFPA 33 – Spray Application Using Flammable or Combustible Materials

F. NFPA 91 - Standard for Exhaust Systems for Air Conveying of Vapors, Gases, Mists, and Noncombustible Particulate Solids

1.05 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. Fittings.
4. Reinforcement and spacing.
5. Seam and joint construction.
6. Penetrations through fire-rated and other partitions.
7. Equipment installation based on equipment being used on Project.
8. 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. Backdraft dampers.
6. Manual-volume dampers: Damper manufacturer's printed application and performance data including pressure, velocity and temperature limitations shall be submitted for approval.
7. Life Safety 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.

8. Sound attenuators: The manufacturer shall supply certified test data for each scheduled silencer. The data shall include dimensions, weights, dynamic insertion loss, generated noise and pressure drop for forward or reverse flow, matching the project's air distribution system requirement. All ratings shall be conducted in the same facility and shall utilize the same silencer. Silencer performance must have been substantiated by laboratory testing according to ASTM E-477-99 and so certified when submitted for approval.
9. Dust collection ductwork

    a. Materials
    b. Accessories
    c. Manufacturer shall provide a duct layout and sizing for the equipment shown on the plans. Duct sizes shall be verified and calculated for proper dust collection. Diagram the floor plan of each system to scale. Include the size and location of each machine, and the location of its dust port or outlet; the floor to joist dimension; the location of the dust collecting unit. Confirm the diameter of each branch line.

1.06 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 fire-rated construction.
6. Items penetrating finished ceiling – examples: lighting fixtures, sprinklers, etc.

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.

1.07 CLOSEOUT SUBMITTALS

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

1.08 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
2. 96: Ventilation Control and Fire Protection of Commercial Cooking Operations

D. Sheet Metal and Air Conditioning Contractors National Association (SMACNA):

1. 3rd Edition: 2005 HVAC Duct Construction Standards, Metal and Flexible
2. 1st Edition: 2012 ANSI/SMACNA 016-2012 HVAC Air Duct Leakage Test Manual

1.09 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

2.01 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. Galvanized Coating Designation: G60 or G90 as indicated. Finishes for Surfaces Exposed to View: Mill phosphatized.

C. Carbon-Steel Sheets: Comply with ASTM A 1008/A-1008M, with oiled, matte finish for exposed ducts.

D. Stainless-Steel Sheets: Comply with ASTM A-480/A-480M, Type 304 or 316, as indicated in the "Duct Schedule" Article; cold rolled, annealed, sheet. Exposed surface finish shall be as indicated in the "Duct Schedule" Article.

E. 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.

F. Reinforcement Shapes and Plates: ASTM A-36/A-36M, steel plates, shapes, and bars; black and galvanized.

G. Tie Rods: Galvanized steel, 1/4-inch minimum diameter for lengths 36 inches or less; 3/8-inch minimum diameter for lengths longer than 36 inches.

2.02 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: Duct coils with transitions and upstream access door as shown.

2.03 DOUBLE-WALL RECTANGULAR DUCTS AND FITTINGS

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

1. McGill AirFlow LLC.
2. MKT Metal Manufacturing.
3. Set Duct Manufacturing.
4. Sheet Metal Connectors, Inc.

B. Rectangular Ducts: Fabricate ducts with indicated dimensions for the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" based on indicated static-pressure class unless otherwise indicated.

D. 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."

E. 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."

F. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. Retain first subparagraph below to require thermal conductivity exceeding the requirements in ASTM C 1071. Retaining subparagraph may create a restrictive proprietary specification. Verify availability of performance with manufacturers.
2. Maximum Thermal Conductivity: 0.27 Btu x in./h x sq. ft. x deg F at 75 deg F mean temperature.
3. Thickness: As required for R6 minimum.
4. Density: 1.5#/cu.ft.
5. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
6. Coat insulation with antimicrobial coating.
7. Cover insulation with polyester film complying with UL 181, Class 1.

G. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

H. Formed-on Transverse Joints (Flanges): Select joint types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 2-1, "Rectangular Duct/Traverse 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."

I. 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."

2.04 ROUND DUCT FABRICATION

A. General Fabrication Requirements: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on indicated static-pressure class unless otherwise indicated.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension).

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."

D. 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.

E. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

2.05 DOUBLE-WALL ROUND AND FLAT-OVAL DUCTS AND FITTINGS

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

1. Linx Industries (formerly Lindab).
2. McGill AirFlow LLC.
3. MKT Metal Manufacturing.
4. SEMCO LLC.

B. Flat-Oval Ducts: Indicated dimensions are the duct width (major dimension) and diameter of the round sides connecting the flat portions of the duct (minor dimension) of the inner duct.

C. Outer Duct: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Chapter 3, "Round, Oval, and Flexible Duct," based on static-pressure class unless otherwise indicated.

1. 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. 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."

3. Tees and Laterals: Select types and fabricate according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Figure 3-5, "90 Degree Tees and Laterals," and Figure 3-6, "Conical Tees," for static-pressure class, applicable sealing requirements, materials involved, duct-support intervals, and other provisions in SMACNA's "HVAC Duct Construction Standards - Metal and Flexible."

D. Inner Duct: Minimum 0.028-inch perforated galvanized sheet steel having 3/32-inch-diameter perforations, with overall open area of 23 percent.

E. Interstitial Insulation: Fibrous-glass liner complying with ASTM C 1071, NFPA 90A, or NFPA 90B; and with NAIMA AH124, "Fibrous Glass Duct Liner Standard."

1. R6 minimum.
2. Install spacers that position the inner duct at uniform distance from outer duct without compressing insulation.
3. Coat insulation with antimicrobial coating.
4. Cover insulation with polyester film complying with UL 181, Class 1.

2.06 HANGERS AND SUPPORTS

A. Hanger Rods: Cadmium-plated steel rods and nuts.

B. Hanger Rods for Outdoor Environments: Electrogalvanized, all-thread rods or galvanized rods with threads painted with zinc-chromate primer after installation.

C. Strap and Rod Sizes: Comply with SMACNA's "HVAC Duct Construction Standards - Metal and Flexible," Table 5-1, "Rectangular Duct Hangers Minimum Size," and Table 5-2, "Minimum Hanger Sizes for Round Duct."

D. Steel Cables for Galvanized-Steel Ducts: Galvanized steel complying with ASTM A-603. 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 Stainless-Steel Ducts: Stainless-steel shapes and plates.
3. Supports for Aluminum Ducts: Aluminum or galvanized steel coated with zinc chromate.

G. Supports For Roof Mounted Items:

1. Equipment rails shall be galvanized steel, minimum 18-gauge, with integral baseplate, continuous welded corner seams, factory installed 2x4 treated wood nailer, 18-gauge galvanized steel counter flashing cap with screws, built-in cant strip; minimum height 11 inches. Provide raised cant strip to start at the upper surface of the insulation.
2. Pipe/duct pedestals: Provide a galvanized unistrut channel welded to U-shaped mounting brackets which are secured to side of rail with galvanized lag bolts.

2.07 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 listed; UL 181A-M or 181B-M listed; and meet NFPA 90A requirements. Pressure sensitive tape shall not be used as a sealing mechanism.

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: 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. Double-lipped, EPDM O-ring seal, mechanically fastened to factory-fabricated couplings and fitting spigots.

2.08 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.

D. Low-point drains: Ductmate moisture drain with funnel collection design; ¾” connection with drain fitting and cap.

2.09 DUCT LINER

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

1. Certainteed Toughgard-2
2. Knauf Textile Duct Liner with Hydroshield Technology
3. John Mansville Linacousic RC
4. McGill Airflow

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. The air stream surface contains an EPA registered antimicrobial agent in order to reduce the potential of microbial growth that may affect this product.

D. Duct dimensions shown on the contract drawings are for airflow area. When ducts are acoustically lined, their dimensions shall be increased as necessary.

E. Liner Thickness: General duty: 1.5 inch (R6 minimum)

F. Fibrous-Glass Duct Liner :All ducts indicated on drawings, shall be insulated with duct liner meeting the requirements of ASTM C1071 and the additional following requirements:

1. Have a liquid water repellency rating not less than 4 when tested in accordance with INDA IST 80.6.
2. Have a potential heat value not exceeding 3500 BTU/lb. when tested in accordance with NFPA 259 and meeting the classification of "Limited Combustible" as defined by NFPA 90A.
3. Maximum rated velocity not less than 6000 FPM when tested in accordance with ASTM C 1071.
4. Antimicrobial Erosion-Resistant Coating: Apply to the surface of the liner that will form the interior surface of the duct to act as a moisture repellent and erosion-resistant coating. Antimicrobial compound shall be tested for efficacy by an NRTL and registered by the EPA for use in HVAC systems. Resistant to microbial growth using a "no growth criteria" when tested in accordance with ASTM C 1138, G 21 and G22.
5. Duct liner adhesive sealants shall meet requirement for "LEED IEQ Credit 4.1: Low Emitting Materials: Adhesive and Sealant". ITW TACC PF-101/PF-102, or approved equal.

G. Round ducts: Certainteed "Tough-Gard Ultra-Round", or equal; a semi-rigid board-type insulation composed of resin-bonded glass fibers with a durable black nonwoven air stream surface. The board shall be grooved to provide the flexibility required to line the inside of spiral metal ducts.

H. 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.

2.10 DUST COLLECTION DUCTWORK:

A. Nordfab duct is a clamp-together design using a rolled edge design with a single lever clamp. The ducting and clamps are made of similar materials. During manufacturing, the duct material sheet blanks, which are five feet long, are rolled and fused together with a laser weld process along the longitudinal seam. Each pipe is checked with a light apparatus for any welding flaws or gaps. The rolled edge is then die-formed after inspection by rolling each end of the pipe simultaneously. The laser weld prevents any gaps in the rolled edge from forming. This rolled end is used for clamping components together as well as offering reinforcement every five feet. All clamps contain a standard gasket made of Nitrile which is suitable for most applications, including oil mist, as long as high temperatures are not an issue. Nordfab Quick-Fit Ducting is available in 1” increments sized 3” to 24” diameter.

B. Manufacturer shall calculate required duct main sizes and transitions. Prepare a complete layout to scale for each system.

C. Ductwork shall be bonded and grounded in accordance with NFPA 664.

D. Ducting shall be galvanized: ASTM A527 with a G90 rating; Temp rating is 500° F with no breakdown of zinc - Zinc melting point is 740° F

E. Ducting manufacturing techniques:

1. Adjustable nipples, and collars attached to other components will have one or both ends die formed-rolled to provide a uniform edge around the circumference of the rolled end. The pipe and adjustable nipples shall have the longitudinal seam laser welded to allow for a tighter slip joint and reduce system pressure losses. All laser welded seams will undergo a light test to ensure there are no voids or imperfections in the system. Pipe lengths using laser welded seams will not exceed a nominal 60” length. The rolled edges provide structural support at 5’ intervals or less and can be interpreted as a stiffener where SMACNA specifications are required. An adjustable nipple is used for adjustment during the install process. Pipe is cut to appropriate length and the adjustable nipple secures the pipe for install.
2. There will be times when certain components will be air direction sensitive. These components will have an arrow sticker attached showing the proper flow direction.

3. All ducting and its components shall have been tested to 80" WG using the following gauged reference:

    a. 3" will use 18 ga material thickness
    b. 4" through 12" will use 22 ga material thickness
    c. 13" and larger will use 20 ga material thickness

F. Clamping rolled edged duct:

1. Clamps shall be constructed with an over-center, spring-lever action for quick connecting of two pieces of ducting. A retaining pin shall be inserted in the handle and an eyelet on the clamp as a safety feature to ensure the handle does not prematurely come undone.
2. When closing the clamp, the internal seal shall be compressed in such a manner as to cover both rolled beads for optimum sealing capacity in a full 360° pattern.

G. Caulking: 3M Scotch Seal Metal Sealant 2084 or equivalent for system temperatures of 250°F or lower

H. Sealing gaskets

1. Buna-N, 70 Duro-Meter hardness with a temperature rating of 250°F maximum and is black in color, used with the adjustable nipple
2. Clamp seals: Nitrile to meet or exceed ASTM D 1056 standards with a temperature rating not to exceed 158°F constant temperature (or intermittent temperature of 194°F).

I. Conductivity: Metal-to-metal contact shall be obtained at all joint connections. Die-formed rolled edges are uniform in shape which provides the most consistent contact. The ears of the clamp contact with the rolled edges and provide maximum conductivity. Conductivity shall be adhered to per NFPA 77 paragraph 8.4.1.1; states all parts of the continuous metal piping system should have a resistance level that does not exceed 10 ohms. Testing is the responsibility of the owner.

J. Provide accessory fittings:

1. Long radius elbows – 30, 35 degree.
2. Y-branches
3. Provide taps and branches having a 30 degree slope or less.
4. Reducers
5. Hose adapters
6. End caps
7. Flanges
8. Provide manual blast gates at each branch connection and as indicated: Nordfab's QF Manual Blast Gate allows manual operation and is constructed of a cast aluminum body with a galvanized steel standard connection collar. Provide the QF (rolled edge) ends for easy connection to Quick-Fit ductwork.
    a. Blast gates shall be located within reach of floor.
9. Hoses: static dissipative urethane hose; medium weight clear polyurethane with a bronze-coated spring steel wire helix. Provide hose clamps for attaching hose to duct fittings or machines.

K. Provide accessory duct hangers:

1. Pipe hanger HJ
2. Clamp hanger
3. Strut hanger
4. Gripple hanger

2.11 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. diameter 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; ½ 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.

2.12 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. Dynamic dampers: Closing rating in ducts up to 4-inch wg static pressure class and minimum 4000-fpm velocity.

D. Fire Rating: 1-1/2 hours.

E. Frame: Curtain type with blades outside airstream except when located behind grille where blades may be inside airstream; fabricated with roll-formed, 0.034-inch-thick galvanized steel; with mitered and interlocking corners.

F. Mounting Sleeve: Factory-provided.

G. Mounting Orientation: Vertical or horizontal as indicated.

H. Blades: Roll-formed, interlocking, 0.034-inch-thick, galvanized sheet steel. In place of interlocking blades, use full-length, 0.034-inch-thick, galvanized-steel blade connectors.

I. Horizontal Dampers: Include blade lock and stainless-steel closure spring.

J. Heat-Responsive Device: Replaceable, 165°F rated, fusible links.

2.13 DUCT SILENCERS (SOUND ATTENUATORS)

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

1. Price
2. Vibro Acoustics
3. Ruskin Company
4. Kinetics
5. IAC
6. Commercial Acoustics

B. General: Factory-fabricated and -tested, round, elbow, or rectangular silencer with performance characteristics and physical requirements as indicated.

C. Fire Performance: Adhesives, sealers, packing materials, fill media, and accessory materials shall have fire ratings not exceeding 5 for flame spread and 35 for smoke developed when tested according to ASTM E 84, NFPA 255, or UL723.

D. Steel gauges shall be as scheduled.

E. Rectangular Units - indoors: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel. Slip and drive connections.

F. Rectangular Units - outdoors: Outer casing shall be weatherproofed and satin coated (paintable) – provide a custom paint color to match the associated duct collector. Seams shall be sealed water-tight. Flanged connections.

G. Circular Silencers**:** Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, gauge as listed below.

H. Rectangular Elbow: Outer casing shall be ASTM A 653/A 653M, G90 galvanized sheet steel, 18 gauge. All acoustical splitters shall be internally radiused and aerodynamically designed for efficient turning of the air. Half and full splitters are required as necessary to achieve the scheduled insertion loss. All elbow silencers with a turning cross-section dimension greater than 48” shall have at least two half splitters and one full splitter.

I. Fibrous Acoustic-Fill Material: Media shall be “Mold Block Media” containing 100% natural cotton fibers treated with an EPA registered, non-toxic borate solution, and “flash dried” to actively inhibit the growth of mold, mildew, bacteria and fungi. Media shall not contain any formaldehydes, phenolic resins or Volatile Organic Compounds (VOC’s) that can off-gas and/or cause health concerns. Media shall be 100% recyclable. Media shall comply with UL181 and NFPA 90A. The media shall be packed with a minimum of 15% compression during silencer assembly. Media shall not cause or accelerate corrosion of aluminum or steel. Glass fiber, fiberglass and rock wool will not be permitted as a substitute for the specified media.

J. Fabricate silencers to form rigid units that will not pulsate, vibrate, rattle, or otherwise react to system pressure variations. Silencers shall be constructed in accordance with ASHRAE and SMACNA standards for the pressure and velocity classification specified for the air distribution system in which it is installed. Material gauges shall be increased as required for the system pressure and velocity classification. The silencers shall not fail structurally when subjected to a differential air pressure of 8 inches water gauge.

K. Source Quality Control: Perform the following factory tests:

1. Acoustic Performance: Test according to ASTM E 477, with airflow in both directions through silencer.
2. Record acoustic ratings, including dynamic insertion loss and self-noise power levels, for both forward flow (air and noise in same direction) and reverse flow (air and noise in opposite directions) with airflow of at least 2000-fpm face velocity.
3. Leak Test: Test units for air tightness at 200 percent of associated fan static pressure or 6-inch wg static pressure, whichever is greater.

2.14 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. Durodyne
6. Cesco
7. 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: Double wall, rated for up to 4.5” static pressure. Door panel filled with 1" fiberglass insulation; ¾ lb. density. Hinges and Latches: 1-by-1-inch continuous piano hinge and cam latches. 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. Locks: Access doors less than 16 InchesSquare: Two cam locks. Doors over 16” shall have four locks.

C. Ruskin ADR and ADF oval access doors for rectangle and round duct are constructed of galvanized steel; Synthetic knobs with metal threaded inserts, which prevent thread stripping and provide ease of turning, eliminating need for a wrench; Cellular sponge gasket permanently bonded to the inside of the door to eliminate leakage; Quick and easy installation; 16” x 12” size.

D. Grease Duct Access Doors: Ductmate Grease Duct Sandwich Access Door or approved equal; two layers of precision stamped, hot-dipped galvanized steel, and one 16 gauge black iron backing plate. Doors shall be tested to -20” W.C. with no leakage noted. The backing plate shall be spot welded to the inside panel. Gasket: Ceramic Fiber Gasket (2300ºF max—meets NFPA 96 standards) shall be permanently bonded to the outside panel of the access door to eliminate leakage. Zinc plated conical springs shall be installed between the inner and outer door, to facilitate opening. Provide zinc coated wing nuts for access; zinc plated carriage bolts, welded and sealed to the inner door. Provide a self adhesive template for the exact size of duct opening required.

2.15 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.

2.16 FLEXIBLE DUCTS

A. General: Comply with UL 181, Class 0 0r 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. Supply & Return 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. Jacket (inner and outer): Polyethylene film.

E. 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.

F. Hangers shall be band type, 1" wide minimum.

PART 3 - EXECUTION

3.01 MATERIALS

A. Hangers, accessories, and dampers shall be same material as parent duct.

B. Refer to Specification Section 23 07 00 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. Un-insulated exterior ductwork: G90 galvanized steel.
2. 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.
3. Exposed Ductwork: Galvaneal (ready for paint)
4. Plenums at outside louvers: G90 galvanized steel, water-tight, pitched to drain. Provide low-point drain fittings at low points.
5. Locker Room Shower area exhaust ductwork: Aluminum
6. Radon exhaust ductwork installed in or beneath slabs: Schedule 40 PVC pipe that conforms to ASTM D 1785.
7. Dust collection: Galvanized steel ASTM 525, G90

3.02 DUCT CLASSIFICATIONS AND SEALING

A. Static-Pressure Classifications: Unless otherwise indicated, construct ducts to the following:

1. Supply duct upstream of VAV terminal units: 3 in. w.g.
2. Supply Ducts downstream of VAV terminal units: 2-inch wg.
3. Supply Ducts, constant volume: 2-inch wg.
4. Return Ducts: 2-inch wg, negative pressure.
5. Exhaust Ducts: 2-inch wg, negative pressure.
6. Exhaust Duct discharges and plenums between fan and louver: welded water-tight.

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.

3.03 DUCT INSTALLATION, GENERAL

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 at no additional cost. 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 shall be altered by Contractor to other dimensions with the same air handling characteristics where necessary to avoid interferences and clearance difficulties.

B. Provide volume dampers at all branch ducts to RGD's. If volume dampers are inadvertently not shown, contractor shall provide, the intent is to provide volume dampers at all branches.

C. Provide ducts and accessories according to SMACNA's "HVAC Duct Construction Standards - Metal and Flexible" unless otherwise indicated.

D. Construct and install each duct system for the specific duct pressure classification indicated.

E. 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.

F. Provide ducts in lengths not less than 12 feet, unless interrupted by fittings. Provide ducts with fewest possible joints.

G. Provide fabricated fittings for changes in directions, changes in size and shape, and connections.

H. Provide couplings tight to duct wall surface with a minimum of projections into duct.

I. Provide ductwork to allow maximum headroom. Provide ducts, unless otherwise indicated, vertically and horizontally, parallel and perpendicular to building lines; avoid diagonal runs. Provide ducts close to walls, overhead construction, columns, and other structural and permanent enclosure elements of building.

J. Provide ducts with a clearance of 1 inch, plus allowance for insulation thickness.

K. Conceal ducts from view in finished spaces. Do not encase horizontal runs in solid partitions, unless specifically indicated.

L. Coordinate layout with suspended ceiling, lighting layouts, and similar finished work.

M. Electrical Equipment Spaces: Route ductwork to avoid passing through transformer vaults and electrical equipment spaces and enclosures.

3.04 INSTALLATION OF EXPOSED DUCTWORK

A. Ductwork will be painted by Section 09 90 00.

B. Protect ducts exposed in finished spaces from being dented, scratched, or damaged.

C. Hangers Exposed to View: Threaded rod and angle or channel supports.

D. Trim duct sealants flush with metal. Create a smooth and uniform exposed bead. Do not use two-part tape sealing system. Seal duct joints to prevent dirt marks.

E. 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.

F. Maintain consistency, symmetry, and uniformity in the arrangement and fabrication of fittings, hangers and supports, duct accessories, and air outlets.

G. Repair or replace damaged sections and finished work that does not comply with these requirements.

3.05 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 23 05 00.

B. Fire or Smoke Rated Penetrations: Provide fire and/or smoke 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. Mechanical room floor penetrations: Provide 4-inch high concrete curbs or other sealing method to prevent leakage from mechanical room into floor penetration.

F. Roof penetrations by ducts shall use counter-flashed curbs.

G. Flexible air ducts or connectors shall not pass through any wall, floor, or ceiling.

3.06 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. Provide 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. Provide upper attachments to structures. Select and size upper attachments with pull-out, tension,

3.07 FLEXIBLE DUCT

A. Provide in accordance with manufacturer's and Air Diffusion Council recommendations.

B. Flexible ducts hall be supported at manufacturer's recommended intervals, but at no greater distance than 5 feet. Maximum permissible sag is ½" per foot of spacing between supports.

C. Provide 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.

3.08 SPECIALTY DUCTWORK

A. Exhaust hoods furnished by Division 11. Exhaust hoods shall be received and installed by the sheet metal contractor.

B. Range Hood Exhaust Duct Installations

1. Materials:

   a. Concealed: Carbon-steel sheet; 16-gauge minimum thickness.
   b. Exposed to View: Type 304, stainless-steel sheet, No. 4 finish.
   c. Weld and flange seams, joints, and penetrations.

2. Kitchen grease hood exhaust ducts: Comply with NFPA 96 and International Mechanical Code.
3. Provide ducts to allow for thermal expansion of ductwork through 2000 deg F temperature range.
4. Provide commercial kitchen hood exhaust ducts without dips and traps that may hold grease, and sloped a minimum of 2 percent to drain grease back to the hood.

5. Provide ducts without dips or traps that may collect residues, unless traps have continuous or automatic residue removal.
6. Provide welded test ports in the sides of the exhaust duct for the duct Pitot tube traverse. Provide each test port with a threaded cap that is liquid tight. Provide in each straight run at the direction of the TAB contractor.
7. Provide fire-rated access panel assemblies at each change in direction and at maximum intervals of 20 feet in horizontal ducts, and at every floor for vertical ducts, or as indicated on Drawings. Locate access panel on top or sides of duct a minimum of 1-1/2 inches from bottom of duct.
8. Do not penetrate fire-rated assemblies except as allowed by applicable building codes and authorities having jurisdiction.
9. Grease duct test: Prior to the use or concealment of any portion of the grease duct system (installed in shafts or covered by coatings or wraps that prevent the ductwork from being visually inspected on all sides), a leakage test shall be performed in the presence of the code official. Provide the necessary equipment. A light test or equivalent approved test method shall be performed to determine that all welded joints are liquid-tight. A light test shall be performed by passing a minimum 100-watt lamp through the entire section of ductwork to be tested. The lamp shall be open so as to permit light equally in all directions perpendicular to the duct walls. A test shall be performed for the entire duct system including the hood-to-duct and duct-to-fan connections. The ductwork shall be permitted to be tested in sections, provided that every joint is tested.

C. Dishwasher Exhaust Duct: Not needed, ventless hoods are specified by Division 11.

D. Clothes Dryer Exhaust

1. Clothes dryers shall be exhausted in accordance with the manufacturer's instructions.
2. Ducts shall be galvanized steel.
3. Ducts shall not be connected or installed with sheet metal screws or other fasteners that will obstruct the exhaust flow. Provide riveted or welded construction, sealed 100% air-tight.
4. The male end of the duct at overlapped duct joints shall extend in the direction of airflow.
5. Each vertical riser shall be provided with a means for cleanout.
6. Terminate ductwork at building exterior with wall cap with back-draft damper. Screens shall not be installed at the duct termination.

E. Spray Booth Exhaust:

1. See 23 34 23 for exhaust stack sketch.
2. Exhaust ducts shall be supported to prevent collapse under fire conditions.
3. Duct supports shall be designed to carry the weight of the duct itself, plus the anticipated weight of any residues. The duct system shall also be designed to support the weight of any accumulation of sprinkler discharge.
4. A cleanout door shall be installed above the dampers in the exhaust stack.
5. Sheet metal shall be 20 gauge minimum. All joints shall be welded and water-proof.
6. Provide guy wires or other method to secure the exhaust stack.

F. Mixing Room & Exhaust Bench (H-B) Exhaust:

1. See 23 34 23.
2. A cleanout door shall be installed at the base of the duct riser near the hood.
3. Sheet metal shall be 22 gauge minimum. All joints shall be welded and water-proof.

G. Fume Hood Exhaust:

1. Provide all-welded stainless steel ductwork, 18 gauge minimum thickness. Ducts exhausting air from fume hoods should be constructed entirely of non-combustible material. Gaskets shall be resistant to degradation by the chemicals involved and fire resistant.
2. Provide stainless steel sheet, ASTM A167, Class 316, Condition A (annealed) Finish No. 4 for exposed ducts and Finish No. 2B for concealed duct or ducts located in mechanical rooms.
3. Continuously "butt" weld (use appropriate filler rod for type of stainless) for joint construction. A VanStone flange can be used if the quality of the weld may be compromised because of inaccessibility to the area.
4. Provide a flanged removable spool piece (minimum of 24 inches long) at each fume hood connection. Use spool sections for leak tests, inspection, and to facilitate removal of equipment. Install acceptable gaskets at flanged joint connections.
5. Horizontal ducting shall be sloped down towards the fume hood (a recommended guideline is that the slope should equal to 1/8 inch per foot).
6. Exhaust duct must have liquid and airtight joints with smooth interior surfaces free of cracks, joints, or ledges
7. Test fume hood exhaust ducts as follows:

    a. Connect a blower to the duct specimen through a shutoff valve. Provide a magnehelic gauge or inclined manometer with 0 to 10 inch W.G. range on the duct side of the shutoff valve.
    b. Provide temporary seals at all open ends of the duct.
    c. Average test pressure shall be 6 inches W.G. Initial pressure shall be 7 inches W.G.
    d. All fume duct joints from the fume hood collar to the fan inlet flex connection, not inclusive, shall be tested.
    e. To prevent over-pressurizing the ducts, start the blower at low airflow. Controlling pressure carefully, pressurize the duct section to the required level. When the pressure of the duct reaches 7 inches W.G., close the shutoff valve.
    f. Using a stopwatch, measure the time elapsed from when the duct is at 7 inches W.G. to 5 inches W.G. Use the formula t=6.23D to determine if the duct passes the test. (“D” is the nominal duct diameter, measured in inches; “t” is the MINIMUM allowable elapsed time, measured in seconds.)
    g. If the test fails to meet the allowable rate, make necessary repairs and retest until satisfactory results are obtained. Contact the Owner’s Representative to witness the test.
    h. Complete test reports.
    i. Comply with precautions listed in the current SMACNA HVAC Air Duct Leakage Test Manual.

3.09 DUCT ACCESSORIES INSTALLATION

A. Provide 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 runout to 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. Provide flexible connectors at all air moving equipment, unless noted otherwise.

E. Adjust operable devices for proper action.

F. Perform the following as directed by the controls contractor:

1. Installation of control devices
2. Access doors where indicated and as required.

G. Provide duct access panels for access components that require servicing.

1. Provide duct access panels to allow access to interior of ducts for cleaning, inspecting, adjusting, and maintaining per equipment manufacturers' requirements.
2. Provide 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. On both sides of duct coils.
    b. Upstream from duct filters.
    c. At outdoor-air intakes.
    d. At drain pans and seals.
    e. Adjacent to and close enough to life safety dampers, to reset or reinstall fusible links. Access doors for access to 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.
    f. Control devices requiring inspection.
    g. 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.

H. 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.

I. 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. Provide 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. Provide 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. Provide 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 LOUVER INSTALLATION

A. Louvers to be furnished and installed by Section 08 91 00. Ductwork shall be connected to the louvers by Division 23.

B. Pitch horizontal ducts and plenums connected to louvers downward toward louvers not less than 1/8" per foot. Connect to louver to allow drainage to exterior. Seal duct water-tight.

3.11 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 in^2, 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. 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 ASTMC916.

3.12 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. Systems shall not be operated without filters in place.

D. Upon completion of installation duct systems and before HVAC system start-up, visually inspect the ductwork proper installation

E. 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.

F. 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.

G. Check all filters in accordance with their manufacturer's instructions. Use specified grade of filters at all times that system is operating.

H. Provide leakage Testing:

1. Comply with SMACNA's "HVAC Air Duct Leakage Test Manual." Submit a test report for each test. 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.
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/P0.65

    a. F = the measured leakage rate in CFM per 100 square feet of duct surface.
    b. P = the static pressure of the test.

3. Disassemble, reassemble, and seal segments of systems to accommodate leakage testing and for compliance with test requirements.
4. Test for leaks before applying external insulation.
5. Conduct tests at static pressures equal to maximum design pressure of system or section being tested. If static-pressure classes are not indicated, test system at maximum system design pressure. Do not pressurize systems above maximum design operating pressure.
6. Give seven days' advance notice for testing.

I. Duct system will be considered defective if it does not pass tests and inspections. Prepare test and inspection reports.

END OF SECTION

SECTION 23 34 23

POWER AND GRAVITY VENTILATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 23 Section "Common Work Results for Mechanical"
2. 23 05 00 Appendix – HVAC Systems Description

1.02 SUMMARY

A. This Section includes:

1. Fans and ventilators.

1.03 ACTION SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated and include the following:

1. Certified fan performance curves with system operating conditions indicated.
2. Certified fan sound-power ratings.
3. Motor ratings and electrical characteristics, plus motor and electrical accessories.
4. Material gages and finishes, including color charts.
5. Dampers, including housings, linkages, and operators.
6. Wiring Diagrams: Power, signal, and control wiring.
7. Vibration Isolation

1.04 CLOSEOUT SUBMITTALS

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

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. AMCA Compliance: Products shall comply with performance requirements and shall be licensed to use the AMCA-Certified Ratings Seal for sound and air performance.

1. Sound-Power Level Ratings: Comply with AMCA 301, "Methods for Calculating Fan Sound Ratings from Laboratory Test Data." Factory test fans according to AMCA 300, "Reverberant Room Method for Sound Testing of Fans." Label fans with the AMCA-Certified Ratings Seal.
2. Fan Performance Ratings: Establish flow rate, pressure, power, air density, speed of rotation, and efficiency by factory tests and ratings according to AMCA 210, "Laboratory Methods of Testing Fans for Rating."

C. NEMA Compliance: Motors and electrical accessories shall comply with NEMA standards.

D. UL Standards: Power ventilators shall comply with UL 705.

E. Power ventilators for use for restaurant kitchen exhaust shall also comply with UL 762.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Deliver fans as factory-assembled unit, to the extent allowable by shipping limitations, with protective crating and covering.

B. Disassemble and reassemble units, as required for moving to final location, according to manufacturer's written instructions.

C. Lift and support units with manufacturer's designated lifting or supporting points.

1.07 COORDINATION

A. Refer to Division 23 Section "Common Work Results for Mechanical"

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations.

C. Coordinate size and location of structural-steel support members.

D. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Cook
2. Solar & Palau Ventilation Group
3. New York Blower Company
4. Penn Ventilation Companies, Inc.
5. Acme Engineering & Mfg. Corp.
6. Greenheck Fan Corp.
7. Hartzell Fan, Inc.

2.02 GENERAL FAN REQUIREMENTS

A. Motors: Include built-in, thermal-overload protection and grease-lubricated ball bearings. Select each motor to be non-overloading over full range of pump performance curve. Comply with NEMA MG 1 requirements for thermally protected motors.

B. Motors Indicated to be premium efficiency, and shall meet or exceed all NEMA Standards Publication MG1 requirements and comply with NEMA premium efficiency levels Class B temperature rise; Class F insulation.

C. Motors used with VFD's: 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. Inverter-Duty Motors: Class F temperature rise; Class H insulation.

D. ECM Motors: Motor to be an open type, DC electronic commutation type motor (ECM) specifically designed for fan applications. Motors are permanently lubricated, heavy duty ball bearing type to match with the fan load and pre-wired to the specific voltage and phase. Internal motor circuitry to convert AC power supplied to the fan to DC power operate the motor. Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by either a potentiometer dial mounted at the motor or by a 0-10 VDC signal. Motor shall be a minimum of 85% efficient at all speeds.

E. Fans selected shall be capable of accommodating static pressure and flow variations of +/-15% of scheduled values.

F. Total efficiency of fans at point of operation shall be within 10% of the fan's maximum total efficiency.

2.03 ROOF OR WALL POWER VENTILATOR

A. Description: centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Construction: Aluminum, completely weatherproof, for curb or wall mounting, exhaust cowl or entire drive assembly readily removable for servicing.

C. Upblast or Downblast as scheduled.

D. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
2. ECM Motor
3. Bird Screens: Removable, 1/2-inch mesh, aluminum wire.
4. Gravity Back-draft Dampers: Counterbalanced, parallel-blade, mounted in curb base; factory set to close when fan stops.
5. Extended lube lines to allow bearing lubrication while the fan is running.
6. Disconnect Switch – NEMA 3R rated disconnect switches; factory mounted.

7. Provide roof curb as specified hereinafter.

2.04 CEILING-MOUNTING VENTILATORS

A. Description: Centrifugal fans for installing in ceiling or for concealed in-line installation as scheduled.

B. Housing: Steel, lined with acoustical insulation. To accommodate different ceiling thickness, an adjustable pre-punched mounting bracket shall be provided.

C. Fan Wheel: Centrifugal wheels directly mounted on motor shaft. Fan shrouds, motor, and fan wheel shall be removable for service.

D. The outlet duct collar shall include a reinforced aluminum damper with continuous aluminum hinge rod and brass bushings.

E. Grille: A powder painted white aluminum grille shall be provided.

F. Electrical Requirements: Junction box for electrical connection on housing and receptacle for motor plug-in. Motor shall have permanently lubricated bearings, built-in thermal overload protection and disconnect plug.

G. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
2. ECM Motor
3. Manual Starter Switch: Single-pole rocker switch assembly with cover and pilot light.
4. Isolation: Rubber-in-shear hanging vibration isolators.
5. Aluminum wall cap, with ½" bird screen, and transition fittings.

2.05 KITCHEN EXHAUST ROOF VENTILATORS

A. Description: Greenheck CUBE direct-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, curb base, and accessories.

B. Fan shall be listed by Underwriters Laboratories (UL 762); designed to eject contaminated or grease laden air. The fan shall be UL listed to operate continuously at elevated temperatures, and continue operation during grease flare-up.

C. The fan shall be of bolted and welded construction utilizing corrosion resistant fasteners. The spun aluminum structural components shall be constructed of minimum 16-gauge marine alloy aluminum, bolted to a rigid aluminum support structure. The aluminum base shall have a one-piece inlet spinning and continuously welded curb cap corners for maximum leak protection. The wind band shall have a rolled bead for added strength. A two-piece top cap shall have quick release latches to provide access into the motor compartment. An external wiring compartment with integral conduit chase shall be provided into the motor compartment to facilitate wiring connections. The motor, bearings and drives shall be mounted on a minimum 14-gauge steel power assembly. These components shall be enclosed in a weather-tight compartment, separated from the exhaust airstream. A one-inch thick, three-pound density foil backed heat shield shall be utilized to protect the motor and drive components from excessive heat.

D. Fan Wheels: Aluminum hub and wheel with backward-inclined blades.

E. Accessories:

1. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
2. Extended lube lines to allow bearing lubrication while the fan is running.
3. Cook Grease Terminator-2 grease capture and containment system.
4. Kitchen Exhaust Roof Curbs: Overall Height: Curb height of 9.5" with a vented extension. The vented extension, constructed of galvanized steel, is used to increase the discharge height of the fan, as required to meet the NFPA 96 of 40" minimum discharge height. Vents in the extension allow the interior ductwork to dissipate heat. Metal Liner: Galvanized steel. NFPA 96 Hinged Sub base: Galvanized steel hinged arrangement permitting service and maintenance.
5. Provide a factory disconnect Switch: NEMA-3R non-fusible type, with thermal-overload protection mounted inside fan housing, factory wired through an internal aluminum conduit.

2.06 SQUARE IN-LINE CENTRIFUGAL FANS

A. Description: Centrifugal square inline fan, duct-mounted.

B. Housing: The fan shall be of bolted construction utilizing corrosion resistant fasteners. Housing shall be minimum 18 gauge galvanized steel with integral duct collars. Bolted access doors shall be provided on three sides, sealed with closed cell neoprene gasketing. Housing shall be pre-drilled to accommodate universal mounting feet for vertical or horizontal installation

C. Direct-Driven Units: Motor encased in housing outside of airstream, factory wired to disconnect switch located on outside of fan housing.

D. Fan Wheels: Wheel shall be centrifugal backward inclined, constructed of 100% aluminum, including a precision machined cast aluminum hub. Wheel inlet shall overlap an aerodynamic aluminum inlet cone to provide maximum performance and efficiency.

E. Motor shall be heavy duty type with permanently lubricated sealed ball bearing.

F. Provide Accessories:

1. Hanging vibration isolators.
2. Variable-Speed Controller: Solid-state control to reduce speed from 100 percent to less than 50 percent.
3. Backdraft damper.

2.07 WALL PROPELLER FANS

A. Wheel:

1. Propeller shall be aluminum blade riveted to steel hub
2. A standard square key and set screw or tapered bushing shall lock the propeller to the motor shaft
3. Statically and dynamically balanced in accordance with AMCA Standard 204-05
4. The propeller and fan inlet will be matched and shall have precise running tolerances for maximum performance and operating efficiency

B. Motors:

1. ECM Motor shall be speed controllable down to 20% of full speed (80% turndown). Speed shall be controlled by a potentiometer dial mounted at the motor.
2. Accessible for maintenance
3. Drive frame assemblies and fan panels shall be galvanized steel
4. Drive frame shall have welded wire or formed channels and fan panels shall have prepunched mounting holes, formed flanges and a deep formed one piece inlet venturi
5. Motor Side Guard: OSHA, protective guard completely enclose the motor and drive side of the fan

C. Provide Accessories:

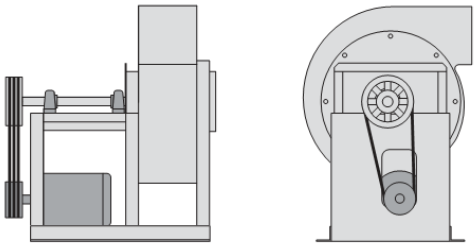
1. Wall Sleeve: Galvanized steel to match fan and accessory size.
2. Disconnect Switch – NEMA 3R rated disconnect switches; factory mounted.
3. Dampers: Type: Gravity backdraft.

2.08 UTILITY SET FAN - EF-P17

A. Description: Belt-driven centrifugal fans consisting of housing, wheel, fan shaft, bearings, motor and disconnect switch, drive assembly, and accessories.

B. Fan Housing And Outlet

1. Process or material handling fans shall be of the heavy duty type with the inlet diameters and outlet areas manufactured in accordance with the standards adopted by AMCA for industrial fans.
2. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
3. The housing shall be of continuously welded heavy gauge steel. All interior and exterior surface steel shall be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be gray, RAL-7023. No uncoated metal fan parts will be allowed.
4. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
5. Provide an OSHA compliant weather hood to completely cover the motor pulley and belt.
6. Arrangement 10 with top horizontal discharge.



C. Fan Wheel - Aluminum
1. The fan wheel shall be of the radial type. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
2. Fan wheel shall be manufactured with continuously welded steel blades and coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be gray, RAL-7023.

3. The wheel and fan inlet shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

D. Fan Motors And Drive

1. Motors shall meet or exceed EISA (Energy Independence and Security Act) efficiencies. Motors to be NEMA T-frame, 1800 or 3600 RPM, TEFC, with a 1.15 service factor.
2. Drive belts and sheaves shall be sized for 150% of the fan operating brake horsepower, and shall be readily and easily accessible for service, if required.
3. Fan shaft to be turned and polished steel that is sized so the first critical speed is at least 25% over the maximum operating speed for each pressure class.
4. Fan shaft bearings shall be Air Handling Quality, bearings shall be heavy-duty grease lubricated, self-aligning or roller pillow block type.
5. Air Handling Quality bearings to be designed with low swivel torque to allow the outer race of the bearing to pivot or swivel within the cast pillow block. Bearings shall be 100% tested for noise and vibration by the manufacturer. Bearings shall be 100% tested to insure the inner race diameter is within tolerance to prevent vibration.
6. Bearings shall be selected for a basic rating fatigue life (L-10) of 80,000 hours at maximum operating speed for each pressure class {Average Life or (L-50) of 400,000 hours}.
7. Bearings shall be fixed to the fan shaft using concentric mounting locking collars, which reduce vibration, increase service life, and improve serviceability. Bearings that use set screws shall not be allowed.
8. Bearings shall have Zerk fittings to allow for lubrication.

E. Accessories:

1. Access Doors: Bolted.
2. Drain connection.
3. Provide a vented steel weather hood to protect the motor and drive components from rain, moisture, dust, and dirt. Weather hood shall meet OSHA guidelines and be easily removed for service access.
4. Isolation base with rubber isolators.
5. Disconnect switch

2.09 FUME-JET EXHAUST FANS

A. Each fan shall be direct drive in AMCA arrangement 4 according to drawings.

B. Fans are to be equipped with lifting lugs.

C. After fabrication, all carbon steel components shall be cleaned and chemically treated by a phosphatizing process to insure proper removal of grease, oil, scale, etc. Fan shall then be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. Coating must exceed 1,000-hour salt spray under ASTM B117 test method.

D. Fan Housing And Integral Stack

1. When properly anchored to the roof structure, the standard fan / stack assembly shall withstand wind loads of up to 22 PSF (pounds per square foot), equivalent to 92 mph (miles per hour) wind speed, without the need for guy wires or additional structural support.

2. Fan housing is to be aerodynamically designed with high-efficiency inlet, engineered to reduce incoming air turbulence.
3. The housings on all fan sizes shall be of continuously welded heavy gauge steel. Panels shall be coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey. No uncoated metal fan parts will be allowed.
4. Partial wheel and housing widths shall be used to attain specific fan performance requirements.
5. Fan wheel will be directly coupled to the motor shaft.
6. Housing and bearing support shall be constructed of welded structural steel members to prevent vibration and rigidly support the shaft and bearings.
7. Housing shall include discharge stack of same material as fan housing to increase the overall discharge height of the unit. Minimum overall unit height with stack to be 8 feet from the roof deck.
8. Stack material to be a minimum of 18 gauge. Stack to match outlet dimensions of the fan and shall not add additional static pressure drop to the exhaust fan.
9. No discharge rain caps or flapper caps are permitted as to interfere with exhaust airflow.
10. Threaded drain connection with plug shall be located at lowest part of scroll housing to prevent moisture build-up in the interior of fan.
11. Shall be provided with integral inlet box and curb cap constructed of same material and coated to match fan housing, with access panel for inspection of fan wheel and duct.

E. Fan Wheel

1. The fan wheel shall be of the non-overloading backward inclined centrifugal type. Wheels shall be statically and dynamically balanced to balance grade G6.3 per ANSI S2.19.
2. Fan wheel shall be manufactured with continuously welded steel blades and coated with a minimum of 2-4 mils of Permatector (Polyester Urethane), electrostatically applied and baked. Finish color shall be RAL 7023, concrete grey.
3. The wheel cone and fan inlet cone shall be carefully matched and shall have precise running tolerances for maximum performance and operating efficiency.

F. Motors shall meet or exceed EISA (Energy Independence and Security Act) efficiencies. Motors to be NEMA T-frame, 690, 870, 1170, 1770 or 3500 RPM in 60 Hz, Totally Enclosed Fan Cooled (TEFC) with a 1.15 service factor.

G. Provide Accessories:

1. Access door – Bolted removable panel provides access for inspection or cleaning.
2. Inlet Flange – Fan inlet is flanged for bolted connection to system ductwork.
3. Companion Inlet flange – For easy connection between inlet flange and system duct work. Companion flange has matching bolt-hole pattern as inlet flange.
4. Restrained Spring Isolators – Both vertical and lateral movement restricted. Isolators are seismically rated to minimum 1.0 g, and sized for all components including stack.
5. Curb Cap Inlet Box (CCIB) – Provides quick transition from roof opening to fan inlet often used in locations with minimal roof deck space. Coated steel construction with fully welded seams and corners.
6. Backdraft Damper – Located in the roof curb, gravity damper prevents airflow back into the building when the fan is not in operation.
7. Duct Drop – Transition between building duct work and inlet box opening. Coated and fully welded, duct drop supplied with matching flange to inlet box and slip-fit end for easy field duct connection.
8. Roof Curb – Model GPFHL is a straight sided, insulated roof curb with internal vertical supports designed for high loads. Roofing material is brought to the vertical surface and sealed to the flashing flange.
9. Disconnect Switch – NEMA 3R rated disconnect switches; factory mounted.

10. Extended Lube Lines – Conveniently located grease fittings mounted on the exterior of weather-hood or motor cover. Nylon or copper depending on airstream temperature.

2.10 GRAVITY ROOF VENTILATORS

A. Mixing Room & Exhaust Bench (H-B) Exhaust: Paintbooths.com Paint Booth Exhaust Ductwork Package; Paint booth exhaust duct kits transfer the exhaust fumes out of the building, as required by NFPA 33 guidelines. The duct kit shall be made of 20-gage galvanized steel. The kit will need to be assembled on-site. The exhaust duct kits include:

1. Two (2) 4' long sections of duct
2. A butterfly style weather head (to keep out rain and snow)
3. Roof curb
4. Roof sleeve with rain collar
5. Sizes:

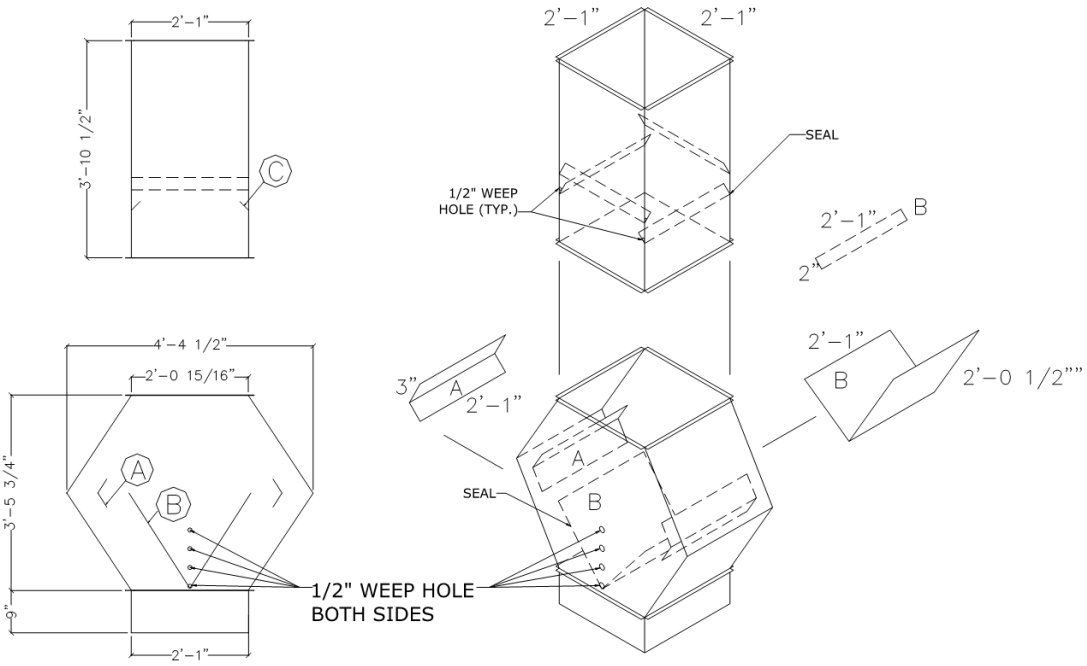
    a. H-B: 30” diameter X 8 ft tall.
    b. Mixing Room: 12” diameter X 8 ft tall.

B. Paint Booth intake & exhaust – from Basis of Design Garmat “Chinook II” modified downdraft spray booth. Provide per sketches below. Confirm exact details with the final spray booth selection.

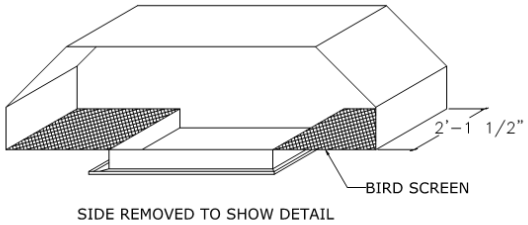
1. Provide a flashed roof curb for the duct penetration through the roof. The top of the exhaust outlets shall be 6 feet minimum above the finished roof.
2. Intake hood curb shall be 36” tall.

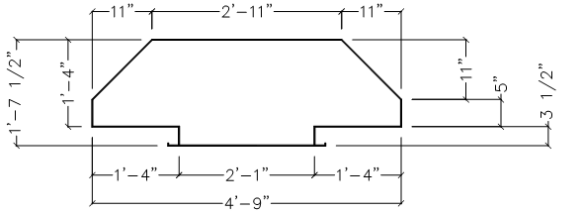
SECTION Lc – The Chinook II Intake and Exhaust with heat
DUCT WORK REQUIREMENTS Duct Caps Page 4lc-3

NOTE: The information provided in this documentation is for PRELIMINARY BIDDING AND PLANNING PURPOSES ONLY



RECOMMENDED EXHAUST CAP





RECOMMENDED INTAKE CAP

2.11 ROOF CURBS

A. Ducts from fans shall be connected to fan with a flex connector; below roofline.

B. Roof Curbs: Galvanized steel; mitered and welded corners; 2-inch- thick, rigid, fiberglass insulation adhered to inside walls; and less wood nailer. Size as required to suit roof opening and fan base.

1. Configuration: per roofing manufacturer's requirements. Coordinate with roofing contractor.
2. Provide a neoprene seal between the fan and the curb cap to help prevent insects and moisture from entering and vibration transmission in the ductwork.
3. Pitch Mounting: Manufacture curb for roof slope.
4. Metal Liner: Galvanized steel.
5. Overall Height: 18 inches.
6. Provide hinged sub-base. Hinged base shall be a factory welded sub-base, hinge and locking hasp that provides a secure and stable means of access to the inlet and interior ductwork for cleaning and inspection. Galvanized aircraft cable shall be installed on the hinged base to support the fan in an open position.
7. Dampers: Counterbalanced, parallel-blade, backdraft dampers mounted in curb base; factory set to close when fan stops.
8. Motorized Dampers: Parallel-blade dampers mounted in curb base with electric actuator; wired to close when fan stops.

2.12 DESTRATIFICATION FANS – BIG ASS FANS BASIC 6

A. Complete Unit

1. Regulatory Requirements: The entire fan assembly shall be Intertek/ETL-certified and built pursuant to the construction guidelines set forth by UL standard 507 and CSA standard 22.2.
2. Sustainability Characteristics: The fan shall be designed to move an effective amount of air for cooling and destratification in industrial applications over an extended life. The fan components shall be designed specifically for high volume, low speed fans to ensure lower operational noise. Sound levels from the fan operating at maximum speed measured in a laboratory setting shall not exceed 55 dBA. Actual results of sound measurements in the field may vary due to sound reflective surfaces and environmental conditions.
3. Good workmanship shall be evident in all aspects of construction. Field balancing of the airfoils shall not be necessary.

B. Airfoil System

1. The fan shall be equipped with six (6) Powerfoil airfoils of precision extruded aluminum alloy. The airfoils shall be connected by means of two (2) high strength locking bolts per airfoil. The airfoils shall be connected to the hub and interlocked with zinc plated steel retainers.
2. The fan shall be equipped with six (6) Powerfoil winglets on the ends of the airfoils. The winglets shall be molded of a polypropylene blend. The standard color of the winglet shall be “Safety Yellow.”

C. Motor

1. The fan motor shall be an AC induction type inverter rated at 1725 RPM, 200–240/400–480 VAC, 50/60 Hz, three-phase.
2. The motor shall be totally enclosed, fan cooled (TEFC) with an IP56. A B5 standard frame shall be provided for ease of service. The motor shall be manufactured with a double baked Class F insulation and be capable of continuous operation in -30o F to 122o F (-34o C to 50o C) ambient conditions.

D. Gearbox: The gearbox shall be a helical gear reducer, precision finished from hardened steel for low noise and long service life with double lip seals to retain oil and prevent contamination. The gearbox shall be lubricated for life. The gear reducer shall have a standard backlash of less than 25 arc minutes and be equipped with a 17-4 stainless steel shaft of 1-1/4” (3.2 cm) diameter.

E. Motor Frame: The motor frame and mount shall be constructed of steel and powder coated for corrosion resistance and appearance. Non-visible, steel, threaded rods in each structural member of the motor frame shall provide a redundant safety feature in the event of a catastrophic event.

F. Mounting System

1. The fan mounting system shall be designed for quick and secure installation on a variety of structural supports. The mounting yoke shall be of ASTM A-36 steel, welded construction, at least 3/16” thick, and powder coated for appearance and corrosion resistance. No mounting hardware or parts substitutions, including cast aluminum, are acceptable.
2. All mounting bolts shall be SAE Grade 8 or equivalent.

G. Hub:

1. The fan hub shall be made of laser cut aluminum for high strength and light weight. The hub shall consist of two aluminum plates, six (6) aluminum spars and one (1) spacer fastened with a pin and collar rivet system.
2. The hub shall be secured to the output shaft of the gearbox by means of a steel coupling interface. The hub shall incorporate six (6) safety retaining clips made of 1/4" thick steel that shall restrain the hub/airfoil assembly.

H. Safety Cable

1. The fan shall be equipped with a safety cable that provides an additional means of securing the fan assembly to the building structure. The safety cable shall be at least 1/4" in diameter and fabricated out of 7 x 19 galvanized steel cable. The end loops shall be secured with swaged Nicopress® sleeves, pre-loaded and tested to 3,200 lbf.
2. Field construction of safety cables is not permitted.

I. Variable Frequency Drive

1. The fan controller shall be a NEMA 4X variable frequency drive (VFD) that is factory programmed to minimize starting and braking torques. The VFD shall have touchpad controls and an LED display for controlling the fan's direction, operation, speed, and programming. The VFD may be equipped with an EMI/RFI filter to limit interference with other electronic equipment and a rotary switch disconnect for lockout/tag-out requirements.

2. Wall mounted keypad: The onboard VFD package shall be provided with a simple hardware kit that mounts the VFD to the fan. A digital keypad with touch controls and an LED display for controlling the fan's direction, operation, speed and programming shall be mounted at the floor level. Equipped with a simple diagnostic program to identify, troubleshoot and reprogram faults in the system. Communication between the fan VFD and wall controller is a shielded 18/4 cable; provide wiring.

J. Provide smart sense control: Featuring three user modes — winter, summer and manual — Smart Sense eliminates the human-error and hassle of fan operation by automatically matching the speed of your Big Ass Fans to seasonal conditions.

K. BAS Integration: The wall controller remains active as a display so fault messages can be viewed and toggling between output frequency and fan RPM displays can be performed. A purpose-built BACnet adapter shall be provided that includes the following features:
1. Multiple fan control from a single adaptor node for easy installation and integration
2. Auto-mapping of fan control nodes to BACnet points
3. Supported for either BACnet IP or MS/TP in one adaptor

L. Fire Integration: Includes a 10–30 VDC pilot relay; wired Normally Open or Normally Closed in the field.

M. Guy wires: Included for installations with extension tubes 4 ft or longer to limit the potential for lateral movement.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide power ventilators level and plumb.

B. Provide vibration isolation as specified.

C. Provide floor-mounting units on concrete bases designed to withstand, without damage to equipment, the seismic force required by code. Concrete, reinforcement, and formwork requirements are specified in Division 23 “Common Work Results for Mechanical”.

D. Secure roof-mounting fans to roof curbs with cadmium-plated hardware. Refer to Division 7 for installation of roof curbs.

E. Coordinate with Division 7 for installation of Kitchen exhaust fan curb with non-combustible materials.

F. Support suspended units from structure using threaded steel rods and spring hangers.

G. Relocate EF-W (see photo below). Provide supports (relocate if feasible).



H. Provide units with clearances for service and maintenance.

I. Label units according to requirements specified in the Division 23 HVAC Identification Section.

J. Big Ass Fans

1. Fan location must have a typical bar joist or existing I-beam structure from which to mount the fan. Mounting structure must be able to support weight and operational torque of fan. Provide I-beam or angle steel supports. Consult structural engineer if necessary.
2. Fan location must be free from obstacles such as lights, cables, or other building components.
3. Check fan location for proper electrical requirements. Consult installation guide for appropriate circuit requirements.

4. Each fan requires dedicated branch circuit protection.
5. The fan shall be installed by a factory-certified installer according to the manufacturer's Installation Guide, which includes acceptable structural dimensions and proper sizing and placement of angle iron for bar joist applications. Big Ass Fans recommends consulting a structural engineer for installation methods outside the manufacturer's recommendation and a certification, in the form of a stamped print or letter, submitted prior to installation.
6. Installation area must be free of obstructions such as lights, cables, sprinklers or other building structures with the airfoils at least 2 ft clear of all obstructions.
7. The fan shall be centered approximately between four adjacent sprinklers. The vertical clearance from the HVLS fan to the sprinkler deflector shall be a minimum of 3 ft.
8. All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72—National Fire Alarm and Signaling Code.

3.02 EF-P17 – LASER CUTTER EXHAUST FAN

A. Epilog model 8000 laser systems require an exhaust fan that is rated at a minimum of 400 CFM at 6" of static pressure.

B. Provide flexible duct connections:



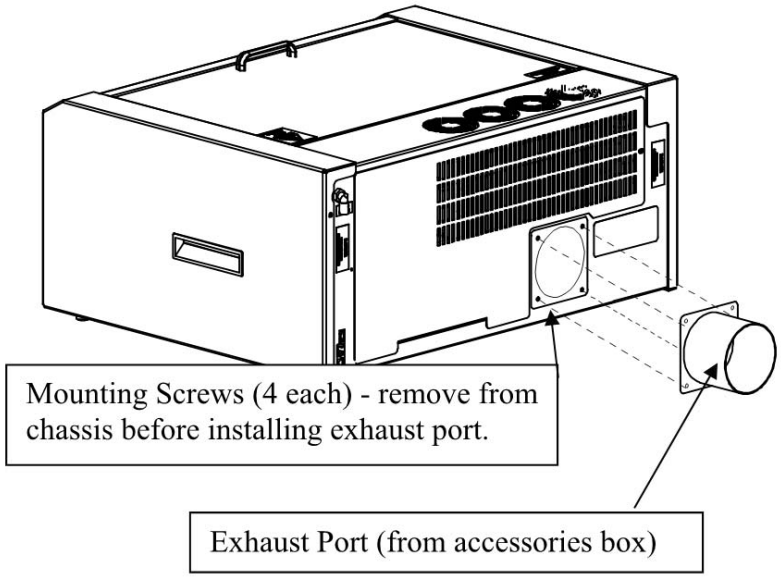
Warning: It's important that either rigid or flexible ***metal*** ducting be used for all connections leading to and from the laser system and the exhaust fan. Vinyl, plastic, or any type of "soft" ducting is potentially flammable and should NEVER be used. Flexible aluminum duct or galvanized sheet metal duct is readily available for your ducting needs.

In the United States flexible aluminum ducting can be acquired from the following location:

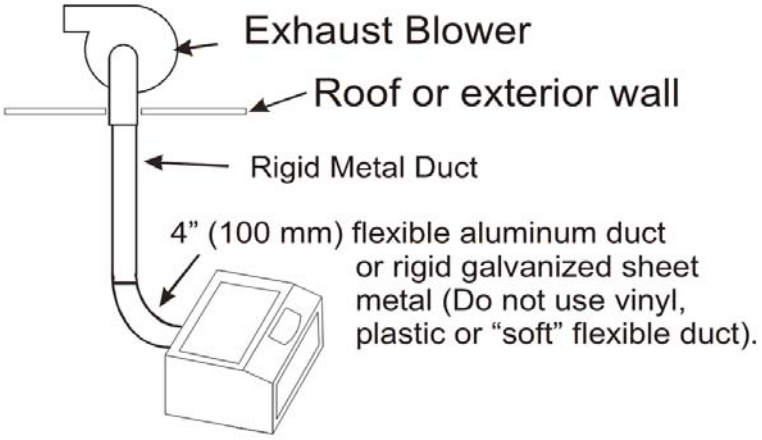
- Grainger http://www.grainger.com/
- McMaster-Carr http://www.mcmaster.com/



Supplier	Size	Part Number	Cost (15 foot length)
Grainger	4"	3C591	$17.52
McMaster-Carr	4"	5525K34	$15.90



C. Mount the blower on the roof.
   1. Provide roof sleepers large enough to support the fan and discharge duct.
   2. Provide a horizontal discharge duct, 4 feet long, with a 45 degree termination to prevent water intake.
   3. Bottom of discharge duct shall be 2 feet minimum above the roof..



3.03 CONNECTIONS

A. Duct installation and connection requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of ducts and duct accessories. Make final duct connections with flexible connectors. Flexible connectors are specified in Division 23 Section "Ductwork."

B. Provide ducts adjacent to power ventilators to allow service and maintenance.

3.04 FIELD QUALITY CONTROL

A. Equipment Startup Checks and Adjustments:

1. Verify that shipping, blocking, and bracing are removed.
2. Verify that unit is secure on mountings and supporting devices. Verify that connections to ducts and electrical components are complete. Verify that proper thermal-overload protection is installed in motors, starters, and disconnect switches.
3. Verify that cleaning and adjusting are complete.
4. Inspect and tighten fasteners and setscrews, particularly fan mounting and bearing fasteners.
5. Disconnect fan drive from motor, verify proper motor rotation direction, and verify fan wheel free rotation and smooth bearing operation.
6. Verify lubrication for bearings and other moving parts.
7. Verify that dampers in connected ductwork systems are in fully open position.
8. Adjust damper linkages for proper damper operation.
9. Adjust VFD speed.
10. Lubricate bearings.

B. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation. Remove malfunctioning units, replace with new units, and retest.

C. Refer to Division 23 Section "Testing, Adjusting, and Balancing" for testing, adjusting, and balancing procedures.

3.05 CLEANING

A. On completion of installation, internally clean fans according to manufacturer's written instructions. Remove foreign material and construction debris. Vacuum fan wheel and cabinet.

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

END OF SECTION

SECTION 23 34 24

EXHAUST CAPTURE SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes exhaust capture systems.

B. Related Documents: The Contract Documents, as defined in Division 1, apply to the Work of this Section. Additional requirements and information necessary to complete the Work of this Section may be found in other Documents.

C. Related Sections:

1. Division 26 - Electrical characteristics and wiring connections.

1.03 REFERENCES

A. ACGIH - Industrial Ventilation, A Manual of Recommended Practice.

B. AMCA 99 - Standards Handbook.

C. AMCA 210 - Laboratory Methods of Testing Fans for Rating Purposes.

D. AMCA 300 - Test Code for Sound Rating Air Moving Devices.

E. AMCA 301 - Method of Calculating Fan Sound Ratings from Laboratory Test Data.

F. ASTM A 90 - Weight of Coating on Zinc-Coated (Galvanized) Iron or Sheet Articles.

G. ASTM A 653 - General Requirements for Steel Sheet, Zinc-Coated (Galvanized) or Zinc-Iron Alloy Coated (Galvannealed) by the Hot-Dip Process.

H. AWS 9.1 - Welding of Sheet Metal.

I. NFPA 33 – Spray Application Using Flammable or Combustible Materials

J. NFPA 68 - Standard on Explosion Protection by Deflagration Venting

K. NFPA 650: Standard for Pneumatic Conveying Systems for Handling Combustible Particulate Solids

L. NFPA 664: Standard for the Prevention of Fires and Explosions in Wood Processing and Woodworking Facilities

M. NFPA 70 - National Electrical Code.

N. SMACNA - HVAC Duct Construction Standards - Metal and Flexible.

O. SMACNA - Rectangular Industrial Duct Construction

P. UL 214 - Tests for Flame-Propagation of Fabrics and Films.

1.04 SUBMITTALS

A. Section 01 33 00 - Submittal Procedures: Procedures for submittals.

1. Product Data: Provide manufacturers literature and data sheets indicating rated capacities, dimensions, weights and point loadings, accessories, electrical characteristics and connection requirements, wiring diagrams, and location and sizes of field connections.
2. Submit sound power levels for both inlet and outlet at rated capacity.
3. Shop Drawings: Indicate dimensions, sizes, weights and point loadings, and locations and sizes of field connections.
4. Submit vendor ducted layout indicating all components (e.g. fans, ductwork, and equipment connections) with dimensions.
5. Manufacturer's Installation Instructions: Indicate assembly and installation instructions.

B. Qualification Documentation: Submit documentation of experience indicating compliance with specified qualification requirements.

C. Section 01 78 00 - Closeout Submittals: Procedures for closeout submittals.

1. Operation and Maintenance Data: Include instructions for fan lubrication, motor and drive replacement, spare parts list, and wiring diagrams.
2. Special Warranty: Submit written special warranty with forms completed in United States Postal Service name and registered with manufacturer as specified in this Section.

1.05 QUALITY ASSURANCE

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

B. Job installation and dust collectors shall conform to NFPA standards 664, 68 and 650.

C. Provide all ductwork, fittings and drops.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Division 1 - Product Requirements: Transport, handle, store, and protect products.

PART 2 - PRODUCTS

2.01 DUST COLLECTORS - GENERAL

A. Manufacturers: Subject to compliance with project requirements, manufacturers offering Products which may be incorporated in the Work include the following:

1. AQC
2. Airflow Systems
3. Belfab
4. Airex

B. Local Representation: The following vendors are familiar with the project and have provided design assistance and budgeting:

1. Ed Rowe, HVAC Products, Inc.; 207-874-6100
2. Jonathan Buliung, Clean Air Technology, Inc. 603-267-7042

C. Exterior Coatings: The metal will be cleaned of all residues. Provide a primer resistant to 4,000 hours of salt spray (ASTM B-117) at 6 mils dry. Provide a thick base and finish coats of polyurethane inside and outside of the cabinet. Finish coat color shall be as selected by the Architect. Structural supports and accessories shall have the same coatings.

D. Provide in accordance with current codes and standards, see Paragraph 1.03 “References” above.

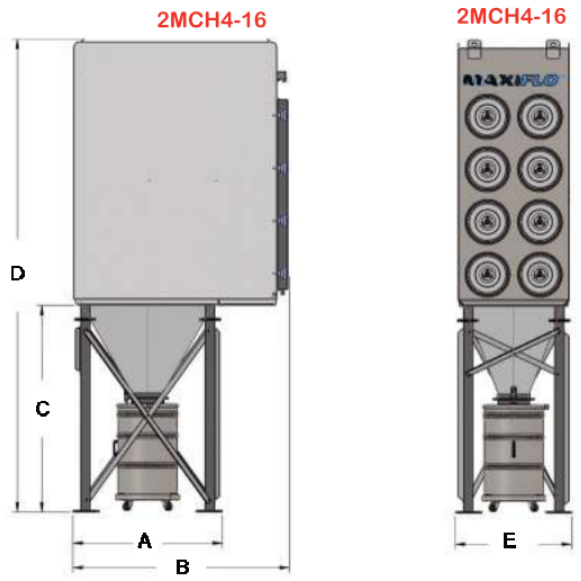
E. Provide weather protection for exterior units.

F. Provide all available sound reduction options.

2.02 PULSE-CARTRIDGE DUST COLLECTORS – METAL

A. Locations:

1. DC-W2 – Welding



B. DC-W2 Specifications
   1. Dimensions
      a. A: 57”
      b. B: 82”
      c. C: 78”
      d. D: 14’-9”
      e. E: 44”
   2. Number of Cartridges, cellulosic: 16
   3. Weight: 3,500 lbs.
   4. Airflow CFM range: 4,000 to 10,000
   5. Filtration Surface Area: 4,160 SF
   6. Air/cloth ratio: 1.73/1
   7. Cartridges efficiency: 99.9% on 1.0 µm dust particles
   8. Maximum sound level, dBA: 73

C. Metal Shop Dust Collection Systems: AQC MaxiFlo or equal, for use with metal collection only. Direct drive TEFC motor BI wheel, includes housing. Provide all ductwork, fittings and drops including 7ft articulating arms.

D. Cartridges shall be horizontal and will be cleaned thru an electronic pulse control system.

E. The all welded dust collectors will be constructed with 1/8 inch thick steel sheets to insure the collector will resist 20 in negative pressures. The tube sheet shall be minimum ¼ in steel sheets to insure the yokes supporting the cartridges retain their horizontal position at all times.

F. Dust collectors will include an integral spark arresting section consisting in an empty section located whiten the cartridge filter modules. This chamber will eliminate sparks and other transportable debris by decelerating the air to the point of separation of particles before re-introducing the air to the filtering modules.

G. Dust collectors will sit on low silhouette hoppers sloped so as the filtered dust will fall into quick connect/disconnect dust container.

H. An acoustic plenum shall be furnished with locking access doors to cover the pulse cleaning reservoir, diaphragm valves and solenoid kits. The plenum and doors will be lined with 1in acoustic insulation.

I. Cartridges will be accessible through individual doors with screw on handles insuring air tightness of the cabinet. The cartridges will be set two in series and slide on supporting yokes. A locking device will be included to prevent non authorized tampering.

J. The dust collector casing shall be cleaned with an industrial degreaser, a primer coat of polyurethane shall be applied inside and outside followed by two coats of hammer tone type polyurethane beige finish.

K. Provide an Explosion vent in accordance with NFPA 68.

L. Cartridges shall be cylindrical, be constructed from cellulosic tissue available on the open market, and have a gravitational efficiency of 99.9 at 1 micron. Cartridges will slide on a supporting structure capable of supporting two cartridges.

M. Cleaning

1. Cleaning will be achieved through pulses of compressed air introduced in the cartridges. Pulses are controlled by an electronic sequencer with a programmable digital control adjustment panel, each compressed air pulse will clean two cartridges at a time.
2. Provide a pressure module for demand-based sequencing.
3. The sequencer will be installed whiten a NEMA 4 electrical box, all pre-assembled and tested at the factory and installed inside the cabinet. A 120 volt power source is required.
4. The cleaning system will consist in a compressed air reservoir to which eight 1 in diaphragm valves are connected. Each diaphragm valve will be actuated by a factory installed solenoid valve in a NEMA 4 solenoid kit.
5. Each compressed air reservoir will include a 1 in NPT connection.

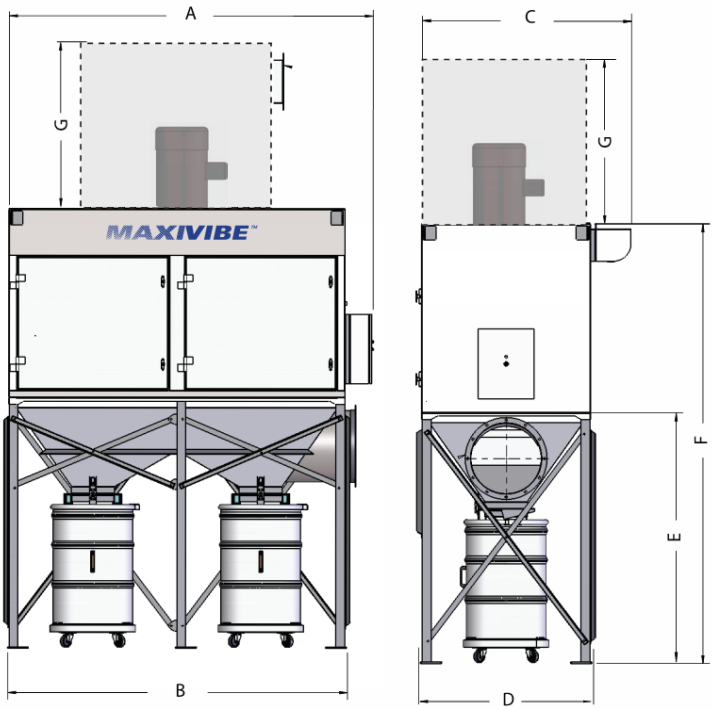
N. Control panel shall be furnished by the dust collector manufacturer and shall be installed on the dust collector and be pre-wired. A stop-run-auto selector switch will be incorporated to the control panel. A remote start-stop panel with green running light shall be supplied.

O. Provide a motor sound enclosure and discharge silencer. Dust collector manufacturer shall provide:
1. The silencer package shall be weather-proof, silicone sealed or welded.
2. Mylar bagged insulation.
3. Factory painting to match the dust collector.
4. Factory duct connections and elbow.
5. Silencer supports

2.03 SHAKER TYPE DUST COLLECTORS - WOOD SAWDUST

A. Locations:

1. DC-B – Marine Tech (recirculating)
2. DC-C – Carpentry
3. DC-IAT – Introduction to Applied Tech



B. DC-B Specifications

1. Dimensions

   a. A: 48.5”
   b. B: 38.25”
   c. C: 45.5”
   d. D: 35”
   e. E: 64.5”
   f. F:125”

2. Number of Filters: 1
3. Weight: 1,200 lbs.
4. Airflow CFM range: 675 to 1,400
5. Filtration Surface Area: 170 SF
6. Maximum sound level, dBA: 73

C. DC-IAT & DC-C Specifications

1. Dimensions

   a. A: 102.75”
   b. B: 96”
   c. C: 65.5”
   d. D: 48.5”
   e. E: 71”
   f. F:124.5”

2. Number of Filters: 2
3. Weight: 2,200 lbs.
4. Airflow CFM range: 2,175 TO 5,700

5. Filtration Surface Area: 722 SF
6. Maximum sound level, dBA: 73

D. The dust collector must not be used in mixed applications of wood dusts and non-reactive metal grinding, sanding or buffing dusts. The MAXIVIBE dust collector should not be connected to sanders or abrasive planers with mechanical material feeds unless it is equipped with a spark detection/extinguishing safety device.

E. Dust collector shall be AQC Maxivibe with envelope filters, electric shaking cleaning mechanism.

F. Envelope filters will be vertically set and will be cleaned by an automatic shaking mechanism. Air will flow upwards from the hopper.

1. Inlet plenum for air distribution and compliance to NFPA 68 explosion regulation.
2. 1 HP shaker motor with cam for shaker mechanism
3. Inlet plenum and explosion vent support
4. Weather protection and silencing plenum
5. Fan outlet silencer with support. Maximum noise level shall be 76 dBA/
6. NFPA 68 rules and regulations make it mandatory that explosion vents be placed so that explosion gases have a clear path of egress to the vent doors without passing through the filters. Filters blocking the exit of gases will cause increased pressure in the collector causing excessive damages.

G. The dust collector will sit on a support structure with hopper with 55 gallon drums to receive debris from the collector. The hopper will incorporate a deflector to spread the air evenly within the hopper and prevent dust re-entrainment towards the filters.

H. Dust collector casing will be built with minimum 16-ga steel with re-enforcement, capable of resisting a negative pressure of 20 inches H^20. Reinforced support structure for fan, rated seismic zone 2a, 125 MPH winds.

I. Envelope filters will be accessible from two service doors mounted on hinges in the front. Access door will be re-enforced with steel angles, all in order to resist the force of an explosion.

J. Filter Sections

1. The filter section will consist in a number of inverted ‘‘V’’ shaped pockets stitched into a single filter element. The mouth of the element will be held at the base on an angle frame and the apex of each pocket is to be supported on top of the shaker frame.
2. Envelope filter will have a net filtering area of 700 sq., feet and will be made from 14 oz. Polyester tissue.
3. Air to cloth ratio of 7.7 to 1
4. Access doors to filters with turn knobs

K. Cleaning: The cleaning of the filters shall be automatic, and will occur every time the dust collector is stopped. An ETL/CSA approved control panel will be included and will incorporate the relays and contactors necessary to insure the operation of the system. When the dust collector is stopped, a time delay relay will command a 15 second delay to insure there is no air flow within the collector, afterwards the shaker motor will be energized for 30 seconds (adjustable) in order to produce the shaking action required to dislodge the accumulated dust, and let it fall in the hopper and drum. Shaker operation not to exceed 74 Dba

L. Control panel shall be furnished by the dust collector manufacturer and shall be installed on the dust collector and be pre-wired to both blower and shaker motors. A stop-run-auto selector switch

will be incorporated to the control panel. A remote start-stop panel with green running light shall be supplied.

M. Blower

1. Blower will be backward inclined centrifugal.
2. Direct drive TEFC motor, includes housing.
3. Blower will be arrangement # 4, direct drive and will be installed on top of the collector in an insulated weatherproof sound attenuation plenum, with access door.

N. Provide an Explosion vent in accordance with NFPA 68:

1. Dust collector to include an explosion vent panel with a sign indicating ''DANGER-EXPLOSION VENT''. The vent panel will be controlled with pressure release handles calibrated to open at a specific pressure such as caused by an explosion.
2. The explosion vent panel will be installed in a frame to which an explosion vent duct will release the explosion plume to the outside out of arms way. The explosion vent duct is to be 12 ga welded steel insulated extending to the outside with a bird screen (by contractor)
3. An explosion plume deflector will be installed to deviate the explosive plume vertically upwards. Deviator will be built in 12 ga steel and painted over, and bolted to the building. Deviator plate to be open top and bottom to insure there will be no snow accumulation.

O. Recirculating systems: Provide a diverter plate to prevent a blow backup in case of an explosion.

P. Provide a motor sound enclosure and discharge silencer. Dust collector manufacturer shall provide:
1. The silencer package shall be weather-proof, silicone sealed or welded.
2. Mylar bagged insulation.
3. Factory painting to match the dust collector.
4. Factory duct connections and elbow.
5. Silencer supports

Q. Provide sound attenuation to reduce noise from the compressed air cleaning pulses. Provide an acoustical attenuation double-walling of the compressed air nozzle area. This shall include adding a 1” insulation layer; separating supports and an outside sheet metal skin sealed against weather and painted to match.

2.04 DUST COLLECTORS – PORTABLE

A. Locations:

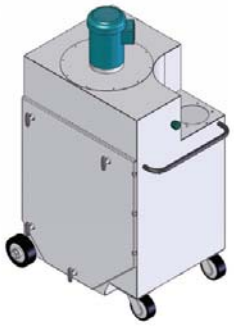
1. ACN-52 – Auto Collision - quantity of 2
2. DC-MT17 – Machine Tech

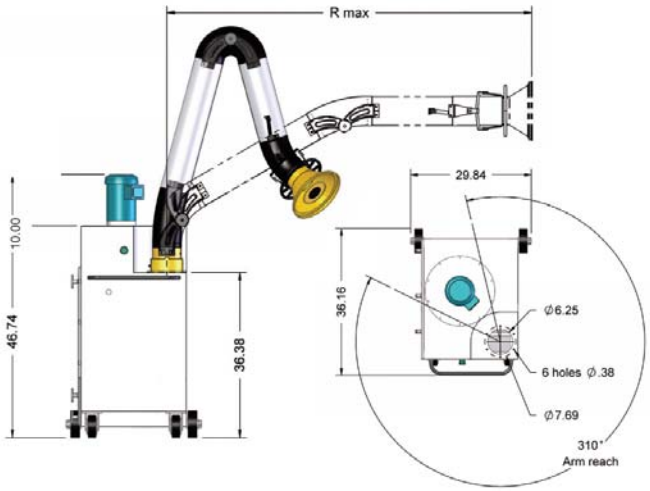
B. Safety note: units are not intended to collect possible explosive dusts such as aluminum, magnesium, wood chips or similar.

C. Construction

1. Powder coat painted steel housing, 14 gauge; 1 HP TEFC direct drive motor/fan assembly withspark proof backward inclined aluminum impeller, 3450 RPM,

15’ power cord; sound insulation foam for noise reduction 69 dB(A), swivel casters with foot brakes, sealed access door with twist handles, spark deterrent primary filter, main polyester filter cartridge (99.9 % efficiency), polyester charcoal filter, cabinet grab handle, starter with overload protection and reset, three (3) gallon reserve air tank for pulse cleaning with palm button operation and air venturi, push button for air cleaning, two (2) removable dust drawer





2. Cartridge filter, 260 sq. feet
3. Air volume: 650 cfm
4. Provide a Maxair capture arm, 6” diameter x 7 feet long
5. Provide motor starter and 15 foot power cord.
6. Automatic pulse cleaning with electronic control panel. Provide compressed air hookup.
7. Provide ON/OFF switch.
8. HEPA final filter.
9. Provide a filter status pressure gauge.

2.05 PORTABLE DOWNDRAFT WELDING TABLES

A. Equal to Airflow Systems model DTH-800-BF3-Light-Casters-HP-1-Steel-PG-5.

B. Locations:

1. ACN-53 – Auto Collision – typ-2



C. Features:

1. Integral collection area and work surface: Draws contaminants away from workers' breathing zone without hindering movement; easily moved to any location in facility.
2. Direct-Drive Blower: Higher static pressure, longer filter life and greater reliability; spark resistant; no belts or pulleys to replace.
3. Non-electrostatic operation: High reliability, low maintenance.
4. Ultra-Seal® filter mounting: Eliminates contaminant bypass of filters.
5. Low profile cabinet Easy access speeds filter change-out and maintenance.
6. Vibra-Pulse® Filter Cleaning System: Cleans filters 75% more effectively than reverse pulse systems.
7. Dust Drawer: Easily remove external dust drawer with positive level lock.

D. Provide Options

1. Pressure Gauge Kit: Indicates when filters require cleaning. 0-5" Minihelic dial pressure gauge, flush mounted.
2. Regulator
3. Silencer: Reduces noise by up to 6 dBA.
4. After-Filters: 99.97% HEPA.
5. Center Divider and Side Shields: Improves collection efficiency; eliminates contaminant migration.
6. Enclosures and Lighting: Enhances work area; encourages productivity. 40 watt, Dust-tite, 115 volt work light, and steel grate.
7. 8" fixed wheels on front, 5" swivel casters on rear

E. Specifications

1. Construction: 12/14/16 ga. welded steel, powder coated cabinet
2. Noise Level (dBA): 70
3. Electrical: 1.5 HP - 115/230/1/60, 15/7.5 amps
4. 25 ft, 12 ga. power cord and on/off switch

F. Dimensions

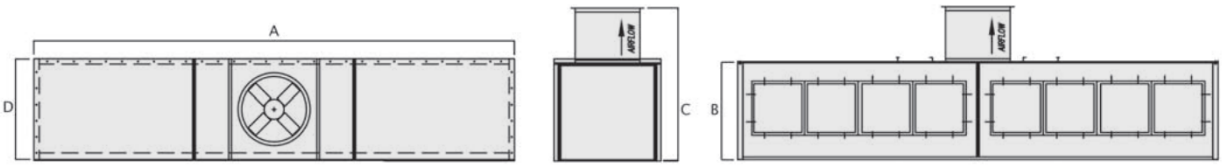
1. Width: 34.38”
2. Height: 33.00”
3. Depth: 31.00”
4. Table Size: Size: 32" W x 24.50" D
5. 150 fpm downdraft velocity

2.06 EXHAUST BENCH – Marine Tech

A. Col-met or equal. This exhaust bench provides a very practical method for removing hazardous and contaminated air generated by refinish, repair and other shop-related operations.

EZ BENCH

Model Number	Exterior Dimensions				CFM @ 1/2" SP	Fan Spec		Filters	Manometer
	Width	Height Less Fan	Height w/ Fan	Length		Dia.	HP	Exhaust	
EB-12	12'-0"	3'-0"	4'-4"	3'-2"	8,000	24"	2	7	YES
EB-15	15'-0"	3'-0"	4'-4"	3'-2"	8,000	24"	2	8	YES
Reference Key	A	B	C	D					



PLAN VIEW *END VIEW* *SIDE ELEVATION*

B. Exhaust fan with capacity of 8,000 CFM. Furnished with 24" diameter blade, 2HP, 460V three-phase explosion proof motor.

C. Heavy-duty construction bench is fabricated with 18-gauge galvanized steel panels.

2.07 ARTICULATING FUME ARMS

A. Exhaust Fume Arm: Equal to AQC Maxair.

B. Locations:

1. H-SE Small Engine Exhaust - Provide fan with fan control switch on the hood.
2. H-MT – MT-26 Heat treating Exhaust - Provide fan with fan control switch on the hood.
3. H-W – Welding exhaust drops



4. Fume arm tubes shall be made of steel with external cast aluminum joints, which include friction discs and are fully adjustable. The arms have a handle that completely encircles the hood to facilitate easy positioning.
5. No internal adjustment
6. Smooth tubes, low static pressure
7. Air volume damper included
8. Self-locking joints
9. (2) grab handles for arm positioning
10. Duct companion flange
11. Hood diameter: 13".
12. Hood diverter increases capture velocity. Provide a protective wire mesh in the hood.
13. Shipped fully assembled
14. Provide support brackets.

C. Direct Drive Fans

1. Backward-inclined spark-proof aluminum impeller.
2. Inlet guard protective mesh.
3. 3,450 RPM direct drive TEFC motor.
4. Adjustable orientation air discharge
5. Powder coat painted housing

2.08 COMPOUND SAW DUST HOOD

A. Provide a Rockler dust hood, or equal. Large 12-1/2" x 16-1/2" hood opening designed for collecting dust from miter saws, lathes, radial arm saws, carving, sanding, and planers without hoods. Product shall be lightweight and portable; easy to position anywhere.

1. Hood Depth: 10-1/2"
2. Weight: 1.5 lbs.
3. Size: 4"
4. Material: Plastic
5. Type: Attachment



2.09 VEHICLE EXHAUST

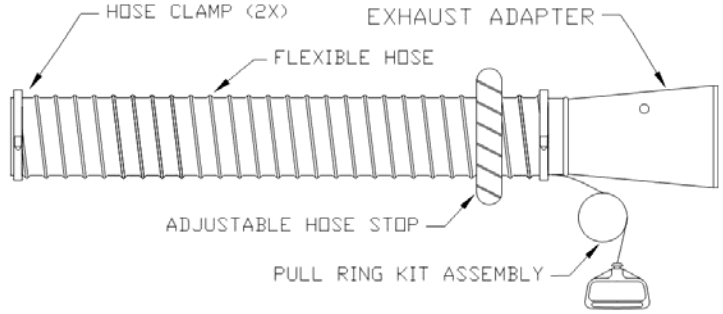
A. Manufacturers: Subject to compliance with project requirements, manufacturers offering Products which may be incorporated in the Work include the following:

1. Airflow Systems Inc.
2. AQC
3. Monoxivent
4. Carmon
5. Nederman
6. Plymovent

B. The contractor shall supply all of the installation for the complete hanging drop system. This system shall include, but is not limited to, hose reels, hose, adapters, ducts, fittings, fans, and accessories for a complete system. All materials and labor required for the complete installation of the system shall be included in the bid. The overhead duct shall be installed at the locations as indicated on floor plan. The rigid duct shall be mounted and supported in an approved manner such that it will fully bear the loads placed upon it by the weight of the flexible tubing set. All elbows, fittings, and transitions shall be made according to SMACNA standards. The rigid duct shall be connected to the exhaust fan by means of a flexible connector to minimize noise and vibration. The flexible tubing set shall be attached to the rigid duct using a hose clamp.

C. The hose reels shall be Ventaire model HRA spring operated type with flexible tubing set. Each reel shall be supplied with a 25' length of hose. The hose reels shall be supplied with a hose guide to keep the hose uniform over the drum as it retracts. The reels shall be constructed of a 14 gauge galvanized steel drum, 16 gauge galvanized steel reinforced side plates, and an 11 gauge galvanized steel frame. The locking mechanism shall be constructed of light weight cast aluminum. The entire assembly shall be capable of being overhead or wall mounted.

1. Provide a micro switch for fan control, Ventaire Model MKS; NEMA 1 enclosure with cover.
2. Each hose reel is provided with a hose stop that enables the user to stop retraction of the flexible hose at a predetermined point where the hose is not obstruct the work area and where the user can easily pull down the hose when needed. Position the adjustable hose stop on the flexible hose assembly at the desired location and tighten the internal gear clamp until the stop is secure being sure not to over tighten.
3. Fasten the exhaust adapter to one end of the flexible hose using the provided hose clamp. Drill and rivet through the hose clamp and exhaust adapter to ensure a rigid connection is established, this shall be done only after the hose reel tension has been precisely adjusted.



4. The flexible tubing shall be Ventaire model SG constructed of high temperature silicone coated fiberglass rated to a minimum of 600°F.
5. All components of the flexible tubing assembly shall be made by a stainless steel hose clamp model BC or HC that is riveted to establish a permanent connection.
6. Automobile / light truck bays: 4" diameter.
7. Medium duty truck bay: 5" diameter.

D. Provide Ventaire PK10 pull down kits.

E. Provide no-crush rubber oval tailpipe adapters. Rubber compound shall be designed to withstand exhaust temperatures up to 600°F.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide equipment in accordance with manufacturer's instructions.

B. Provide units with clearances for service and maintenance.

C. Outdoor Dust Collectors: Level concrete pads will be provided by the site contractor. Coordinate pad sizes, including extra size needed for duct supports. Locate dust collectors to provide minimum service clearances. Firmly anchor the equipment to the pad.

D. Do not operate fans for any purpose until ductwork is clean, bearings lubricated, and fan has been test run under observation.

E. Coordinate location and mounting heights of hose reel stations with mechanic work bench areas.

F. Exterior Dust Collector remote start-stop panels shall be furnished and installed by Division 23. Wiring shall be by Division 26. Exact location of panels shall be as directed by the Owner or Architect.

3.02 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. Start, test, and check equipment in accordance with manufacturer’s instructions.

3.03 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain the exhaust capture systems.

END OF SECTION

SECTION 23 36 00

AIR TERMINAL UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes single-duct air terminals.

1.03 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.
3. Documentation indicating that units comply with ASHRAE 62.1, Section 5 - "Systems and Equipment."
4. For adhesives and sealants, documentation including printed statement of VOC content.

1.04 CLOSEOUT SUBMITTALS

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

1.05 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. The Terms "Listed" and "Labeled": As defined in NFPA 70, Article 100. 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, coil type, and ARI certification seal.

E. NFPA Compliance: Provide 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.

PART 2 - PRODUCTS

2.01 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

2.02 SINGLE-DUCT AIR TERMINALS

A. The unit casing shall be comprised of 22 gauge galvanized steel. Outlet connection shall be slip and drive. Basis of Design: Trane VariTrane Single-Duct VCCF – Cooling Only or Trane VCWF – With Hot Water Coil.

B. Terminal units shall be ARI 880 - 98 certified and UL Listed.

C. Casings: 22 gauge galvanized steel. Maximum casing leakage: 7 cfm at 1-inch wg inlet static pressure.

D. 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).

E. 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.

F. Hot Water Coil: Factory mounted on outlet. Provide full fin collars provided for accurate fin spacing and maximum fin-tube contact. The seamless copper tubes shall be mechanically expanded into the fin collars. Coils shall be proof tested at 450-psi and leak tested at 300-psi air pressure under water. Coil connections shall be sweat with left hand or right hand coil connections as per field constraints. Coils shall be provided with an access for cleaning.

G. Provide access panels large enough for inspection, adjustment and maintenance without disconnecting ducts, and for cleaning heating coils attached to unit, even if there are no moving parts. Panels shall be insulated to same standards as the rest of the casing and shall be secured and gasketed airtight. It shall require no tool other than a screwdriver to remove.

H. Disconnect Switch: A NEMA-1 toggle disconnect shall disengage primary power to terminal.

I. Controls: The terminals will have pressure independent direct digital controls supplied and mounted by the control contractor. 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. Flow measuring taps and flow curves shall be supplied with each terminal for field balancing airflow. All pneumatic tubing shall be UL listed fire retardant (FR) type.

J. Each terminal shall be equipped with labeling showing unit location, size, and scheduled cfm.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Provide 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. Inlet and outlet duct must be installed in accordance with SMACNA guidelines. Locate air terminal units to provide a straight section of inlet duct for proper functioning of volume controls. Provide a minimum of 2.5 equivalent duct diameters of straight duct at the inlet.

3.02 CONNECTIONS

A. Provide piping adjacent to air terminals to allow service and maintenance.

B. Hot-Water Piping: In addition to requirements in Division 23 Section "Hydronic Piping," connect heating coils to supply with shutoff valve, strainer, and union; and to return with control valve, balancing valve and union.

C. 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.

3.03 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. Leak Test: After installation, fill water coils and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

B. Air terminal unit will be considered defective if it does not pass tests and inspections.

C. Prepare test and inspection reports.

3.04 STARTUP SERVICE

A. Perform startup service.

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

3.05 CLEANING

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

END OF SECTION

SECTION 23 37 13

DIFFUSERS, REGISTERS, AND GRILLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

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

1.03 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.

1.04 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.

1.05 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

2.01 GENERAL

A. Diffusers, registers, and grilles are scheduled on Drawings.

B. Mounting and border type shall match the mounting surface. Coordinate with mounting conditions.

C. Material shall match the specified ductwork. Coordinate with Section 23 31 13 “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

2.02 RETURN OR EXHAUST

A. Return/Exhaust Register, 45-degree deflection

1. Material: steel (Price 530 Series) or aluminum (Price 630 Series)
2. Provide damper.
3. Provide 45 degree deflection fixed louver type with blades spaced 3/4" on center.

B. Filter Return/Exhaust Grille.

1. Provide Price Model (630FF aluminum) filter return grilles.
2. Grilles shall be 45 degree deflection fixed louver type with blades spaced 3/4 inch on center.
3. The blades shall run parallel to the long dimension of the grille. The border shall be mounted to the filter frame with 1/4–turn quick-release fasteners.
4. The mounting frame shall accept a standard 2 inch filter media. Provide MERV 8 filters.

2.03 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 ¾" on center. The front set of blades shall run parallel to the short dimension of the register.
4. The integral balancing 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. High-induction Ceiling Diffusers

1. Material: steel (Price Model SMX)
2. Air pattern shall be 4-way.
3. Rapid mixing diffusers shall consist of an outer frame assembly which facilitates mounting. A collar that allows connection to the square (or rectangular) duct size

indicated shall be an integral part of the frame assembly. This collar shall fit inside the duct.

4. Internally mounted discharge vanes shall be engineered to create a high rate of induction that will rapidly mix warm room air with the conditioned supply air. This rapid mixing (induction) shall quickly equalize the temperature differential between the two air masses, thus minimizing the chances of uncomfortable drafts.
5. Provide a square to round adaptor shall be of coated steel construction.

D. 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. Provide the optional heavy duty balancing damper; shall be of opposed blade type and shall be constructed from a minimum 18 gage thick cold rolled steel. Damper frame corners shall overlap and be of welded construction for added strength. The damper shall be operable from the register face. The damper shall come fitted with a face accessible screw type blade locking mechanism. The damper shall be coated steel.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas where diffusers, registers, and grilles are to be installed for compliance with requirements for installation tolerances and other conditions affecting performance of equipment. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.02 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. Provide diffusers, registers, and grilles with airtight connection to ducts.

D. Provide 2 feet minimum of straight ductwork at the entrance to diffusers.

E. Plenum boxes on grilles/registers shall be 8” minimum height.

3.03 ADJUSTING

A. After installation, adjust diffusers, registers, and grilles to air patterns indicated, or as directed, before starting air balancing.

B. Adjustable outlets: adjust pattern for draft-free air distribution.

3.04 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

SECTION 23 51 23

GAS VENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Refer to Division 1 Section “Alternates”.

1.02 SUMMARY

A. Section includes venting for gas-fired appliances.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for product.

1. Catalog cuts
2. Certified Sizing Calculations: Manufacturer shall certify venting system sizing calculations.
3. Installation drawings
4. Installation instructions
5. Sample of warranty

1.04 QUALITY ASSURANCE

A. Provide per NFPA 58.

B. Provide per Maine Fuel Gas Code.

C. Shall comply with UL 1738 Standard for Venting Systems for Gas Burning Appliances.

PART 2 - PRODUCTS

2.01 LISTED SPECIAL GAS VENTS

A. Available Manufacturers – Note: submitted manufacturer must be approved by the manufacturer of the gas appliance that it serves.

1. AMPCO
2. Heat-Fab Inc.
3. Metal-Fab, Inc.

4. Schebler Co.
5. Selkirk
6. Van-Packer Co.
7. MG Duravent
8. Security Chimney
9. Centrotherm InnoFlue

B. Provide an Al294C stainless steel or flame-resistant polypropylene concentric vent system for use with ANSI Category IV gas-burning condensing boilers. Vent system shall be listed for zero clearance to combustibles. Materials must be as per boiler manufacturer's requirements.

C. Double Wall Metal Vent:

1. Description: Double-wall metal vents tested according to UL 1738 and rated for 480 deg F continuously, with positive or negative flue pressure complying with NFPA 211.
2. Construction: Inner shell and outer jacket separated by at least a 1/2-inch airspace.
3. Inner Shell: ASTM A 959, Type 29-4C stainless steel.
4. Outer Jacket: Stainless steel.

D. Polypropylene Vent:

1. Polypropylene vent pipe for use with ANSI Category IV gas-burning appliances. Vent system shall be UL1738 listed to be suitable for exhaust temperatures up to 230°F, and a maximum positive pressure of 15 in-w.c.
2. Materials and Construction: Rigid pipe constructed of 2.2mm (minimum) thick polypropylene. Flex is double-wall polypropylene. EPDM or Viton gaskets.
3. Intertek / ETL listed to ULC-S636 Listed as a Class IIA, IIB, and IIC vent system.

E. Combustion Air: UL1738 polypropylene or ANSI/ASTM D2661 CPVC Schedule 40. CPVC shall comply with ASTM F441 pipe and fittings; ASTM F493 cement/primer.

F. Provide support clamps, termination, condensate drains, roof supports, appliance adapters, elbows, and other fittings as recommended by the vent manufacturer and appliance manufacturer.

G. Roof penetration pieces shall be UL Listed and provided by the vent manufacturer.

H. Termination:

1. Provide listed vent and intake caps designed to exclude minimum 90 percent of rainfall.
2. Termination height shall be 4' minimum above roof.

PART 3 - EXECUTION

3.01 EXAMINATION

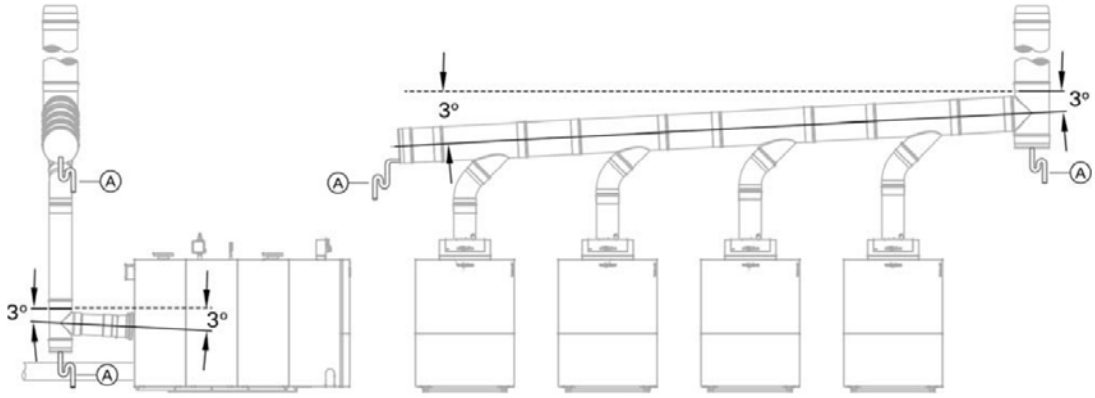
A. Examine areas and conditions for compliance with requirements for installation tolerances and other conditions affecting performance of work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Provide common venting and combustion air in accordance with manufacturers' recommendations, UL Listing, and state or local codes.

B. Slope vents and connectors in accordance with NFPA 211. Condensate must drain from the flue pipe to the boiler. Ensure a suitable gradient of at least 3º [approx. 2 in. per 3.3 ft.). Provide low point drains, trapped and piped to floor.



Legend
Ⓐ Condensate drain piping
a air intake
b exhaust vent

IMPORTANT

Condensate must drain from the flue pipe to the boiler. Ensure a suitable gradient of at least 3º [approx. 2 in. per 3.3 ft. (50 mm per 1 m)] on any horizontal venting components.

C. Coordinate installation of roof curbs, equipment supports, and roof penetrations. Provide in accordance with Division 7.

D. The venting system must be installed by a licensed professional heating contractor familiar with the operation and maintenance of heating appliances and venting. Before installing, ensure that the complete installation literature has been read.

E. It is the responsibility of the installer to contact local building and fire officials concerning any installation restrictions and/or inspection requirements that may apply. Permits shall be obtained before commencement of the installation

F. Provide in accordance with boiler manufacturers requirements, coordinate with Section 235216.

G. Route vent pipe as directly as possible and with as few bends as possible to the boiler.

1. Do not to use back-to-back 90º elbows.
2. Use 45º elbows (not 90º elbows) in case redirection of flue gas is required.

H. Locate to comply with minimum clearances from combustibles and minimum termination heights according to product listing or NFPA 211, whichever is most stringent.

I. Seal between sections of positive-pressure vents according to manufacturer's written installation instructions, using sealants recommended by manufacturer. The system shall be

installed and sealed per manufacturers' instructions so all joints are gas tight, preventing leakage of products of combustion into a building.

J. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading. Support vents and chimneys from building structure with bolts, concrete inserts, steel expansion anchors, welded studs, C-clamps, or beam clamps according to manufacturer's written instructions.

K. Provide flue vent dampers per boiler manufacturer's recommendations.

L. Erect stacks plumb to finished tolerance of no more than 1 inch out of plumb from top to bottom.

M. Termination height of chimneys shall be in accordance with NFPA-211.

3.03 CLEANING

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

B. Clean vents internally, during and after installation, to remove dust and debris. Clean external surfaces to remove welding slag and mill film. Grind welds smooth and apply touchup finish to match factory or shop finish.

C. Provide temporary closures at ends of vents and chimneys that are not completed or connected to equipment.

END OF SECTION

SECTION 23 52 16

CONDENSING BOILERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Refer to Division 1 Section “Alternates”.

1.02 SUMMARY

A. Section includes packaged, factory-fabricated and assembled, gas-fired, condensing boilers, trim, and accessories for generating hot water.

1.03 ACTION SUBMITTALS

A. Product Data: Include performance data, operating characteristics, furnished specialties, and accessories.

B. Shop Drawings: For boilers, boiler trim, and accessories. Include plans, elevations, sections, details, and attachments to other work.

C. Common vent sizing calculation.

D. Include diagrams for power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Warranty: Special warranty specified in this Section.

1.05 CLOSEOUT SUBMITTALS

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

1.06 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASME Compliance: Fabricate and label boilers to comply with ASME Boiler and Pressure Vessel Code.

C. ASHRAE/IESNA 90.1 Compliance: Boilers shall have minimum efficiency according to "Gas and Oil Fired Boilers - Minimum Efficiency Requirements."

D. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.

E. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.

F. UL Compliance: Test boilers for compliance with UL 795, "Commercial-Industrial Gas Heating Equipment." Boilers shall be listed and labeled by a testing agency acceptable to authorities having jurisdiction.

1.07 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.08 WARRANTY

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

1. Warranty Period:

a. Heat Exchanger Damaged by Thermal Shock: 10 years from date of Substantial Completion.
b. Heat-Exchanger Corrosion: Non-prorated for ten years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 BASE BID BOILERS

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

1. Viessmann
2. Buderus
3. Cleaver Brooks
4. Weil McLain

B. General

1. The gas-fired hot water condensing heating boiler shall be fabricated of high grade stainless steel (SA240-316Ti). The heat exchanger shall utilize the heating surface for maximum heat transfer and condensation for optimum energy savings. The smooth, non-

fin heat exchanger surfaces shall provide a self-cleaning effect while promoting clean combustion through low heat exchanger loading and a straight-through design.

2. The boiler shall incorporate a modulating compact pre-mix cylindrical stainless steel gas burner with a high-alloy stainless steel surface capable of operating with consistently high efficiency. The burner shall be equipped with a variable speed combustion fan for quiet and economical operation.
3. Boiler turn-down ratio shall be 5:1.
4. Combustion efficiency shall not be below 95% and thermal efficiency shall not be below 97% as tested to AHRI, BTS-2000 Testing Standard Method to Determine Efficiency of Commercial Heating Boilers.
5. ASME maximum allowable working pressure (MAWP): 75 psig. Provide a 55 PSIG pressure relief valve.
6. ASME maximum water temperature (Fixed High Limit): 210°F.
7. Maximum boiler operating temperature (Adjustable High Limit): 190°F.
8. The boiler shall be capable of accommodating a 50% glycol mixture.
9. The boiler shall have low flow resistance. At the maximum flow rate through the heat exchanger, the boiler shall have head resistance not greater than 14 inches of water column.
10. The condensation rate, controlled by optimum combustion, shall be able to meet a CO_2 value of 10% through the entire firing range.
11. The standard control options shall be able to operate independently, or integrate with building management system protocols as referenced in the control section.

C. Construction

1. The combustion chamber, heat exchanger and condensate collector shall be constructed of high-alloy stainless steel and titanium.
2. The R-value of the insulation shall be equivalent to 4" mineral wool with nylon backing.
3. The flue gasses shall pass by the return water in a counter-flow direction only, for maximum heat transfer effectiveness.
4. The heat exchanger shall be of a compact design for ease of handling, and incorporate a full-swing door, left- or right-hinge, to allow for easy inspection and cleaning.
5. The burner shall be constructed from high-grade stainless steel for universal use with natural gas or propane gas. Burner ignition shall be by a direct spark ignition system.
6. The burner shall be capable of operating at natural gas pressures from 4 up to 14" W.C., and propane gas pressure of 10 up to 14" W.C.

D. Certifications

1. Individual components shall be accepted as part of the system under the governing body having jurisdiction. Field approval shall not be required for any component. Boiler shall be CSA approved and shall be built in compliance with ASME Section IV, carrying the "H" stamp.
2. The boiler shall have the following approvals and listings, or be in compliance with: CSA, CRN, ASME, and AHRI.

E. Venting

1. Boilers shall be installed and vented with individual direct piped combustion air.
2. Vent: Provide per 235123.

F. Provide Options:

1. Combustion air vent kit including hoses, burner inlet adaptor, retaining clamps, and hardware.
2. Flue gas vent coupling.

3. Flue vent damper and controls.
4. Condensate Neutralization Kit complete with neutralizing granulate; ¾" inlet/outlet.
5. Low Water Cutoff w/Manual Reset & Test
6. The Firing Control System shall meet CSD-1 and FM requirements.
7. Valve adapters for the interface between the boiler controller and the mixing valve and isolation valves.
8. Provide heating loop mixing valve.
9. Provide boiler isolation valves.

2.02 ALTERNATE #1 BOILERS

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

1. Viessmann – Basis of Design
2. Heat Transfer Products "Elite"
3. Weil McLain Evergreen
4. Buderus

B. All individual components shall be accepted as part of the system under the governing body having jurisdiction. Field approval shall not be required for any component. Boiler shall be CSA approved and shall be built in compliance with ASME Section IV, carrying the "H" stamp.

C. The boiler shall have the following approvals and listings, or be in compliance with: CSA, CRN, ASME, I=B=R, AHRI (GAMA), Energy Star

1. ASME maximum allowable working pressure (MAWP): 60 psig.
2. Certified AFUE efficiency shall not be below 92.0%.
3. ASME maximum water temperature (Fixed High Limit): 210°F.
4. All individual components shall be accepted as part of the system under the governing body having jurisdiction. Field approval shall not be required for any component. Boiler shall be CSA approved and shall be built in compliance with ASME Section IV, carrying the "H" stamp.
5. All individual components shall be accepted as part of the system under the governing body having jurisdiction. Field approval shall not be required for any component.
6. All electrical wiring is to be done in accordance with the latest editions of ANSI/NFPA 70 National Electrical Code.
7. Burner and Hydrostatic Test: Factory adjust burner to eliminate excess oxygen, carbon dioxide, oxides of nitrogen emissions, and carbon monoxide in flue gas and to achieve combustion efficiency; perform hydrostatic test.
8. Test and inspect factory-assembled boilers, before shipping, according to ASME Boiler and Pressure Vessel Code.
9. The Firing Control System shall meet CSD-1 and FM requirements.

D. The gas-fired hot water condensing heating boiler shall be fabricated of high-quality stainless steel (SA240-316Ti), featuring the latest innovations of condensing boiler technology. The boiler shall incorporate a modulating compact cylindrical stainless steel gas burner with a high-alloy stainless steel heat exchanger surface capable of operating with consistently high efficiency. The boiler control system shall maintain optimized combustion, even in case of fluctuating gas composition and air resistance. The boiler control shall have priority for both electrical and fuel savings with its intelligent combustion controller. Boiler shall be equipped with a variable speed combustion fan for quiet and economical operation.

E. The boiler shall include a single compact heat exchanger made of high-alloy stainless steel, designed based on the laminar heat transfer principle for high operational reliability and a long

service life. A radial design shall be used to obtain maximum heat transfer performance in a single pass. Rectangular design of the coil is required to maximize the coil gap length and ensure maximum utilization of the heat exchanger surface. Defined gaps (0.8 mm) between coil passes and a heat exchanger length of 53 mm shall be sized to promote laminar flue gas flow for efficient heat transfer. The heat exchanger design shall allow for self-cleaning functionality.

F. The burner shall be constructed from high-grade stainless steel for universal use with natural gas or propane gas. Burner ignition shall be by a direct spark ignition system. The boiler shall be equipped with a digital boiler control unit interface.

G. Wire and cable entry to boiler shall be facilitated by strain reliefs to protect electrical wires. All controls, relays, transformers, ignition module, wiring, and redundant seat combination gas valve shall be installed behind the boiler enclosure.

H. The boiler shall be rated for zero (0") clearance to combustibles, including its vent system.

I. Standard equipment shall also include the following items:

1. Manual reset fixed high limit set at 180°F, wired in series with ignition system
2. Integrated Graphical User Interface (GUI) with digital temperature display
3. 45 psig relief valve
4. Temperature & Pressure gage and pipe fittings
5. Low Water Cutoff w/Manual Reset & Test

J. Provide Options:

1. Combustion air vent kit including hoses, burner inlet adaptor, retaining clamps, and hardware.
2. Condensate Neutralization Kit complete with neutralizing granulate; ¾" inlet/outlet.
3. Low Water Cutoff w/Manual Reset & Test
4. Valve adapters for the interface between the boiler controller and the mixing valve and isolation valves.
5. Provide heating loop mixing valve.

K. Boiler Venting: Provide per manufacturers requirements and Section 235123. The boiler shall be equipped with a coaxial flue gas vent opening at the top of the boiler. Venting shall be a side wall horizontal or vertical sealed (direct vent) chimney system. A vent damper shall not be necessary, provide a built-in flapper between the fan and the heat exchanger that keeps flue gasses from back flowing.

L. Low Loss Header

1. The low-loss header shall be constructed of mild carbon steel with NPS or ANSI fittings. The device must be designed and tested with various flow rates having predictable hydronic resistance charts available for the design purpose.
2. The low-loss header shall be designed and tested with time-proven, standard control strategies allowing for optimum boiler efficiency, ease of installation and programming.
3. The boiler manufacturer shall make approved drawings available, which contain piping and control diagrams with low-loss header configurations and sizing.

2.03 BOILER PLANT CONTROLLER

A. Control Specifications: Vitotronic 300, GW6B – Alternate #1. Provide same functionality for Base Bid.

1. General

   a. The Vitotronic 300 GW6B shall be capable of operating as a standalone boiler control with outdoor reset capabilities or shall be cascadable as part of a multi boiler system (to a maximum of 8 boilers using the Viessmann LON protocol) for boiler set point operation.
   b. In standalone operation the control unit shall provide control for a boiler with one high temperature circuit and one mixing valve circuit with the integrated mixing valve module, using digital weather responsive reset. Additional circuits shall be added with the order of an ancillary mixing valve controller and/or a custom control panel. System components shall use the Viessmann LON communication protocol. The outdoor reset supply temperature of every heating circuit shall result from the outside temperature, the set room temperature, the operating mode and the heating curve.
   c. In cascade operation each boiler shall be supplied with an integrated LON card for communication between boilers, via the Viessmann LON Protocol. In cascaded operation one boiler will be selected and programmed as the 'Master Boiler' with the remaining boilers being programmed as 'Slave Boilers'. The boilers shall be operated on a set point temperature only generated through the 'Master Boiler' and delivered to the cascade system via the Viessmann LON protocol. The 'master' control unit shall provide control for a heating system with one high temperature circuit and two mixing valve circuits with the integrated mixing valve module, using digital weather responsive reset. Additional circuits shall be added with the order of an ancillary mixing valve controller and/or a custom control panel.
   d. The controller shall have the following features:

      1) 5 Inch color touch screen user interface.
      2) Compatible with Viessmann modulating burner.
      3) EPROM memory is maintained without main power.
      4) Control algorithms are PID-based.
      5) LON ready with integrated Viessmann LON communication module.
      6) Quick connect plug & play system for low voltage controls.
      7) Communication with other protocols such as Modbus, BacNet and LON (Ethernet/IP) shall be available (through accessories gateways).

   e. The controller shall be factory tested and approved by CSA as part of a package with the compatible series of boilers.
   f. The controller (in standalone or master boiler operation) shall be able to support the following output devices. Provide wiring from controller to output devices.

      1) (1) Viessmann Modulating burner.
      2) (1) Modulating boiler isolation valve.
      3) (1) Boiler Pump.
      4) (1) Domestic hot water pump.
      5) (1) Domestic hot water re-circulation pump.
      6) (2) Low Temperature heating loop circulation pumps in conjunction with mixing valves.
      7) Heating loop modulating mixing valve.

2. Construction

   a. Control Interface: The control interface shall be a digital display capable of displaying temperatures as °C or °F, with menu driven selection functions, with access to the following operating points:

1) Able to display all system temperatures and set points.
2) Displays unique fault message during an alarm.
3) A program selection mode.
4) Domestic hot water temperature set point adjustment.
5) Information indicator with confirmation.
6) Boiler operating hours display.
7) Number of burner starts display.
8) Operating status check.
9) Emission/service test switch (TUV).
10) Adjust the display contrast.
11) Temporary occupied mode function.
12) Slope and shift adjustment for heating curve.

b. The controller shall have the following additional features:

1) On/Off switch.
2) Default factory settings reset.
3) Operating status indication light.
4) Tamper-proof fixed high limit (integrated in burner control).
5) TUV service switch (overrides electronic high limit).
6) Fault Indicator light.
7) Operating condition scans.
8) Maintenance requirement status.
9) Relay test function.
10) Integrated boiler flue gas temperature sensor.
11) Participant check (LON nodes).
12) Quick heat up and quick set-back functions.
13) Start-up and shut-down optimization functions.
14) Warm weather shut-down.
15) Energy savings mode.
16) Ability to restore the control to factory defaults.

c. The fixed high limit shall have the following tamper-proof features: CSA certified burner control with integrated Electronic Fixed and Adjustable High limit sensors are used.

3. Boiler System Supply Water Temperature Control

a. Each controlled zone shall have a calculated heating curve which describes the required supply water temperature at different outside air temperatures. The slope and shift of each heating curve shall be adjusted to fit any type of building or system.
b. In the unoccupied mode, the supply water temperature set-point shall be reduced by a pre-determined amount. A call for domestic hot water or an external demand signal shall override this set-point to pre-determined values.
c. Control logic shall be equipped to protect the heating system from freeze-up if left powered during the off season.

4. Domestic Hot Water Control

a. The DHW temperature shall be controlled through starting and stopping the DHW circulation pump. An automatic or individual time program shall be selected for the control of the DHW and the DHW tank re-circulating pump. An individual time program shall enable up to four switching periods per day to be set to control the DHW heating and the DHW re-circulation pump.

b. The DHW control sequence shall use an adaptive algorithm that takes into account the rate at which the temperature changes and whether the boiler will be required to supply heat after the DHW tank has been heated or whether residual boiler heat should be transferred to the DHW tank. Available domestic hot water strategies shall include: priority control (supply water set-point increases, the mixing valve closes and the heating circuit pumps are shut off on a call for DHW), modulating priority (the supply water set-point of the mixing valve circuits shall be reduced until the DHW supply temperature requirements have been met), or no priority at all.
c. A frost protection function shall energize the DHW production should the supply water temperature drop below a pre-determined value. An optional second temperature sensor placed in the cold water inlet can be incorporated to determine if DHW production should begin prematurely.

5. If a fault occurs on a boiler, the fault code shall be indicated in the display window and by the flashing red fault lamp. A compiled failure alarm contact shall close in order to signal the alarm condition to a Building Automation System (BAS). The message shall also be broadcasted on the LON communication bus. The error history shall be saved to memory.
6. Scheduling: There shall be separate time schedules for central heating, DHW heating and the DHW re-circulation pump. Each device shall be able to be scheduled to switch between occupied and unoccupied modes up to four times per day.
7. Boiler Rotation (Master Boiler): The boilers shall be rotated once a month according to an equal run-time strategy or on a schedule every 200 to 2000 hours. A dry contact shall be incorporated to make the current lead boiler the lag boiler whenever contact is closed. If the system has both condensing and non-condensing boilers, the condensing boiler shall be programmed to always be the lead.
8. Provide temperatures sensors for boiler plant control as required.
9. Auxiliary Inputs - The following dry contact inputs shall be available to be wired to each boiler to control the following functions (functionality dependent on operating mode):

    a. Boiler disable.
    b. Change between modulating to staged burner control.
    c. External heat demand.
    d. Boiler sequencing.
    e. External enable.
    f. External blocking.
    g. Heating program changeover.

10. Building Management System Interface

    a. The controller shall have the ability, through the use of an Extension Module, to accept a 0-10V signal from a Building Management System for the purpose of allowing remote control of the boiler supply water temperature set point.
    b. The controller shall be able to fully integrate with Building Management Systems running on the BACNet communication protocol via a gateway.

11. Certifications

    a. All individual components shall be accepted as part of the system under the governing body having jurisdiction. Field approval shall not be required for any component.
    b. All electrical wiring is to be done in accordance with the latest editions of: CSA C22.1 Canadian Electrical Code and/or local electrical codes (for Canada) ANSI/NFPA 70 National Electrical Code (for U.S.)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Before boiler installation, examine roughing-in for concrete equipment bases, anchor-bolt sizes and locations, and piping and electrical connections to verify actual locations, sizes, and other conditions affecting boiler performance, maintenance, and operations.

B. Final boiler locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Examine mechanical spaces for suitable conditions where boilers will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 BOILER INSTALLATION

A. Equipment Mounting: Provide floor-mount boilers on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 23 05 00.

B. Install gas-fired boilers according to NFPA 54 or 58.

C. Assemble and install boiler trim.

3.03 BOILER PLANT WIRING

A. Gas-fired boilers shall be wired in accordance with NFPA 54 requirements.

B. Wire the boiler plant controls in accordance with manufacturer’s recommendations. Coordinate work with Section 23 09 93.

C. Install electrical devices furnished with boiler but not specified to be factory mounted.

D. Install control wiring to field-mounted electrical devices.

E. A flow switch is used to guarantee flow through the boiler before allowing it to fire. The flow switch shall be installed at the boiler outlet.

F. Ground equipment according to Division 26 "Grounding and Bonding for Electrical Systems."

G. Connect wiring according to Division 26 "Low-Voltage Electrical Power Conductors and Cables."

3.04 BOILER PLANT WIRING – MAINE FUEL BOARD RULES

A. The following requirements must be met with respect to the electrical wiring and equipment used in connection with propane or natural gas burning equipment:

1. The electrical wiring and equipment used must be installed in accordance with NFPA #70, *National Electrical Code* (2011 edition);

2. Safety control circuits must be two-wire, one side grounded, having a nominal voltage not exceeding 150 Volts. A safety control or protective device must be connected so as to interrupt the ungrounded conductor; and
3. The control circuit must be connected to a power supply branch circuit fused at not more than the value appropriate for the rating of any control or device included in the circuit.

B. Emergency Switch

1. For central heating equipment and water heating appliances where the interruption of an electrical circuit will arrest the combustion process, an identified emergency shutdown switch must be placed outside of and adjacent to the entrance of the room where the appliance is located.
2. An emergency switch shall not be placed outside of any building.
3. If the entrance to the boiler room is only accessible from the outside, the emergency switch may be placed at the inside not more than one foot beyond the door opening.
4. On multi-unit installations of commercial and industrial equipment, the emergency switch must be installed in accordance with Figure 13-1.
5. On multi-unit installations, the emergency shut-off switch must be placed at the outside entrance of the room containing the appliances. The emergency switches and the thermal cut-off switches must be wired in series through individual unit relays so that, if the emergency switch is opened, all heating equipment in the room and any electrically operated gas valves will be rendered inoperable. This application also applies if there are two or more appliance rooms in the same building that are connected to a common fuel supply system.

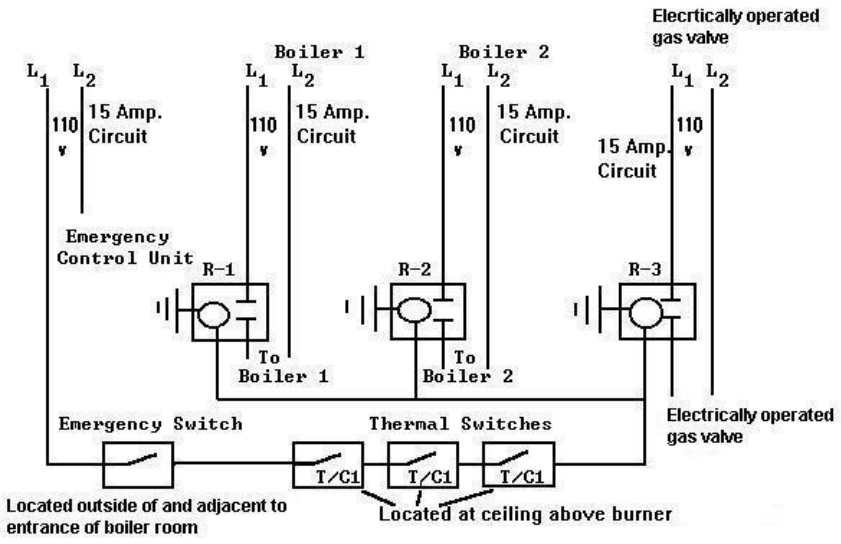


Figure 13-1 For use on commercial and industrial equipment only. This requirement shall not apply to one and two family residences.

PART 4 -

A. Service Switch: For central heating equipment and water heating appliances where the interruption of an electrical circuit will arrest the combustion process, a service disconnect switch for control of the burner while observing the flame must be placed at the unit, within 3´ of the burner.

B. Thermal Cut-Off Switches

1. For central heating equipment and water heating appliances where the interruption of an electrical circuit will arrest the combustion process, a thermal cut-off switch must be wired into the burner circuit to shut off the burner in the event of a fire at the unit. The switch must be placed at the highest point directly above the unit to be fired with the thermal element pointed downwards, and must be placed on the bottom of the floor joist or stringer at the front of the unit. In no case shall it be lower than the point where the flue connector enters the chimney. The switch must be wired to shut off the burner, circulating fan, forced or induced draft fan and any electrically-operated gas valves. A thermal electric switch is required for each electrically-powered gas-fired unit in a multi-appliance installation.
2. On multi-unit installations the emergency and thermal electrical switches must be wired in series through individual unit relays so that, if one switch is opened, all equipment will be rendered inoperable whenever the "EMERGENCY" switch is opened.

4.02 LOW WATER CONTROL FOR BOILERS

A. All gas-fired boilers must be provided with a properly installed and operating low water cut-off.

B. Provide a Taco LF Series, or equal, low water cutoff in the HW piping, located as recommended by the boiler manufacturer. The low water cut-off may be installed in or attached to the boiler at the level recommended by the boiler manufacturer, but in no case shall the low water cut-off be installed below the crown sheet. The low water cut-off, when not installed directly in the boiler, may be installed either in the main supply line (vertical riser) as close to the boiler as possible or in a water column of continuous piping attached directly to the boiler.

C. No Obstructions: No valves or other obstructive devices shall be installed between the boiler and safety controls.

D. A pressure switch installed by the manufacturer and specified by the manufacturer as low-water protection shall be accepted as meeting the criteria of Chapter 10, Section 10 .3 .5 of NFPA #54 (2012 edition).

4.03 CONNECTIONS

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

B. Install piping adjacent to boiler to allow service and maintenance.

C. Install piping from equipment drain connection to nearest floor drain. Piping shall be at least full size of connection. Provide an isolation valve if required.

D. Connect gas piping to boiler gas-train inlet with union. Piping shall be at least full size of gas train connection. Provide a reducer if required.

E. Provide pressure regulator to provide proper gas pressure to boilers. Provide 18” minimum straight piping at inlet and outlet of pressure regulator.

F. Connect hot-water piping to supply- and return-boiler tappings with shutoff valve and union or flange at each connection.

G. Install piping from safety relief valves to nearest floor drain.

4.04 INSTALLATION OF VENTS

A. Provide in accordance with manufacturers' recommendations and Section 23 51 00.

B. All joints must be sealed. Provide cementing as per CPVC manufacturer's and boiler manufacturer's recommendations.

C. Support vents at intervals recommended by manufacturer to support weight of vents and all accessories, without exceeding appliance loading.

D. After completing system installation, including outlet fittings and devices, inspect exposed finish. Remove burrs, dirt, and construction debris and repair damaged finishes. Clean vents internally, during and after installation, to remove dust and debris

E. Provide temporary closures at ends of vents and chimneys that are not completed or connected to equipment.

4.05 NEUTRALIZATION SYSTEM

A. Remove the neutralization system cover.

B. Fill the relevant area provided with neutralizing granulate.

C. Fill the neutralization system with water

D. Check the container and the supply and drain lines for leaks.

E. Connect PVC drain piping to the boiler, route to the neutralizer kit. Install the PVC tee assembly (shipped with the unit). Leave the top of the 1/2 inch tee open. This is needed as a vacuum break. Pipe to the nearest floor drain.

4.06 FIELD QUALITY CONTROL

A. Thoroughly flush the system (without boiler connected) to remove sediment.

B. Testing Agency: Engage a qualified testing agency to perform tests and inspections.

C. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

D. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Perform installation and startup checks according to manufacturer's written instructions.
2. Leak Test: Hydrostatic test. Repair leaks and retest until no leaks exist.
3. Operational Test: Start units to confirm proper motor rotation and unit operation. Adjust air-fuel ratio and combustion.

4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

    a. Check and adjust initial operating set points and high- and low-limit safety set points of fuel supply, water level and water temperature.
    b. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

E. Remove and replace malfunctioning units and retest as specified above.

F. Prepare test and inspection reports.

G. 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.

H. Performance Tests:

1. Engage a factory-authorized service representative to inspect component assemblies and equipment installations, including connections, and to conduct performance testing.
2. Boilers shall comply with performance requirements indicated, as determined by field performance tests. Adjust, modify, or replace equipment to comply.
3. Perform field performance tests to determine capacity and efficiency of boilers.

    a. Test for full capacity.
    b. Test for boiler efficiency at low fire 20, 40, 60, 80, 100, 80, 60, 40, and 20 percent of full capacity. Determine efficiency at each test point.

4. Repeat tests until results comply with requirements indicated.
5. Provide analysis equipment required to determine performance.
6. Provide temporary equipment and system modifications necessary to dissipate the heat produced during tests if building systems are not adequate.
7. Notify Architect in advance of test dates.
8. Document test results in a report and submit to Architect.

4.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain boilers. Refer to Division 1 "Demonstration and Training."

END OF SECTION

SECTION 23 56 13

SOLAR THERMAL SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Solar thermal system components and indirect water heaters.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for solar collectors.
2. Include rated capacities, operating characteristics, and furnished specialties and accessories.
3. Submit proposed diagrams, instructions, and other sheets, including a system schematic, wiring and control diagrams, and a complete layout of the entire system for the system type to be installed. Include with the instructions, in typed form, condensed operating instructions explaining preventive maintenance procedures, methods of checking the system for normal safe operation and procedures for safely starting and stopping the system, methods of balancing and testing flow in the system, and methods of testing for control failure and proper system operation.
4. Operating and Maintenance Manuals: Submit manuals that detail the step-by-step procedures required for system filling, startup, operation, and shutdown. Include in the manuals the manufacturer's name, model number, service manual, parts list, and brief descriptions of all equipment and their basic operating features. List routine maintenance procedures, possible breakdowns and repairs, recommended spare parts, troubleshooting guides, piping and equipment layout, balanced fluid flow rates, and simplified wiring and control diagrams of the system as installed.

B. Shop Drawings: For solar collectors.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1.04 INFORMATIONAL SUBMITTALS

A. Product Certificates: For each type of solar collector, certifying compliance with SRCC OG-100.

B. Sample Warranty: For manufacturer's special warranty.

1.05 QUALITY ASSURANCE

A. Collector Certification: Certified by FSEC and SRCC.

B. Manufacturer and collector model shall be listed in "Directory of SRCC Certified Solar Collector Ratings."

PART 2 - PRODUCTS

2.01 COLLECTORS

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

1. Viessmann Manufacturing Company Inc. (Basis of Design)
2. HTP
3. Hydronic Specialties Co.
4. Sun-Ray
5. Stiebel Eltron
6. Caleffi

B. The flat plate solar collector shall consist of a blue powder coated aluminum frame, ThermProtect selectively coated aluminum absorber with meander-shaped copper piping, hail-resistant low-iron solar glass, and non-degrading thermal insulation.

1. Each collector shall have a total gross area of 27.0 ft2, and an aperture area of 25.1 ft2.
2. Quantity: 10

C. Performance Criteria

1. The collector shall have a FR tau alpha coefficient of at least 0.75 and a FRUL coefficient of at least 5.74, as listed by the Solar Rating and Certification Corporation (SRCC).
2. The collector shall be designed for operating at:

   a. Maximum pressure loading capacity of 87 psig.
   b. Maximum stagnation temperature of 293°F / 145°C

D. Each collector shall have a one-piece aluminum absorber sheet, which shall be coated with ThermProtect selective surface. The ThermProtect absorber shall ensure high absorption of solar radiation and low emission of thermal radiation. This selective surface shall have a coefficient of absorption of at least 95% and a coefficient of emission of 5%. Should the collector temperature become elevated >167°F (>75°C) the absorber shall switch or transition to a higher rate of thermal emission (45% at 120°C). The net result is that the collector shall operate at a reduced

temperature as the absorber will be rejecting excess thermal radiation. The ThermProtect switching absorber effectively limits the stagnation temperature of the collector to 293°F.

E. The absorber sheet shall be laser welded to a meander-shaped copper pipe. The meander pipe shall connect at the top and bottom of the absorber to an internal 3/4" copper header through which the heat transfer fluid flows.

F. The absorber sheet shall be insulated underneath with at least 2" (50 mm) non-degrading and water resistant melamine resin foam insulation, and the collector perimeter shall be insulated with at least 1/2" melamine resin foam insulation.

G. The collector housing shall be constructed of a powder-coated aluminum frame with a blue finish. The aluminum frame shall be constructed with a one piece wrap around design with no joints, screws or rivets on all the corner sections.

H. The collector glazing shall be 3.2 mm low-iron solar safety glass. The glazing shall be permanently sealed to the aluminum frame with a continuous glass seal. The glass edge shall be finished with a continuous snap in aluminum glass trim with no screws or rivets used.

I. Collectors shall be joined together using flexible stainless steel connection pipes, with brass fittings and O-ring seals. This shall allow up to 12 collectors to be joined together in one collector array. The collector array shall be connected to system piping with 3/4" brass fittings, O-ring seals and stainless steel clamps.

J. The mounting hardware shall be constructed of aluminum, and shall come with stainless steel fasteners.

K. Flat roof mounting kit, 25°-60° - 10 x panel : Provide support structure for the collector array of aluminum or stainless steel. Furnish a support structure, which secures the collector array at the proper tilt angle with respect to horizontal and orientation with respect to true south. The collector tilt angle shall vary by not more than +/- 5 degrees from the angle of the local latitude, and the azimuthal angle may vary by not more than +/-5% from due true south. Provide a support structure that will withstand the static weight of filled collectors and piping, snow loads, wind, seismic, and other anticipated loads without damage. Provide structural reinforcement for the roof as necessary to accommodate the additional loads imposed by the solar water heating system. Provide a support structure, which allows access to all equipment for maintenance, repair, and replacement. Neoprene or EPDM washers shall separate all dissimilar metals.

2.02 DHW TANK

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

1. Viessmann Manufacturing Company Inc.
2. Cemline
3. Buderus
4. Patterson-Kelley
5. Heat Transfer Products

B. The DHW tank shall have a storage capacity of no less than 119 gallons. The tank shall be suitable for domestic hot water production in combination with a hot water heating system. The tank shall be designed for use on heating systems with the following operating conditions:

1. Tank operating conditions: maximum operating pressure 150 psig at 210°F

2. Heat exchanger coil operating conditions: maximum hot water operating pressure 220 psig at 392°F

C. Each hot water storage tank shall have an integrated stainless steel, smooth-surfaced, non-finned, conically shaped, rectangular-coiled heat exchanger. Both the tank and heat exchanger shall be made of fully hygienic, high-alloy stainless steel, austenitic, chrome-nickel-steel, titanium stabilized (X6CrNiMoTi17122 - SA 240 - 316 Ti).

D. The 1¼" diameter internal tubular heat exchanger shall be designed with a large surface coil area in the lower portion of the tank to allow rapid and uniform heating of the water in the tank with a low pressure drop through the heat exchanger coil. The coil shall be designed so as to be both self-draining and self-venting, be non-finned with space between passes, and be tapered to allow full output from all passes of the coil.

E. The tank shall be equipped with a stainless steel sensor well.

F. Tank enclosure panels shall encase the tank with a minimum of 4" (R16 minimum) wrap-around foam insulation (HCFC-free). The tank shall be equipped with NPT threaded connections, for attachment of each threaded nipple to boiler water or domestic water piping, without the use of adaptors.

G. Each tank shall have a front-mounted inspection / clean-out port, and be equipped with a thermometer registering tank water temperature.

H. Four levelling feet shall be provided on the tank base to allow for easy adjustment.

I. Certifications: The tank shall have the following approvals and listings, or be in compliance with: CSA, CRN (BC, PQ), NY City approval, MA State approval

J. A 3/4" pressure and temperature relief valve shall be factory supplied and field installed to meet local codes. The maximum pressure relief setting shall be 150 psi at 210°F.

K. Provide a 1-1/4" NPT Brass elbow c/w 11.4" long sensor well

2.03 SOLAR CONTROLLER

A. Viessmann SCU345 Solar Controller.



B. General

1. Extra-large graphic display
2. 4 relay outputs
3. 5 sensor inputs
4. Data logging onto SD card
5. Thermal disinfection
6. Time-controlled thermostat function
7. VBus®
8. Energy-saving switch-mode power supply

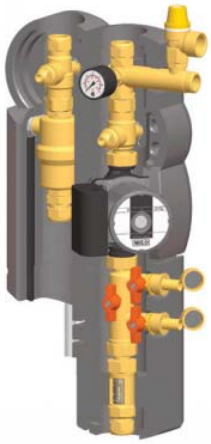
C. Technical

1. Mounting: wall mounting, also suitable for mounting into patch panels
2. Display: System-Monitoring-Display for system visualization,16-segment display, 7-segment display, 9 symbols, control lamp (directional pad) and background illumination
3. Operation:
4. 7 push buttons at the front of the housing
5. Functions: Controller for multi-tank solar thermal systems. Functions such as: ΔT control, pump speed control, energy metering, operating hours counter for the solar pump, thermostat function, vertical tank loading, priority logic, heat dump function, thermal disinfection function, function control according to BAFA guidelines.
6. Inputs: 5 inputs for Pt1000 temperature sensors, 1 V40 impulse input
7. Outputs: 3 semiconductor relays, 1 standard relay
8. Interfaces: VBus®, SD card slot
9. Power supply: 100 ... 240 V~, 50 ... 60 Hz
10. Total switching capacity: 4 A
11. Standby power consumption: < 1W
12. Mode of operation: type 1.Y

D. Provide immersion sensors and wells.

2.04 PREASSEMBLED SOLAR PUMPING STATION

A. The solar pump station shall be a prefabricated unit complete with pre-formed insulation shell to reduce heat loss.



B. The solar pump station shall include the following components:

1. Pressure Relief Valve, 87 psig relief setting
2. 3-speed circulation pump with max flow rate of 16 GPM and maximum head of 20 ft.
3. Pressure gage 0 – 87 psi
4. Temperature gages in both supply and return lines
5. Spring-loaded flow check valves in both supply and return lines
6. Isolation ball valve in both supply and return lines
7. System fill manifold c/w 3 ball valves
8. Air separator c/w manual bleed valve
9. Flow meter with 0 to 10 GPM range

2.05 ACCESSORIES

A. Expansion Tank: The solar expansion tank shall be specifically designed for the temperatures and pressures of a solar water heating system. The membrane of the tank shall be compatible with the solar glycol mixture specified. The tank shall be rated for a maximum of 145 psig and 248°F. The tank shall come pre-charged with a nitrogen cushion pressure of 45 psig. Provide an expansion tank adapter and gasket.

B. Heat Transfer Fluid: The heat transfer fluid shall be made with non-toxic glycols, water and inhibitors, and shall be designed for solar heating applications. The fluid shall not contain any nitrites. The pH value of the fluid at 68°F shall be between 7.5 and 8.5. The fluid shall have a boiling point of no less than 225°F, and frost resistance down to -31°F. The fluid shall be able to withstand temperatures higher than 338°F for short periods of time without degrading. The shelf life of the fluid in air-tight containers shall be at least 3 years.

C. Provide a quick acting air vent (with shutoff valve) at the highest point of the system.

D. Pipe connection set - provide to connect multiple solar collectors.

1. Interconnection.
2. General connections.
3. Installation fittings.

E. Provide a sensor well set.

2.06 PIPING

A. Provide a piping system complete with pipe, pipe fittings, valves, strainers, expansion loops hangers, inserts, supports, anchors, guides, sleeves, and accessories with this specification and the drawings. Provide, install and test the piping. Provide piping flow rates below 5 feet per second.

B. Flexible Insulated Stainless Steel Piping, FlowMaxx or equal. The piping shall be an all-in-one splitable twin-tube piping system, complete with insulation and 20/2 sensor wire, designed for use in solar thermal installations. Each tube shall be made of AISI 316L corrugated stainless steel, and shall come individually wrapped in UV-resistant polyethylene foil for extra insulation and protection. The piping system shall have a maximum fluid temperature of at least 248°F, and a maximum working pressure of at least 87 psig. Bending radius for the piping shall be 2 inches or less.

1. Quick connects for connecting to piping, tanks, or collectors.
2. Insulation : high temperature rubber insulation 13mm
3. Integrated thermistor wire for temperature sensors
4. Wrapped in UV resistant plastic
5. Provide mounting clamps

C. For limited use where the packaged flexible solar piping is not feasible, use Drawn-Temper Copper Tubing: ASTM B 88, Type L, bronze fittings. Use high temperature solder or brazing material, 450F minimum.

D. Pressure Gauges: Provide pressure gauges with throttling type needle valve or a pulsation dampener and shutoff valve. Furnish a 3-1/2 inch minimum dial size.

E. Thermometers: Supply thermometers with wells and separable bronze sockets.

F. Pipe Hangers and Supports: Support and hang piping so that the weight of the piping is not supported by drywall, siding, or other building members not designed to bear load. Support piping so that thermal expansion and contraction of pipe lengths is accommodated.

G. Valves: Provide valves compatible with the piping. Ball valves shall be used for shutoff, with full port, bronze body, bronze ball and Teflon seat. Bronze hose-end gate valves shall be used for draining low points of piping.

H. Air Vents: Brass or bronze valves or cocks suitable for 125 psig service. Air vents shall be provided with threaded plugs or caps. Vent high points.

I. Strainers: ASTM F 1199, removable basket and screen, Y pattern, cast iron strainer with pressures to 125 psig.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine substrates, areas, and conditions for compliance with requirements for installation and other conditions affecting performance of the Work.

B. Examine roughing-in for solar-collector piping to verify actual locations of piping connections before solar-panel installation.

C. Examine walls and roofs for suitable conditions where solar collector will be installed.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 SOLAR-COLLECTOR INSTALLATION

A. Comply with manufacturer's written instructions for collector mounting and installation.

B. Install the collector according to ASHRAE's "Active Solar Heating Systems Installation Manual."

C. Install low-voltage wiring from the sensor to the energy-management panel.

D. Install array support in accordance with the recommendations of the collector manufacturer.

E. Mount the collector frame support feet to the structural support steel using stainless-steel bolts. Attach each pair of legs using two bolts for each.

F. Place high-temperature-resistant covers over the header to prevent contaminants from entering the headers.

G. Coat the controller's sensor with a layer of thermal paste and insert into the collector sensor port to full depth. Apply a silicone sealant around the entire perimeter of the sensor where it enters the collector. Completely cover the opening with insulation to prevent water ingress. Only use high-temperature-rated (minimum 395 deg F) sensors and cabling.

H. After connecting the inlet and outlet of the collectors to the system, purge the system of all air.

I. Install collectors with not less than minimum space for access and service as recommended by solar-collector manufacturer.

3.03 DOMESTIC-WATER, HEAT-EXCHANGER INSTALLATION

A. Domestic-Water, Heat-Exchanger Mounting: Install domestic-water heat exchangers on concrete base.

B. Install domestic-water heat exchangers level and plumb, according to layout drawings, original design, and referenced standards. Maintain manufacturer's recommended clearances. Arrange units so controls and devices needing service are accessible.

C. Install temperature and pressure relief valves in top portion of storage-tank shells of domestic-water heat exchangers with domestic-water storage.

D. Install heat-exchanger drain piping as indirect waste to spill by positive air gap over floor drains. Install hose-end drain valves at low points in water piping for domestic-water heat exchangers that do not have tank drains.

E. Fill domestic-water heat exchangers with water.

F. Charge domestic-water compression tanks with air.

3.04 CONNECTIONS

A. Comply with requirements for piping specified in Section 221116 "Domestic Water Piping."

B. Comply with requirements for heating hot-water piping specified in Section 232113 "Hydronic Piping" and Section 232116 Hydronic Piping Specialties."

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

D. Where installing piping adjacent to domestic-water heat exchangers, allow space for service and maintenance of heat exchangers. Arrange piping for easy removal of domestic-water heat exchangers.

E. Install piping straight and true to bear evenly on hangers and supports. Do not hang piping from sheet rocks or suspended ceilings. Keep interior and ends of new piping thoroughly cleaned of foreign matter. Keep piping systems clean during installation by means of plugs or other approved

methods. Discharge storage tank pressure and temperature relief valves into floor drains. Provide air vents with threaded plugs or caps. Install control and sensor wiring in conduit.

F. Where installing piping adjacent to solar collectors, allow space for service and maintenance.

G. Install flexible connections on piping between collectors installed in series.

H. Install ball valve and union at inlet and outlet of solar collectors.

I. Array Piping: Install collector array piping in a reverse-return configuration so that path lengths of collector supply and return are of approximately equal length. Install air vents in the high points of the collector array piping. Provide proper pitch for draining of collector array.

3.05 SOLAR SYSTEM STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Instructions: Provide instructions for the system type. Include in these instructions a system schematic, and wiring and control diagrams showing the complete layout of the solar system. Prepare condensed operating instructions explaining preventative maintenance procedures, balanced flow rates, methods of checking the system for normal safe operation, and procedures for safely starting and stopping the system, in typed form, framed as specified above, and posted beside the diagrams. Post the framed instructions before acceptance testing of the system.

C. Acceptance Testing and Final Inspection: Maintain a written record of the results of all acceptance tests, to be submitted in booklet form. Provide the following tests:

1. Hydrostatic Test: Hydrostatically test the system. Isolate valving and instrumentation not suitable for the intended test pressure.
2. Operational Test: Operationally test the system over a period of 48 consecutive hours with sufficient solar insolation to cause activation of the solar energy system during daylight hours.

D. Overall System Operations: Demonstrate the solar energy system will operate properly while unattended for a period of at least 72 hours. As required by system design, demonstrate the system controller will start the pumps after being warmed by the sun and that it will properly shut down during cloudy weather or in the evening over a minimum of three complete cycles. It is permissible to manipulate the temperature of the storage tank by the introduction of cold water.

E. Temperature Sensor Diagnostics: As required by system design, demonstrate the controller will correctly identify open and short circuits on both the solar collector temperature sensor circuit and the storage tank sensor circuit.

F. Complete installation and startup checks according to manufacturer's written instructions.

G. Verify tilt angle, mounting, fluid concentrations, and collector array arrangement.

H. System piping shall be flushed with clean, fresh water prior to concealment of any individual section and prior to final operating tests. Prior to flushing piping, relief valves shall be isolated or removed. Solar collectors shall be covered to prevent heating of cleaning fluid, unless cleaning is performed during hours of darkness. The solution shall be circulated through the section to be cleaned at the design flow rate for a minimum of 2 hours.

I. Adjust tilt angle per design requirement and adjust the collector balance valve to provide the design flow.

3.06 WATER HEATER STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

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.
2. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
3. Operational Test: After electrical circuitry has been energized, start units to confirm proper operation.
4. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

END OF SECTION

SECTION 23 64 23

WATER-TO-WATER HEAT PUMPS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Refer to Division 1 Section “Alternates”.

1.02 SUMMARY

A. Section includes packaged, water-to-water heat pumps.

1.03 ACTION SUBMITTALS

A. Product Data: Include refrigerant, rated capacities, operating characteristics, furnished specialties, and accessories.

1. Performance at AHRI standard conditions and at conditions indicated.
2. Performance at AHRI standard unloading conditions.
3. Minimum evaporator and condenser flow rate.
4. Refrigerant capacity.
5. Oil capacity of heat pump.
6. Fluid capacity of evaporator.
7. Fluid capacity of condenser.
8. Characteristics of safety relief valves.
9. Minimum entering condenser-water temperature.
10. Performance at varying capacity with constant design condenser-water temperature. Repeat performance at varying capacity for different condenser-water temperatures from design to minimum in 5 deg F increments.

B. Shop Drawings: Complete set of manufacturer's prints of heat pumps assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Wiring Diagrams: For power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Source quality-control test reports.

B. Startup service reports.

C. Sample Warranty: For special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each heat pump to include in emergency, operation, and maintenance manuals.

1.06 QUALITY ASSURANCE

A. All equipment listed in this section shall be rated in accordance with Air-Conditioning, Heating and Refrigeration Institute/International Standards Organization (AHRI/ISO 13256-2).

B. All equipment shall be tested, investigated, and determined to comply with the requirements of the standards for Heating and Cooling Equipment UL-1995 for the United States and CAN/CSA-C22.2 NO.236 for Canada, by Intertek Testing Laboratories (ETL).

C. The units shall have AHRI/ISO and ETL-US-C labels.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Ship heat pumps from the factory fully charged with refrigerant and filled with oil.

1.08 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of heat pumps that fail in materials or workmanship within specified warranty period. Extended warranties include, but are not limited to, the following:

1. Extended 4-year compressor warranty covers compressor for a total of 5 years.
2. Extended 4-year refrigeration circuit warranty covers coils, reversing valve, expansion valve and compressor for a total of 5 years.
3. Extended 4-year control board warranty covers the control board for a total of 5 years.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Climate Master – Basis of Design
2. Addison
3. Daikin
4. Trane
5. Johnson Controls

2.02 WATER-TO-WATER PACKAGED HEAT PUMP

A. Furnish and install ClimateMaster "TMW" Water-Source Heat Pumps as indicated on the plans. Equipment shall be completely assembled, piped and internally wired. Capacities and characteristics as listed in the schedule and the specifications that follow.

B. Units shall be supplied completely factory built capable of operating over an entering water temperature range from 20° to 120°F.

C. All units shall pass a factory acceptance test. The quality control system shall automatically perform factory acceptance test via computer. A detailed report card from the factory acceptance test shall ship with each unit. If unit fails the factory acceptance test, it shall not be allowed to ship. Unit serial number shall be recorded by factory acceptance test and furnished on report card for ease of unit warranty status.)

D. Basic Construction:

1. All units shall have multiple removable panels for serviceability of compressor compartment.

2. Units shall be floor mount, vertical configuration.
3. The heat pumps shall be fabricated from heavy gauge galvanized steel with powder coat paint finish. Both sides of the steel shall be painted for added protection. All interior surfaces shall be lined with 1/2 inch thick, 1-1/2 lb/ft3 acoustic type glass fiber insulation. Insulation placement shall be designed in a manner that will eliminate any exposed edges.
4. Standard cabinet panel insulation shall meet NFPA 90A requirements, air erosion and mold growth limits of UL-181, stringent fungal resistance test per ASTM-C1071 and ASTM G21, and shall meet zero level bacteria growth per ASTM G22.
5. Cabinets shall have separate holes and knockouts for entrance of line voltage and low voltage control wiring. All factory-installed wiring passing through factory knockouts and openings shall be protected from sheet metal edges at openings by plastic ferrules.
6. Supply and return water connections shall be copper FPT fittings. Water connections shall be on the top of the heat pump. Due to physical space considerations, side connections will not be accepted.
7. Units shall have exterior indicator lights showing, 1) compressor operation (on/off) and 2) unit "fault" status. Contractor shall be responsible for providing control circuitry and indicator lights for units not providing this feature.
8. Provide the optional Ultra-Quiet package to include sound attenuating insulation on unit base pan and all removable panels plus a refrigerant line muffler. Provide a sound blanket on each compressor.

E. Refrigerant Circuit:

1. Units shall have sealed, isolated refrigerant circuits, each including a high efficiency scroll compressor designed for heat pump operation, a thermostatic expansion valve for refrigerant metering, a reversing valve, load and source coaxial (tube in tube) refrigerant to water heat exchangers, and safety controls including a high pressure switch, low pressure switch (loss of charge), and low water temperature sensors. Access fittings shall be factory installed on high and low pressure refrigerant lines to facilitate field service. Activation of any safety device shall prevent compressor operation via a microprocessor lockout circuit.
2. Units with brazed plate heat exchangers will not be accepted.
3. Unit shall be supplied with extended range insulation, which adds closed cell insulation to internal water lines, and provides insulation on suction side refrigeration tubing including refrigerant to water heat exchangers.

4. Hermetic compressors shall be internally sprung. The compressors shall have a dual level vibration isolation system. The compressors will be mounted on specially engineered sound-tested EPDM vibration isolation grommets to a large heavy gauge compressor mounting plate, which is then isolated from the cabinet base with rubber grommets for maximized vibration attenuation. Compressors shall have thermal overload protection.
5. Refrigerant to water heat exchangers shall be of copper inner water tube and steel refrigerant outer tube design, rated to withstand 625 PSIG working refrigerant pressure and 450 PSIG working water pressure. The refrigerant to water heat exchanger shall be "electro-coated" with a low cure cathodic epoxy material a minimum of 0.4 mils thick (0.4 – 1.5 mils range) on all surfaces. The black colored coating shall provide a minimum of 1000 hours salt spray protection per ASTM B117-97 on all external steel and copper tubing. The material shall be formulated without the inclusion of any heavy metals and shall exhibit a pencil hardness of 2H (ASTM D3363-92A), crosshatch adhesion of 4B-5B (ASTM D3359-95), and impact resistance of 160 in-lbs (184 kg-cm) direct (ASTM D2794-93). For all models except 170 & 340, which are powder coated.

F. Electrical: A control box shall be located within the unit compressor compartment and shall contain a 75VA transformer, 24 volt activated, 3 pole compressor contactor, terminal block for thermostat wiring and solid-state controller for complete unit operation. Reversing valve wiring shall be routed through this electronic controller. Units shall be name-plated for use with time delay fuses or HACR circuit breakers. Unit controls shall be 24 Volt and provide heating or cooling as required by the remote aquastat / sensor. Units with two compressors shall have a solid-state time delay relay and random start to prevent both compressors from starting simultaneously.

G. Units shall have a solid-state control system. Units utilizing electro-mechanical control shall not be acceptable. The control system microprocessor board shall be specifically designed to protect against building electrical system noise contamination, EMI, and RFI interference. The control system shall interface with a heat pump type thermostat. The control system shall have the following features:

1. Anti-short cycle time delay on compressor operation.
2. Random start on power up mode.
3. Low voltage protection.
4. High voltage protection.
5. Unit shutdown on high or low refrigerant pressures.
6. Unit shutdown on low water temperature.
7. Condensate overflow electronic protection.
8. Option to reset unit at thermostat or disconnect.
9. Automatic intelligent reset. Unit shall automatically reset the unit 5 minutes after trip if the fault has cleared. If a fault occurs 3 times sequentially without thermostat meeting temperature, then lockout requiring manual reset will occur.
10. Ability to defeat time delays for servicing.
11. Light emitting diode (LED) on circuit board to indicate high pressure, low pressure, low voltage, high voltage, low water/air temperature cut-out, condensate overflow, and control voltage status.
12. The low-pressure switch shall not be monitored for the first 120 seconds after a compressor start command to prevent nuisance safety trips.
13. 24V output to cycle a motorized water valve with compressor contactor.
14. Unit Performance Sentinel (UPS). The UPS warns when the heat pump is running inefficiently.
15. Water coil low temperature sensing (selectable for water or anti-freeze).
16. Air coil low temperature sensing.

H. The control board will be supplied with a BACnet MS/TP interface board. This will permit all units to be daisy chain connected by a 2-wire twisted pair shielded cable. Provide the upgraded 75VA control transformer with load side short circuit and overload protection via a built in circuit breaker. The following points shall be available at the BAS:

1. Source leaving water temperature
2. Load leaving water temperature
3. Command of space temperature setpoint
4. Cooling status
5. Heating status
6. Low temperature sensor alarm
7. Low pressure sensor alarm
8. High pressure switch alarm
9. Hi/low voltage alarm
10. Unoccupied/occupied command
11. Cooling command
12. Heating command
13. Fault reset command
14. Itemized fault code revealing reason for specific shutdown fault (any one of 7)

PART 3 - EXECUTION

3.01 EXAMINATION

A. Before heat pump installation, examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, controls, and electrical connections to verify actual locations, sizes, and other conditions affecting heat pump performance, maintenance, and operations.

B. Heat pump locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping, controls, and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 HEAT PUMP INSTALLATION

A. Coordinate sizes and locations of bases with actual equipment to be installed. Cast anchor-bolt inserts into concrete bases.

B. Equipment Mounting: Install heat pumps on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Division 3.

C. Maintain manufacturer's recommended clearances for service and maintenance. Maintain clearances required by governing code.

D. Heat pump manufacturer's factory-trained service personnel shall charge heat pump with refrigerant if not factory charged and fill with oil if not factory installed.

E. Install separate devices furnished by manufacturer and not factory installed.

F. Piping System Flushing Procedure: Provide in accordance with Section 23 21 13. Prior to supplying water to the heat pump the Water Treatment Specification shall be consulted for requirements regarding the water quality during heat pump operation. The appropriate heat

pump manufacturer's service literature shall be available to the operator and/or service contractor and consulted for guidelines concerning preventative maintenance.

3.03 PIPING CONNECTIONS

A. Comply with requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 "Hydronic Piping Specialties." Drawings indicate general arrangement of piping, fittings, and specialties.

B. Where installing piping adjacent to heat pumps, allow space for service and maintenance.

C. Connect each drain connection with a drain valve, full size of drain connection. Connect drain pipe to drain valve with union and extend drain pipe to terminate over floor drain.

3.04 ELECTRICAL POWER CONNECTIONS

A. Connect wiring according to Division 26.

B. Ground equipment according to Division 26.

3.05 CONTROL CONNECTIONS

A. Install control and electrical power wiring to field-mounted control devices.

B. Connect control wiring between heat pumps and other equipment to interlock operation as required for a complete and functioning system.

C. Connect control wiring between heat pump control interface and DDC System for remote monitoring and control of heat pumps. Comply with requirements in Section 23 09 23.

3.06 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assemblies, installations, and connections.

C. Complete installation and startup checks according to manufacturer's written instructions and perform the following:

1. Verify that refrigerant charge is sufficient and heat pump has been leak tested.
2. Verify that pumps are installed and functional.
3. Verify that thermometers and gages are installed.
4. Operate heat pump for run-in period.
5. Check bearing lubrication and oil levels.
6. Verify that refrigerant pressure relief device for heat pumps installed indoors is vented outside.
7. Verify proper motor rotation.
8. Verify static deflection of vibration isolators, including deflection during heat pump startup and shutdown.

9. Verify and record performance of chilled- and condenser-water flow and low-temperature interlocks.
10. Verify and record performance of heat pump protection devices.
11. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

D. Inspect field-assembled components; equipment installation; and piping, controls, and electrical connections for proper assembly, installation, and connection.

E. Visually inspect heat pump for damage before starting. Repair or replace damaged components, including insulation. Do not start heat pump until damage that is detrimental to operation has been corrected.

F. Prepare a written startup report that records results of tests and inspections.

3.07 DEMONSTRATION

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

1. Instructor shall be factory trained and certified.
2. Provide not less than eight hours of training.
3. Train personnel in operation and maintenance and to obtain maximum efficiency in plant operation.
4. Provide instructional videos showing general operation and maintenance that are coordinated with operation and maintenance manuals.
5. Obtain Owner sign-off that training is complete.
6. Owner training shall be held at Project site.

END OF SECTION

SECTION 23 64 26

AIR COOLED SCROLL WATER CHILLERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Refer to Division 1 Section “Alternates”.

1.02 SUMMARY

A. Section includes air cooled chillers.

B. Related Section:

1. Division 15 Section "Refrigerant Detection and Alarm" for refrigerant monitors, alarms, supplemental breathing apparatus, and ventilation equipment interlocks.

1.03 PERFORMANCE REQUIREMENTS

A. Site Altitude: Chiller shall be suitable for altitude in which installed without affecting performance indicated. Make adjustments to affected chiller components to account for site altitude.

B. Sound Data: Do not exceed these sound levels:

Acoustical Performance

	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Sound power	**87 dB**	**88 dB**	**90 dB**	**93 dB**	**92 dB**	**87 dB**	**81 dB**	**76 dB**

Note: Sound data measured in accordance with AHRI Standard 370.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include refrigerant, rated capacities, operating characteristics, and furnished specialties and accessories.
2. Performance at AHRI standard conditions and at conditions indicated.
3. Performance at AHRI standard unloading conditions.
4. Minimum evaporator flow rate.
5. Refrigerant capacity of water chiller.
6. Oil capacity of water chiller.
7. Fluid capacity of evaporator.

8. Characteristics of safety relief valves.
9. Force and moment capacity of each piping connection.

B. Shop Drawings: Complete set of manufacturer's prints of water chiller assemblies, control panels, sections and elevations, and unit isolation. Include the following:

1. Assembled unit dimensions.
2. Weight and load distribution.
3. Required clearances for maintenance and operation.
4. Size and location of piping and wiring connections.
5. Diagrams for power, signal, and control wiring.

1.05 INFORMATIONAL SUBMITTALS

A. Installation instructions.

B. Source quality-control reports.

C. Startup service reports.

D. Sample Warranty: For special warranty.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each water chiller to include in emergency, operation, and maintenance manuals.

B. Spare Parts List: Recommended spare parts list with quantity for each.

1.07 QUALITY ASSURANCE

A. AHRI Certification: Certify chiller according to AHRI 590 certification program.

B. The quality management system applied by Trane has been subject to independent third-party assessment and approval to ISO 9001-2008.The products described in this catalog are designed, manufactured and tested in accordance with the approved system requirements described in the Trane Quality Manual.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Ship water chillers from the factory fully charged with refrigerant and filled with oil.

B. Package water chiller for export shipping.

1.09 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of water chillers that fail in materials or workmanship within specified warranty period.

1. Extended warranties include, but are not limited to, the following:

a. Complete chiller including refrigerant and oil charge.
b. Complete compressor and drive assembly including refrigerant and oil charge.
c. Refrigerant and oil charge.

1) Loss of refrigerant charge for any reason due to manufacturer's product defect and product installation.

d. Parts only.

2. Warranty Period: Five years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PACKAGED AIR-COOLED CHILLERS

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

1. Trane
2. Daikin
3. Carrier
4. Johnson Controls

2.02 GENERAL

A. Units are constructed of galvanized steel frame with galvanized steel panels and access doors.

B. Component surfaces are finished with a powder-coated paint. Each unit ships with full operating charges of refrigerant and oil.

C. Compressor and Motor: The unit is equipped with two or more hermetic, direct-drive, 3600 rpm 60 Hz suction gas-cooled scroll compressors. The simple design has only three major moving parts and a completely enclosed compression chamber which leads to increased efficiency. Overload protection is included. The compressor includes: centrifugal oil pump, oil level sight glass and oil charging valve. Each compressor will have compressor heaters installed and properly sized to minimize the amount of liquid refrigerant present in the oil sump during off cycles.

D. Unit-Mounted Starter: The control panel is designed per UL 1995.The starter is an across-the-line configuration, factory mounted and fully pre-wired to the compressor motor and control panel. A factory-installed, factory-wired 820VA control power transformer provides all unit control power (120Vacsecondary) and Trane CH530 module power (24Vac secondary). Power line connection type is standard with a terminal block.

E. Evaporator Braze plate heat exchanger is made of stainless steel with copper as the braze material. It is designed to withstand a refrigerant side working pressure of 430 psig and a waterside working pressure of 150 psig. Evaporator is tested at 1.1X maximum allowable refrigerant side working pressure and 1.5times maximum allowable waterside working pressure. It has one water pass.

1. Immersion heaters protect the evaporator to an ambient of -20°F. The evaporator shall be covered with factory-installed 0.75" Armaflex II or equal (k=0.28) insulation.
2. Foam insulation shall be used on the suction line.
3. Water pipe extensions with insulation shall go from the evaporator to the edge of the unit.
4. Provide factory strainer and flow switch.

F. Condenser: Air-cooled microchannel condenser coils use all aluminum brazed fin construction. Each slab is split horizontally into separate condensing and subcooling coils that are connected by either a copper tube or receiver tank. The maximum allowable working pressure of the condenser is 650psig. Condensers are factory proof and leak tested at 715psig. Coils can be cleaned with high pressure water. Optional round tube and plate fin air-cooled condenser coils have aluminum fins mechanically bonded to internally-finned copper tubing. The condenser coil has an integral subcooling circuit. The maximum allowable working pressure of the condenser is 650psig.Condensers are factory proof and leak tested at 715 psig. Direct-drive vertical discharge condenser fans are balanced. Three-phase condenser fan motors with permanently lubricated ball bearings and external thermal overload protection are provided. Units start and operate from 0°F to 125°F for wide ambient. Wide ambient allows operation down to 0°F which is accomplished by a variable speed fan on each circuit that modulates to maintain system differential pressure.

G. Refrigerant Circuit and Capacity Modulation: The 20-35 ton units have single refrigerant circuits. The 40-130 ton units have dual refrigerant circuits. Each refrigerant circuit has Trane scroll compressors piped in parallel with a passive oil management system. A passive oil management system maintains proper oil levels within compressors and has no moving parts. Each refrigerant circuit includes filter drier, electronic expansion valve, and liquid line and discharge service valves.

H. Capacity modulation is achieved by turning compressors on and off. The 20-35 ton units have two capacity stages. The 40-120 ton units have four capacity stages. The 130 ton unit has six capacity stages.

I. Unit Controls (Trane CH530)

1. The microprocessor-based control panel is factory-installed and factory-tested. The control system is powered by a pre-wired control power transformer, and will turn on and off compressors to meet the load. Microprocessor-based chilled water reset based on return water is standard.
2. The Trane CH530 microprocessor automatically acts to prevent unit shutdown due to abnormal operating conditions associated with lower vapor at or refrigerant temperature and high condensing temperature. If an abnormal operating condition continues and the protective limit is reached, the machine will shut down.
3. The panel includes machine protection for the following conditions:

    a. Low evaporator refrigerant temperature and pressure
    b. High condenser refrigerant pressure
    c. Critical sensor or detection circuit faults
    d. High compressor discharge temperature (with low temp evaporator)
    e. Lost communication between modules
    f. Electrical distribution faults: phase loss, phase reversal or over temperature protection
    g. External and local emergency stop
    h. Loss of evaporator water flow

4. When a fault is detected, the control system conducts more than 100 diagnostic checks and displays results. The display will identify the fault, indicate date, time, and operating mode at time of occurrence, and provide type of reset required and a help message.

J. Clear Language Display Panel

1. Factory-mounted to the control panel door, the operator interface has an LCD touch-screen display for operator input and information output. This interface provides access to the following information: evaporator report, condenser report, compressor report, ASHRAE Guideline 3 report, operator settings, service settings, service tests, and diagnostics. All diagnostics and messages are displayed in “clear language.”
2. Data contained in available reports includes:

    a. Water and air temperatures
    b. Refrigerant pressures and temperatures
    c. Flow switch status
    d. EXV position
    e. Compressor starts and run-time

3. All necessary settings and set points are programmed into the microprocessor-based controller via the operator interface. The controller is capable of receiving signals simultaneously from a variety of control sources, in any combination, and priority order of control sources can be programmed.
4. The control source with priority determines active setpoints via the signal it sends to the control panel. Control sources may be:

    a. Local operator interface (standard)
    b. Hard-wired 4-20 mA or 2-10Vdc signal from an external source
    c. BACNet® (provide interface)

2.03 PROVIDE OPTIONS

A. Circuit Breaker: A molded case standard interrupting capacity circuit breaker, factory pre-wired with terminal block power connections and equipped with a lockable external operator handle, to disconnect the chiller from main power.

B. BACNet Interface: Allows user to easily interface with BACNet® via a single twisted-pair wiring to a factory-installed and tested communication board.

C. External Chilled Water and Demand Limit Set point Controls, sensors, and safeties allow reset of chilled water temperature, based on temperature signal, during periods of low outdoor air temperature (chilled water reset based on return chilled water temperature is standard).The demand limit set point is communicated to a factory-installed and tested communication board through a 2-10VDC or 4-20 mA signal.

D. Half Louvers: Louvered panels cover the condenser coil only.

E. Comprehensive Acoustic Package: This option includes acoustical treatment for compressor.

F. Condenser Coil Complete Coat Condenser coils are made of aluminum fins (plate fins) mechanically bonded to internally finned copper tubes. The condenser box is then submerged in an epoxy polymer bath where an electrostatic charge is used to uniformly deposit the epoxy onto the coil. This option resists bimetallic corrosion and allows for operation in coastal environments.

G. Isolators: Factory molded elastomeric isolators sized to reduce vibration transmission to the supporting structure when the unit is installed.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine chillers before installation. Reject chillers that are damaged.

B. Examine roughing-in for equipment support, anchor-bolt sizes and locations, piping, and electrical connections to verify actual locations, sizes, and other conditions affecting chiller performance, maintenance, and operations before equipment installation.

1. Final chiller locations indicated on Drawings are approximate. Determine exact locations before roughing-in for piping and electrical connections.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 CHILLER INSTALLATION

A. Install chillers on support structure indicated using elastomeric pads.

B. Maintain manufacturer's recommended clearances for service and maintenance.

C. Charge chiller with refrigerant and fill with oil if not factory installed.

D. Install separate devices furnished by manufacturer and not factory installed.

3.03 CONNECTIONS

A. Provide flexible pipe connectors to reduce transmitted vibration. Provide a removable coupling.

B. Install piping adjacent to chiller to allow service and maintenance.

C. Pipe Connections: Provide as per manufactures' instructions and details on the plans.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service.

1. Complete installation and startup checks according to manufacturer's written instructions.
2. Verify that refrigerant charge is sufficient and chiller has been leak tested.
3. Verify that pumps are installed and functional.
4. Verify that thermometers and gages are installed.
5. Operate chiller for run-in period.
6. Check bearing lubrication and oil levels.
7. Verify proper motor rotation.
8. Verify and record performance of fluid flow and low-temperature interlocks for evaporator.
9. Verify and record performance of chiller protection devices.
10. Test and adjust controls and safeties. Replace damaged or malfunctioning controls and equipment.

B. Inspect field-assembled components, equipment installation, and piping and electrical connections for proper assembly, installation, and connection.

C. Prepare test and inspection startup reports.

3.05 DEMONSTRATION

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

END OF SECTION

SECTION 23 70 00
CLOSED LOOP GEOTHERMAL HEAT EXCHANGER

PART 1 - GENERAL

1.1 SUMMARY OF WORK

A. The work of the section includes permitting, fabrication, construction, and testing of a complete closed-loop vertical bore ground source heat exchanger (GSHX). This work includes:
   (1) Regulatory permitting and/or registration, including assistance to Owner, for the installation and operation of the GSHX.
   (2) Regulatory permitting for discharge of water during drilling
   (3) Shop drawings and submittals
   (4) Drilling boreholes to depths indicated
   (5) Installing vertical u-bends and grouting
   (6) Installing horizontal manifolds and piping connecting vertical u-bends to vault, and mains into building
   (7) Pressure testing, flow testing, and pressure drop testing
   (8) Bedding horizontal piping in sand
   (9) Flushing debris out of entire system
   (10) Fill system with prescribed antifreeze
   (11) Purge system
   (12) Offsite disposal of drilling spoils (Bid as an optional adder)
   (13) Additional water management equipment and labor to meet all local, state and federal requirements, beyond the erosion control measures provided by the Site Contractor.
   (14) On-site Materials Testing Agency shall provide spot review of GSHX installation.
   (15) Site work by site contractor
   (16) Piping and components inside the building by HVAC and controls contractors

1.2 INSTALLATION PERSONNEL AND TRAINING REQUIRED

A. The geothermal loop contractor, or contractor designate, must be certified and be current as an International Ground Source Heat Pump Association (IGSHPA) Accredited Installer and/or Accredited Well Driller, having completed an IGSHPA training course in the fundamentals of design, installation, and operation of geothermal systems, and having passed the examination and pipe fusion tests.

B. Ground heat exchanger fabricators must have completed a heat fusion school in which each participant has performed heat fusion procedures under direct supervision of an IGSHPA-certified heat fusion technician. The fusion technician must be thoroughly familiar with heat fusion procedures, and have had formal training and testing at a heat fusion school under direct supervision of an IGSHPA-certified instructor.

C. Certified pipe fusion technicians must attend a retraining school every three years. A single failure of a fusion joint will void the certification, and the technician must be retested to demonstrate satisfactory performance.

D. Local and state laws and ordinances as they pertain to buried pipe systems shall be strictly followed or a variance obtained.

1.3 DESIGN BASIS

A. The geothermal bore field design is based upon the thermal conductivity test taken on April 22 through 24, 2017. The test borehole encountered approximately 26ft of boulders, gravel and clay overburden, with underlying schist (mudstone) to 420ft total depth. Significant water of 100+gpm was encountered in the first 100ft. The average earth conductivity was measured at 2.15 btu/hr-ft-ºF, with average diffusivity of 1.37 ft^2/day. The mean earth temperature was measured at 49.8 to 50.4ºF. However, the measured conductivity and diffusivity are fairly high for the formation and may be seasonally or annually effects due to the water production. Therefore the design basis utilizes the recommended lower values of earth conductivity at 1.80 btu/hr-ft-ºF, and average diffusivity of 1.15 ft^2/day.

B. The geothermal designer shall be notified at least 5 days in advance of scheduled installation of the first bore. The bore depths may be adjusted based on the encountered conditions as bores are installed.

C. Installation including earth characteristics, loop field sizing and layout, pipe sizing and flows are as shown on G-series drawings.

1.4 PLANNING

A. Prior to any excavation, trenching, or drilling, all buried utilities, drainage, and irrigation systems shall be located and flagged by the appropriate utility and contractor representatives.

1.5 RECORDS

A. The site contractor shall provide final record documentation of the buried GSHX piping relative to a permanent structure and buried conduits.

B. Any loop registration program shall conform to IGSHPA specifications.

1.6 RESTORATION

A. The site contractor shall be responsible for all site restoration requirements.

1.7 SUBMITTALS

A. All items listed and identified on the WellSpring Geothermal Submittal Log shall be submitted by the appropriate contractor. Each item must be clearly referenced per the item number on the log. See end of this section for blank log sheet example.

1.8 PROJECT COORDINATION

A. Related to the geothermal borefield installation, the Geothermal Contractor shall coordinate with the General Contractor, Site Contractor, the Geothermal Engineer, and other trades all work including permitting, drilling, trenching, separation from storm drains, piping installation and fusion, pressure testing, bedding in sand, flushing and purging. The 8” main supply and return HDPE header to the geothermal vault shall be provided by the Geothermal Contractor at the appropriate timing related to construction of mechanical room footers and slab.

B. Refer to the C-series drawings for the locations of the geothermal bores, the Site Development Plans, and the Erosion and Sedimentation Control Plan.

C. The site and geothermal contractors must meet the most stringent of NPDES, local and state requirements.

D. Prior to drilling the vertical bores, the site contractor shall locate the vertical bores with stakes, and the locations shall be verified by the GC. The civil/site engineer and geothermal designer shall be notified of any discrepancies or conflicts.

E. Site contractor shall provide excavation for trenching, water containment pit, and underground valve vault. Site contractor shall set the vault, including preparation of base, rigging to offload from truck, anti-buoyancy measures, and backfill. The geothermal contractor shall provide the vault.

F. After all vertical bore have been drilled and u-bends installed, the site contractor shall excavate the geothermal horizontal piping trenches and install minimum 6 inches of bedding sand.

G. The geothermal contractor shall install the horizontal piping and coordinate with geothermal engineer for inspections prior to burial. Piping trenches shall not be backfilled until inspections are completed.

H. Drilling contractor shall install 14 gage copper tracer wire over horizontal piping. Site contractor shall remove any rocks, then cover the geothermal piping minimum 6” bedding sand. Site contractor shall backfill trenches and compact in 12 inch lifts, and install marking tape ~1ft below final grade.

I. The Geothermal Contractor may or may not have access to temporary construction utilities. The Geothermal Contractor shall be responsible for completing the work and possibly providing temporary construction utilities at no cost to the owner.

J. The HVAC and controls contractors shall be responsible for piping and components inside the building, other than isolation valves just inside the mechanical room.

1.9 BIDDING

A. The Geothermal Contractor shall bid on a complete and ready to operate geothermal system outside the facility, including the piping and isolation valves just inside the mechanical room. There shall be no allowances, and the only unit pricing shall be for use of water containers and/or frac tanks to handle water production that cannot be handled by the Special Erosion Control measures provided by the Site Contractor per the Site Plan contract documents.

B. The Geothermal Contractor may propose on alternate water containment, treatment and discharge to sewer following special provisions with the Wells Sanitary District, if desired.

C. The geothermal contractor shall bid offsite disposal of drilling spoils as an optional adder.

D. The Geothermal Contractor is ultimately responsible for ensuring any discharged water meets all local, state and federal requirements, and must include this in the base bid.

E. The Site Contractor, HVAC and Controls Contractors shall bid their scopes as detailed in section 1.8 Project Coordination.

PART 2 - PRODUCTS

2.1 BOREHOLES

A. The vertical boreholes shall be located by geothermal contractor at locations marked by the Site Contractor, according to the locations on the C-series drawings.

B. The drill log of the first borehole must be submitted to WellSpring Geothermal immediately after completion. Upon completion of each subsequent borehole, the drilling logs shall also be submitted to WellSpring Geothermal. This is necessary to corroborate the anticipated formations at the site, and may result in altered borefield parameters.

C. Vertical boreholes must be grouted per IGSHPA standards with high conductivity thermally enhanced bentonite grout. The average thermal conductivity of the grout must be 1.4 Btu/hr-ft-F or greater.

D. Manufacturer's published data sheets including thermal conductivity, permeability, percent solids, grout weight, linear shrinkage potential, maximum particle size and unit yield shall be submitted and must be approved prior to use.

E. The thermally enhanced grouting material shall be mixed according to manufacturer's written instructions.

F. Grout material shall be pressure pumped through a tremie pipe from the bottom to the top of the bore. The grouting process shall conform to the manufacturer's instructions and "Grouting for Vertical Geothermal Heat Pump Systems – Engineering Design and Field Procedures Manual" as published by IGSHPA. Completed grouted surface shall be placed at ground level to ensure complete fill of the bore column.

2.2 HORIZONTAL & PIPING SYSTEMS

A. Refer to G-1.0 and G-2.0 for vertical borehole locations and piping sizes for horizontal connections. Geothermal Contractor must submit detailed layout of horizontal piping prior to installation.

B. Site Contractor shall provide trenching for the geothermal heat exchanger piping, as well as sand for bedding piping. Geothermal Contractor shall lay, fuse and test all piping prior to final bedding and burial by the Site Contractor.

C. Sharp bending of pipe around trench corners must be prevented by using a shovel to round corners, or by installing an appropriate elbow fitting. Manufacturer's procedures must be followed.

D. Backfilling procedure will include prevention of any sharp-edged rocks from coming into contact with the pipe by removal of the rocks before backfilling. Geothermal Contractor is responsible for ensuring the quality of the bedding around all the geothermal piping prior to and during backfilling. Use the IGSHPA Slinky backfilling procedures founding IGSHPA's Slinking Installation Guide to assure elimination of air pockets around the pipes.

E. Return bends in narrow trenches must be partially backfilled by hand to properly support the pipes and prevent kinking.

F. All buried GHP pipes in systems containing an antifreeze and passing parallel within 5 feet (1.524 m) of any wall or structure shall be insulated with R2 minimum closed cell insulation.

G. Any horizontal geothermal pipe that crosses any other utility pipes shall cross under the utility pipe by minimum 1ft, with 4 inches of closed cell foam board between the pipes

extending 1ft past the side of all pipes. The geothermal pipe shall be locally deeper than the nominal 5ft to provide the minimum 1ft clearance beneath the utility pipe.

2.3 GROUND HEAT EXCHANGER MATERIALS

A. The acceptable pipe and fitting materials for the underground portion of the ground heat exchanger is polyethylene, as specified in Section 2.3B2.

B. Specifications for the polyethylene heat exchanger are as follows:

(1) General: All pipe and heat fused materials shall be manufactured from virgin polyethylene extrusion compound material in accordance with ASTM D-2513, Section 4.1 and 4.2. Pipe shall be manufactured to outside diameters, wall thickness, and respective tolerances as specified in ASTM, D-3035, D-2447 or F-714. Fittings shall be manufactured to diameters, wall thickness, and respective tolerances as specified in ASTM D-3261 for butt fusion fittings, ASTM D2683 for socket fusion fittings and ASTM F-1055 for electro fusion fittings.

(2) Material: The material shall have a Hydrostatic Design basis of 1600 psi (11.03Mpa) at 73°F (23°C) per ASTM D-2837. The material shall be listed in PPI TR4 as either PE 3408/3608 or PE 4710 piping formulation. The material shall be a high-density polyethylene compound having a minimum cell classification of PE345464C as specified in ASTM D-3350.

(3) Dimensions:

(a) Pipe with diameter of less than 1 ¼" (3.175cm) (nominal) shall be manufactured in accordance with ASTM D-3035 with a minimum (based on pressure rating) dimension ratio of 11.
(b) Pipe manufactured with a diameter of 1 ¼" (3.175cm) (nominal) and larger shall be manufactured in accordance with ASTM D-3035 (minimum [based on pressure rating] dimension ratio of 15.5) or ASTM D-2447 (Schedule 40). If the pipe is used in a vertical bore application it shall be manufactured in accordance with ASTM D-3035 with a minimum (based on pressure rating) dimension ration of 11.
(c) Pipe 3" (7.62cm) (nominal) and larger shall be manufactured in accordance with ASTM D-3035, (with a minimum [based on pressure rating] dimension ratio of 17) or D-2447 (Schedule 40).
(d) Table of Water Pressure Ratings at 73.4F (23.5C) for DR-PR PE 3408/3608 Plastic Pipe

Dimension Ratio	Pressure Rating, psi
7	267
9	200
9.3	193
11	160
13.5	128
15.5	110
17	100

(e) Table of Water Pressure Ratings at 73.4F (23.5C) for DR-PR PE 4710 Plastic Pipe

Dimension Ratio	Pressure Rating, psi
9	252
11	102
13.5	161
15.5	139
17	126

(4) Markings**:** Sufficient information shall be permanently marked on the length of the pipe as defined by the appropriate ASTM pipe standard.

(5) Certification Materials: Manufacturer shall supply a notarized document confirming compliance with the above standards.

2.4 GEOTHERMAL HDPE VALVE VAULT

A. The geothermal contractor shall provide underground HDPE geothermal valve vault as specified below and shown on drawings. It shall include:
(1) Seven (7) sets of supply/return GHX module circuit pipes at nominal 3” pipe size
(2) One set of nominal 6” main supply/return pipes
(3) Supply and return 3” nominal purging connections
(4) OSHA approved entry way and ladder
(5) Isolation valves and P/T test ports on mains and circuit piping
(6) Bypass valve connecting end of 6” supply and return headers
(7) 16” top port at opposite end of manway

B. As located on C-series drawings, the Site Contractor shall dig the pit, prepare the base material, rigging and place vault, as well as provide anti-flotation requirements.

C. The raw materials for the Vault shall be made from materials meeting the following requirements:
(1) HDPE material requirements
(a) HDPE Material – The HDPE material supplied under this specification shall be PE 3608 grade resin grade. The HDPE material shall conform to ASTM D 3350-07 with minimum cell classification values of 345464C.

(2) Valves
(a) The isolation shut-off valves shall be Butterfly valves suitable for above ground and/or buried service applications.
(b) Body shall be Cast Iron, Wafer or Lug Style.
(c) Disc shall be aluminum bronze with stainless steel stem.
(d) Flange locating holes or tapered holes shall be as per ANSI 125/150.
(e) Elastomeric sealing members of valves shall be made of EPDM or Buna-N material selected for use in water service.
(f) Wrench / lever operated valves shall be available in sizes ½” through 8”. Gear operated valves shall be available in sizes 10” and above.
(g) Valves shall have a position indicator.
(h) Valves shall be suitable for use at temperatures of 0º F to 140º F, and shall be suitable for pressures and vacuums compatible with the piping.
(i) Purge Valves shall be quarter-turn type brass full port ball valves. The valves shall provide positive stops at the full-open and full closed positions.

(3) Pressure Temperature (P/T) Test Ports
(a) Test ports shall be suitable for use in geothermal applications.
(b) Test ports shall be located per project drawing. At a minimum, (1) Test port shall be located on the Return main piping, and (1) Test port on each of the Circuit piping with flow coming from the bore field.
(c) Test ports shall be capable of receiving a thermometer probe with a minimum diameter of 1/16” and a maximum diameter of 1/8”.
(d) The test ports shall be capable of allowing the injection/extraction of liquids through an inducement probe not to exceed 1/8” in diameter.

(e) The test ports outer body shall be of all brass construction including a 9/16" knurled cap with a plastic retainer.
(f) Test ports shall have a dual seal core design of Nordel allowing sealing of the system before complete removal of any probe, good up to 350º F for water.
(g) Core membrane shall be of a design that maintains proper alignment for increase ease when inserting probes.
(h) Test ports shall be rated zero leakage from full vacuum to 1000 PSIG.

D. Vault submittals and quality assurance

(1) QA/QC Certification
(a) The vault supplier shall submit certification that the HDPE material meets the specifications.
(b) The fabricator of the structure shall submit drawings showing the position of the inlets, outlets and the overall dimensions along with any other special features such as manways, ladders, etc.
(c) The fabricator of vertical structures shall submit data indicating that the structures meet the requirements of ASTM F 1759, "Design of High Density Polyethylene (HDPE) Manholes for Subsurface Applications". The structure should be proven to have acceptable design for the following areas: Ring Compressive Strain, Combined Ring Compressive and Ring Bending Strain, Ring Buckling, Axial Strain, Axial Buckling, and Thickness of the bottom based on depth and groundwater. Thickness of the bottom should be based on acceptable stress and deflection amounts. Horizontally oriented vaults should provide calculations that prove the vault cylinder can withstand burial and traffic loads with acceptable design criteria for pipe deflection, wall buckling and wall crush.
(d) Calculations supporting these requirements will be part of the submittal package.
(e) The fabrication technician shall perform work in accordance to butt fusion of high-density polyethylene per ASTM F 2620-09 and for extrusion and hot air welding per ASTM C 1147. The fabricator shall submit the written quality assurance program used during fabrication of the structures. The fabricator may be required to submit their overall QA/QC program for fabricating thermoplastic structures and the welding certification program for al personnel involved in the fabrication of the structure.
(f) Shop welds on pipe and fittings larger than 4" OD shall be made using a McElroy Manufacturing DataLogger. The fabricator shall maintain records of the temperature, pressure, and graph of the fusion cycle and shall maintain records in a distinct and exclusive file related to the job/job number.
(g) The structure and piping shall be tested with water, air, or vacuum. The structure shall be determined to be leak free before shipping. An identification plate indicating, the job number, testing data, and when built and by whom, shall be attached to the structure.

(2) Approval or Rejection
(a) Written approval or rejection of substitution given by the ENGINEER.
(b) ENGINEER reserves the right to require proposed components to comply with all of the requirements of specified product, or establish and accept approved equal components.
(c) In the event substitution results in a change of Contract Price or time, provisions in the Agreement will be applied for adjustment.
(d) Substitutions will be rejected if:
(i) Submittal is not through the CONTRACTOR with his stamp or approval.
(ii) Requests are not made in accordance with this Section.

(iii) In the ENGINEERS opinion, acceptance will require substantial revision of the original design.
(iv) In the ENGINEERS opinion, substitution is not equal to original product specified or will not perform adequately the function for which it is intended.

(3) Deviations - Procedure for requesting substitute
(a) Consider after award of Contract.
(b) A letter defining the deviation and justification must be sent to the engineer. The letter must identify:
(i) The Product
(ii) Manufacturer's Name
(iii) Representative Contact Name and Telephone Number
(iv) Specification Section or drawing reference of originally specified product
(v) Discrete name or tag number assigned to original product in the Contract Document.
(c) Manufacturer's literature clearly marked to show compliance of proposed product with Contract Document.
(d) Itemize comparison of original and proposed product addressing product characteristics including but not necessarily limited to:
(i) Size
(ii) Composition or material of construction
(iii) Weight
(iv) Electrical or mechanical requirements
(v) Product Experience
1. Location of past projects utilizing product
2. Name and telephone numbers of persons associated with referenced projects knowledgeable concerning proposed product.
3. Available field data and reports associated with proposed products
(vi) Data relating to changes in construction schedule
(vii) Data relating to changes in cost.
(viii) Samples: At request of the Engineer, a full size sample may be required. This sample may be held by the Engineer until completion of the project.

(4) Rejection – The Geothermal Vault structure may be rejected for failure to meet any of the requirements of this specification.

E. HDPE Vault Construction

(1) The HDPE Vault shall be made from a HDPE profile wall cylinder with a nominal ID of at least 72" for horizontal construction/orientation.
(a) HDPE Material – The internal HDPE piping material supplied under this specification shall be high density, high molecular weight. The HDPE material shall conform to ASTM D 3350-07 with minimum cell classification values of 345464C.
(2) The end-cap thickness shall be no less than 1-1/2" and of the same material as the structure cylinder.
(3) The inlets and outlets shall be extrusion welded on the outside of the structure using good welding practice.
(4) All external connections to structure shall be butt fusion welded or electrofusion welded.
(5) Structures shall be factory tested with a 1 psi Air Test for no less than 30 minutes, with no leaks. The Piping system shall be hydrostatically tested to 100 psi with water for no less than 30 minutes, with no leaks. Data showing the structure to be leak-free can be supplied. The owner or their representative may request to observe the test.
(6) Entry Way

(a) Man-way
  (i) The man-way shall be constructed of the same material as specified in C (1).
  (ii) The man-way shall be attached by means of extrusion welding to outside wall of the structure.
  (iii) The minimum ID of the man-way cylinder shall be no less than 24”.
(b) Ladder
  (i) The entry ladder shall conform to current OSHA guidelines.
  (ii) Ladders constructed from HDPE Pipe shall not be allowed.
  (iii) The first rung of the entry ladder shall be no less than 2” from bottom of man-way.

(7) Top of the man-way shall be built to the requirements of the drawings. If air testing is required, flanged tops or manways will be required. An H20 load rated reinforced concrete pad and cover around the HDPE man-way will be constructed on site by the Site Contractor.

F. CONSTRUCTION PRACTICES

(1) Handling of units. HDPE structures shall be stored on clean, level, and dry ground to prevent undue scratching or gouging of the pipe or cylinder. The handling of HDPE structures shall be done in such a manner that there is no damage. Nylon slings are preferred.
(2) Pipe Joining - HDPE pipe joined in the field external to the Vault shall be joined using butt fusion. All butt fusion welds shall be made as described in ASTM F 2620-09. Electrofusion welding can be substituted for making pipe welds. Hot air and extrusion welding are not permitted for pipe joining. Welds on pipe and fittings larger than 4” OD shall be made using a McElroy Manufacturing DataLogger. The fabricator shall maintain records of the temperature, pressure, and graph of the fusion cycle.
(3) Handling of Fused Pipe- Fused segments of pipe shall be handled so as to avoid damage to the pipe. Limit bending of the pipe welded to fittings or to the structures. Nylon slings are preferred.
(4) Equipment Mounting- Special provisions must be made when mounting equipment inside a Circuit Maker Vault®. Bolting directly to the wall of an HDPE structure is not recommended under normal circumstances.

G. DIRECT BURIAL INSTALLATION

(1) Trench Construction- The trench and trench bottom shall be constructed in accordance with ASTM D 2321, Section 6, Trench Excavation, and Section 7, Installation. The HDPE structure shall be installed on a stable base consisting of 12” of Class I materials compacted to 95% proctor density per ASTM F 1759, Section 4.2. All required safety precautions for vault installation are the responsibility of the contractor.
(2) Embedment materials- Embedment materials shall be Class I or Class II materials as defined by ASTM D 2321, Section 5, Materials. Class I materials are preferred. Backfill and bedding materials shall be free of debris.
(3) Bedding of the structure shall be performed in accordance with ASTM D 2321, Section 7.2. Compaction shall conform to Section 7.5 and 7.51.
(4) Backfilling shall be shall be done to conform to the ASTM F 1759, Section 4.2, “Design Assumptions”. This Specification indicates that backfill shall extend at least 3.5 feet beyond the edge of the structure for the full height of the structure and extend laterally to undisturbed soils. Compaction shall be to 90% proctor density.
(5) H-20 Highway Loads- A reinforced concrete pad designed by a licensed professional engineer will be required when HDPE structures are used in traffic

areas. A traffic rated frame and cover or hatch shall be required along with 24" minimum cover above the top of HDPE structure. A drawing showing key design features must be submitted by the Site Contractor, as indicated in Section E (7) of this specification.

(6) Groundwater Consideration- If high groundwater conditions are suspected, anti-buoyancy calculations are to be provided as part of the submittal package, specifying the expected buoyant forces and the counteraction of those forces, including amount and location/placement of concrete around the structure to anchor the HDPE vault. Anti-buoyancy installation requirements are the responsibility of the Site Contractor.

H. Warranty Conditions

(1) The Circuit Maker Vault is factory tested to be leak-free and free of defectives before shipment. To ensure leak free condition after installation, a field air test must be performed on the structure after all fusion connections are made and backfilling is complete. A 1" male threaded port will be provided in the manway to use for a low pressure air test(1 psi or less), for a period not to exceed 30 minutes. The installing contractor along with the owner representative and/or general contractor should witness the test and provide a signed document to the manufacturer with the location, date, witnesses and test conditions. The manufacturer or its representative should be contacted to be available to witness the testing, which is expected to occur within 60 days of structure delivery. A successful test will extend the warranty to one year from the test date.

PART 3 - EXECUTION

3.1 PIPE JOINING METHODS

A. The only acceptable methods for joining buried pipe systems are a heat fusion process. Stab-type fittings quality controlled to provide a leak-free union between pipe ends that is stronger than the pipe itself may be submitted, two-weeks prior to required approval and subject to engineer approval.

B. Polyethylene pipe shall be heat fused by butt, socket, sidewall, or electro- fusion in accordance with the pipe manufacturer's procedures.

C. Barbed fittings are not permitted to be connected directly to polyethylene pipe, with the exception of stab-type fittings as described above. All mechanical connections must be accessible.

D. All fusion joints must meet the requirements of Performance Pipe's bulletin PP 750 - "Heat Fusion Joining Procedures and Qualification Guide".

3.2 UNDERGROUND HDPE INSULATION REQUIREMENTS

A. Any underground geothermal HDPE piping that within 5 feet of a sewer, storm drain, or other water containing conduit must be separated by insulation.

B. The insulation shall be 4 inch thick closed cell foam board, located within 12" of the HDPE piping and between it and the conduit. The insulation shall be a minimum of 2ft wide, by minimum 2ft longer than the engagement length within 5ft of the conduit.

3.3 GSHX CONSTRUCTION OVERSIGHT

A. The Geothermal Engineer shall witness the installation and testing of the first vertical u-bend.

B. The Geothermal Engineer shall inspect all HDPE fused joints prior to burial.

C. The Geothermal Engineer shall witness a sampling of the following construction items:
   (1) Drilled bore depth
   (2) Vertical u-bend inserted depth
   (3) Verification of grouting from bottom to top of vertical bore
   (4) Flow rate tests
   (5) Pressure hold tests

3.4 FLUSHING, PURGING, PRESSURE AND FLOW TESTING

A. All fusion joints and loop lengths shall be checked to verify that no leaks have occurred due to fusion joining or shipping damage.

B. Heat exchangers will be tested hydrostatically at the small of 150% of the pipe design or 300% of the system operating pressure.

C. All vertical u-bend loops will be pressure tested before installation in borehole. Chart of approved test results for all system boreholes must be submitted.

D. After installation and grouting vertical borehole, each u-bend loop shall be tested for pressure drop at full flow and compared to anticipated values. Lack of flow or high pressure drop, exceeding 15% difference from anticipated values, indicates obstructed or collapsed u-bend and it must be remedied at no cost to the owner. Chart of approved test results for all system boreholes must be submitted.

E. All horizontal circuit components of the GSHX shall be pressurized to 60psi and maintain pressure for 1 hour prior to bedding in sand and backfilling. Chart of approved test results for all circuits must be submitted.

F. Flow rates and pressure drops will be compared to calculated values to assure that there is no blockage or kinking at any pipe.

G. A minimum velocity of 2ft/sec (0.6069m/sec) in each piping section must be maintained for a minimum of 15 minutes, until all air is removed. A change of more than one inch (2.54cm) in the level of fluid in the purge pump tank during pressurization indicates air still trapped in the system.

3.5 ANTIFREEZE SELECTION AND USE

A. FLUID MATERIAL. The propylene glycol fluid must meet the following requirements:
   (1) The fluid must be industrially inhibited propylene glycol (phosphate-based).
   (2) The fluid must be easily analyzed for glycol concentration and inhibitor level, and easily reinhibited using inhibitors readily available from the fluid manufacturer.
   (3) If the system contains more than 250 gallons of fluid, annual analysis must be provided free of charge by the fluid manufacturer. Manufacturer must also provide testing guidelines for use by the operator of a smaller system.
   (4) The fluid must pass ASTM D1384 (less than 0.5 mils penetration per year for all system metals).

(5) The system shall be charged with a 25% solution by volume of propylene glycol, for a maximum of 14F freeze protection.

B. FLUID INSTALLATION. Follow these installation procedures:
(1) All piping shall be thoroughly flushed of debris prior to charging with glycol.
(2) Use only good quality water in solution with the propylene glycol fluid. Use water with low levels (less than 25 ppm) of chloride and sulfate, and less than 50 ppm of hard water ions (Ca++, Mg++). Distilled or deionized water is recommended.

C. The geothermal contractor shall coordinate with the mechanical contractor about the requirements and installation of the propylene glycol antifreeze. The geothermal contractor shall provide all the antifreeze and the geothermal contractor shall install the appropriate amount of antifreeze in the entire ground heat exchanger.

D. The geothermal contractor is responsible for the water quality properties in the entire ground heat exchanger. The water must meet the minimum requirements of both the in-building equipment and the antifreeze manufacturer prior to installation of antifreeze. The geothermal contractor shall include treatment of water in the ground heat exchanger as part of the base bid.

3.6 SYSTEM STARTUP

A. Particulate contaminants must be flushed from entire piping system prior to initial start-up.

B. Start-up pressurization of the circuit to a minimum of 20 to 30 psi (1.38-2.07 bar) when installed in the summer with circulating water temperature of 70-90F (20-30C) and 40 to 50 psi (2.76-3.45 bar) when installed in the winter with circulating water temperature of 40-50F (5-10C) is required. Standing column designs of circulating systems that ensure a flooded volute and meet the manufacturer's requirements are excluded from these pressure requirements.

C. The circulation system must incorporate provisions for flow and temperature-sensing capability for testing the performance of the water side of the heat pump system.

D. Loop charging valve handles must be removed and/or the ports sufficiently plugged to prevent accidental discharge of system fluid and pressure.

3.7 WARRANTY

A. The geothermal contractor shall guarantee all workmanship for this project for a period of 18 months from the date of acceptance by the Owner as determined by the Construction Manager. The warranty shall apply to:
(1) All vertical heat exchangers installed within the property limits.
(2) All horizontal piping and manifolding.
(3) All valves, valve vault, and fittings serving the ground heat exchanger, excluding those installed inside the building by the mechanical contractor.

Mid Coast School of Technology

SUBMITTAL LOG for VERTICAL CLOSED LOOP SYSTEMS
WellSpring Geothermal

A=Accepted (No Exception Taken)
B=Make Corrections as Noted (No Need to Resubmit)
C=Revise and Resubmit
D=Submit Specified Item
E=Rejected

Item No.	Rev No.	Item Description	Submitted By	Date Received	Date Checked	Action	Comments
1	1	Casing steel pipe					
2	1	Detailed Shop Drawing of Loop Field and Manifold					
3	1	SDR-11 HDPE Vertical Loop Pipe and U-Bend					
4	1	HDPE Horizontal Pipe					
5	1	HDPE Fusion Method					
6	2	Grout Materials					
7	1	Well Drilling Logs, all boreholes					
8	1	Vertical Loop Pre-installation Pressure Test Results/Signoff					
9	1	Vertical Loop Post-Installation Pressure Drop/Flow Results/Signoff					
10	1	GHX Module to Vault Pressure Test Results/Signoff (Prior to Backfilling each GHX module)					
11	1	Vault to Building Mech Room Pressure Test Results/Signoff (Prior to backfilling main S/R header to vault)					
12	1	HDPE Geothermal Valve Vault					
13	1	Structural Fill					
14	1	Bedding Sand					
15	1	Isolation Valves at In-building Manifold					
16	1	GHX water quality results, prior to adding antifreeze					
17	1	Antifreeze & Concentration					
18	1	Ground Heat Exchanger Purging Results					
19	1	In-building Purging Results					
20	1	System Pressurization Results					

NOTES:
1. Items 1 through 6 must be submitted prior to drilling boreholes
2. Items 8 through 14 must be submitted prior to backfilling trenches
3. Items 15 through 17 must be submitted prior to installation of those components
4. Items 18 through 20 must be submitted after final installation, prior to startup

5/30/2017

MCST - Geothermal Submittal Log

Vertical Closed Loop Pre-Install U-Bend Pressure Test

WellSpring Geothermal
design and consulting solutions

PROJECT NAME:_____

Bore ID	Date	Method (check one)		Pass/Fail	Witness Initials	
		Mfg Pressure Release	Site Pressure Test		Loop Contractor	General Contractor

Page ___ of ___

Vertical Closed Loop Post-Install U-Bend Flow/Pressure Drop Test

WellSpring Geothermal
design and consulting solutions

PROJECT NAME:_____

Bore ID	Date	Flow Rate (gpm)	Pressure Drop (psi)	Pass/Fail	Witness Initials	
					Loop Contractor	General Contractor

Page ___ of ___

Vertical Closed Loop Circuit Pressure Test

WellSpring Geothermal
design and consulting solutions

PROJECT NAME:_____

CIRCUIT ID:_____

Date	Time	Pressure Reading (psi)	Pass/Fail*	Witness Initials	
				Loop Contractor	General Contractor

* - pressure reading must not change for a period of at least 30 minutes to pass. Pressure reading is expected to drop due to expansion of pipe after initial pressurization.

Page ___ of ___

WellSpring Geothermal
design and consulting solutions

Vertical Closed Loop Circuit Purge and Flow Test

PROJECT NAME: _____

Circuit ID	Date	PURGE			FLOW TEST				Witness Initials	
		Purge Flow Rate (gpm)	Diameter of Return Reservoir (inch)	Drop in Return Reservoir* (inch)	Flow Rate (gpm)	Pressure Drop (psi)	Pass/Fail	Loop Contractor	General Contractor

* - drop in return reservoir is measurement of change in height of water in purge cart return reservoir between full purge flow rate, and fully closing the return line from the loop field circuit to the return reservoir.

Page ___ of ___

END OF SECTION

SECTION 23 72 00

AIR-TO-AIR ENERGY RECOVERY EQUIPMENT

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes packaged energy recovery units with heating and cooling.
   1. AHU
   2. DOAS

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include rated capacities, furnished specialties, and accessories.

   1. Complete fan performance curves for Supply and Exhaust Air, with system operating conditions indicated, as tested on an AMCA Certified Chamber.
   2. Sound performance data for Supply Air, as tested on an AMCA Certified chamber.
   3. Motor ratings, electrical characteristics and motor and fan accessories.
   4. Performance ratings for hydronic coils.
   5. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
   6. Estimated gross weight of each installed unit.
   7. Installation, Operating and Maintenance manual (IOM) for each model.
   8. Microprocessor Controller (DDC) specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
   9. Remote Panel description to include all functions
   10. AHRI Certified coil performance ratings with system operating conditions indicated. Ratings shall be in accordance with Standard 410.
   11. Color chart including a palette of available standard paint finishes.
   12. Energy wheel performance data for both summer and winter operation.

1.04 QUALITY ASSURANCE

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

B. ARI Compliance: Capacity ratings for air-to-air energy recovery equipment shall comply with ARI 1060, "Rating Air-to-Air Energy Recovery Equipment."

C. ASHRAE Compliance:

1. Applicable requirements in ASHRAE 62.1-2004, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."
2. Capacity ratings for air-to-air energy recovery equipment shall comply with ASHRAE 84, "Method of Testing Air-to-Air Heat Exchangers."

D. NRCA Compliance: Roof curbs for roof-mounted equipment shall be constructed according to recommendations of NRCA.

E. UL Compliance: UL 1812.

1.05 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 curbs, equipment supports, and roof penetrations with actual equipment provided.

PART 2 - PRODUCTS

2.01 PACKAGED ENERGY RECOVERY – ROOF MOUNTED

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

1. Greenheck RVE Series
2. American Energy Exchange, Inc.
3. Des Champs Technologies.
4. SEMCO Incorporated.
5. Venmar CES Inc.
6. Daikin
7. Trane
8. Johnson Controls

B. General

1. Unit shall be fully assembled at the factory and consist of an insulated metal cabinet, exhaust air blower, hydronic coil, energy wheel, phase and brownout protection, motorized dampers, filter assembly intake air, supply air blower assembly, exhaust/relief blower assembly, filter assembly for exhaust air, and an electrical control center.
2. All specified components and internal accessories factory installed are tested and prepared for single-point high voltage connection.

C. Cabinet

1. Materials: Formed, double wall insulated metal cabinet, fabricated to permit access to internal components for maintenance.
2. Outside casing: 18 gauge, galvanized (G90) steel meeting ASTM A653 for components that do not receive a painted finish.
3. Provide a painted finish using 4-6 mils thick Hi-Pro Polyester powder coating that meets or exceeds the performance characteristics of Air Dry Heresite and Heresite Baked

Phenolic. It has been formulated for exterior durability, color and gloss retention. This coating is resistant to salt water, chemical fumes and moisture in more corrosive atmospheres. It has superior chemical resistance, excellent abrasion and outdoor UV protection. Custom color shall be as selected by the Architect.

4. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum14 gauge galvanized (G90) steel.
5. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181.

    a. Materials: Fiberglass insulation.
    b. Thickness: 2 inch minimum.
    c. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.

6. Access panels / doors: Unit shall be equipped with insulated, hinged doors or removable access panels to provide easy access to all major components. Doors and access panels shall be fabricated of 18 gauge galvanized G90 steel or painted galvannealed steel.

D. Filters:

1. Unit shall have permanent metal filters located in the outdoor air intake and shall be accessible from the exterior of the unit.
2. MERV 8 disposable pleated filters shall be provided in the supply final air stream and MERV 8 filters in the exhaust air stream.
3. Provide factory installed dirty filter sensors for both airstreams.

E. Supply & Exhaust Air blower assemblies: Blower assembly shall consist of an electric motor and a direct-drive fan. Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor shall be capable of continuous speed modulation and controlled by a VFD.

1. Provide direct drive plenum fans (no exceptions).
2. Blower section construction, Supply Air: direct drive motor and blower shall be assembled on a 14 gauge galvanized steel platform and shall be equipped with 1.125 inch thick neoprene vibration isolation devices.
3. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower.
4. Fan: Direct-drive airfoil plenum fan statically and dynamically balanced, AMCA certified for air and sound performance, mounted on ground and polished steel fan shafts with ball bearing pillow blocks. Bearings shall be selected for a minimum L10 life in excess of 50,000 hours at maximum catalogued speeds.
5. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, “Laboratory Methods of Testing Fans for Rating.”
6. Blower motors shall be “NEMA Premium™”. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure

F. Chilled and hot water coils shall be AHRI Certified and shall be (silver) soldered or brazed.

1. Coils shall be constructed of copper tubing, permanently bonded to aluminum fins and enclosed in a galvanized steel frame.
2. The coils shall be coated with ElectroFin® coil coating.
3. Provide an insulated piping vestibule and curb to keep the pipe risers out of the weather.

G. Condensate drain pan: Drain Pan shall be an integral part of the unit. Pan shall be formed of welded austenitic stainless steel sheet material and provided with a welded stainless steel drain connection at the front for connection to a P-trap. Drain pan shall be sloped in two directions to provide positive draining and drain connector shall be sealed at penetration through cabinet wall.

1. A P-trap kit shall be provided with the unit.

H. Control panel / connections: Rooftop Ventilator units shall have an electrical control center where all high and low voltage connections are made. Control center shall be constructed to permit single-point high voltage power supply connections.

1. RTU shall be equipped with a factory-installed unit disconnect switch.

I. Energy wheel (as scheduled): Energy wheel shall be of total enthalpy, rotary air-to-air type and shall be an element of a removable energy wheel cassette. The cassette shall consist of a galvanized steel framework (designed to produce laminar air flow through the wheel), an energy wheel as specified and a motor and drive assembly. The cassette shall incorporate a pre-tensioned urethane drive belt with a five year warranty. The wheel media shall be a polymer film matrix in a stainless steel framework and be comprised of individual segments that are removable for servicing. Non-segmented energy wheels are not acceptable. Silica gel desiccant shall be permanently bonded to the polymer film and is designed and constructed to permit cleaning and servicing. The energy wheel is to have a five year warranty. Performance criteria are to be as specified in AHRI Standard 1060, complying with the Combined Efficiency data in the submittal.

1. Modulating frost control. Control system shall include an outdoor air thermostat and pressure sensor on the wheel assembly to initiate frost control sequence.

J. Motorized dampers:

1. Intake Air & Exhaust Air: Motorized damper of insulated low leakage type shall be factory installed.
2. Motorized Recirculating Air Damper designed to permit 100% maximum recirculation of return air shall be provided.

K. Sensors are considered to be part of various optional operational modes or device controllers and shall be factory supplied and installed.

2.02 UNIT CONTROLS

A. Unit Controls

1. This unit shall be controlled by a factory-installed microprocessor programmable controller (DDC) that is connected to various optional sensors. The controller shall be integrated with the BACnet BAS system.
2. Unit shall incorporate a DDC controller with integral LCD screen that provides text readouts of status. DDC controller shall have a built-in keypad to permit operator to access read-out screens without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable. Owner-specified ventilating conditions can be input by means of pushbuttons.

B. Microprocessor Controller Sequence of Operation: Controller shall be provided with required sensors and programming for rooftop unit. Controller shall be factory programmed, mounted and tested.

C. Unit Start Command:

1. Factory mounted and wired damper actuators are powered.
2. Exhaust fan starts after a 10 second (adjustable) delay.
3. Supply fan starts 5 seconds (adjustable) after exhaust fan.
4. Tempering options and energy wheel option to function as described below.

D. Unit Stop Command (Or De-Energized):

1. Supply fan, exhaust fan, energy wheel and tempering options de-energized.
2. Outdoor air damper actuator is spring return close, and the recirculated air damper actuator is spring open.

E. Occupied/Unoccupied Modes: The BAS shall control the occupied/unoccupied mode.

1. Occupied Mode:

a. Supply fan ON.
b. Exhaust fan ON.
c. Energy wheel control per below.
d. Heating per below.
e. Cooling per below.
f. Damper control per below.

2. Unoccupied Mode (Unit Off).

a. Supply fan OFF
b. Exhaust fan OFF
c. Tempering OFF
d. Outdoor air damper closed
e. Exhaust damper closed

3. Supply Blower Sequence

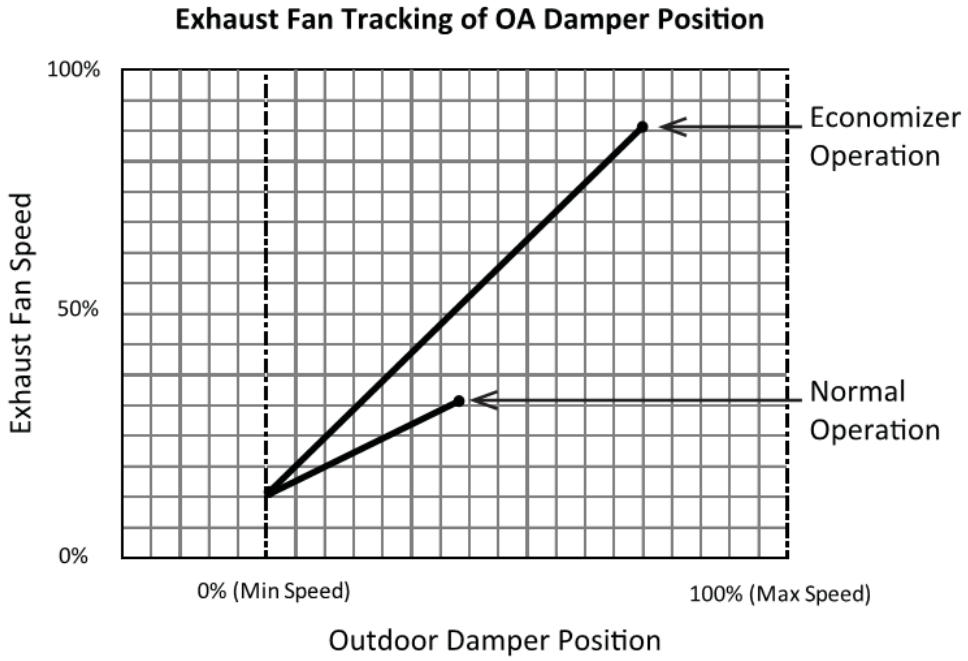
a. The supply blower is provided with a factory mounted variable frequency drive.
b. The supply blower is provided with a factory mounted VFD, and is intended to operate at a speed as commanded by the BAS.

F. If the unit is currently unoccupied, the occupancy can be temporarily overridden for a period of override time. The override time parameter can be set from one to three hours.

G. Exhaust Blower Sequence:

1. The exhaust blower is provided with a factory mounted variable frequency drive.
2. Normal Operation: During non-economizer operation, the exhaust fan will track the outdoor air damper between the minimum outdoor air position (Min OA) and the maximum sequence position (Max BAS). The exhaust fan tracking algorithm references an adjustable minimum position on the display. The outdoor air damper must open above this position before the exhaust fan begins increasing speed.

3. Economizer Operation: During economizer operation, the exhaust fan will track the outdoor air damper between the minimum outdoor air position and the maximum economizer position (Max Econ).



H. Heating & Cooling Sequence:

1. The cooling shall be controlled to maintain the supply temperature setpoint.
2. The controller shall modulate a hot water valve and a chilled water valve (provided by the BAS contractor) in sequence to maintain the supply air setpoint (adj.).
3. For dehumidification, the controller will adjust the cold coil leaving temperature setpoint between the minimum (50F, adj) and the maximum (55°F, adj) setpoints, to satisfy the BAS setpoint for dehumidification.
4. Cooling shall be locked out when the outside air is below 55°F (adj.).
5. Heating shall be locked out when the outside air is above 68°F (adj.).

I. Supply Set Point Reset Function. The controller shall adjust the desired temperature setpoint to satisfy the BAS setpoint.

J. Building Freeze Protection: If the supply air temperature drops below 35°F (adj), the DDC will de-energize the unit and activate the alarm output after a preset time delay.

K. Temperature Protection: When the system requirements are met, the temp protection functionality enables OA/RA damper to modulate down to help the unit keep up with the heating demand in event of wheel failure or outside design conditions. Once set point is achieved the unit goes back to normal operation.

L. Frost Control:

1. The DDC controller will output a signal when frosting is occurring which is determined by a temperature set point (OA<5F – 2F hysteresis, adjustable) and a pressure setpoint.
2. Modulate Wheel: When frosting is occurring, the VFD modulates the wheel down to a slow rotational speed to defrost wheel. Once the pressure drop decreases below the set point, frost mode is de-energized and the wheel returns to full speed.

M. Energy Wheel Sequence

1. Modulate Wheel: When economizer mode is enabled and there is a signal for cooling, the wheel VFD modulates wheel speed to maintain the discharge temperature set point.
2. The unit will be provided with energy wheel bypass dampers for both the outdoor air and return airstreams. During normal operation, the dampers shall remain closed to allow full operation of the energy wheel. During economizer sequences, the bypass dampers will be open to alleviate pressure drop through the wheel, while allowing more outdoor air to be used for economizer cooling.

N. Economizer Sequence:

1. When the application requires cooling, and the outdoor air conditions are suitable for free cooling, the microprocessor can control the wheel and dampers for free cooling. If the discharge temperature is not being met, the controller will start to increase the call for cooling to meet the discharge temperature and this could engage the mechanical cooling.
2. AHU's: During economizer operation, the exhaust fan will track the outdoor air damper between the minimum outdoor air position and the maximum economizer position (Max Econ).
3. Dew Point/Dry Bulb: The economizer will be locked out when: the outside air is < 40°F DB or > 75°F DB or > 55°F dew point; the unit is operating in dehumidification mode; or there is a call for heating.
4. Economizer deadband for enable/disable: maximum 2F DB, 2 Btu/lb. enthalpy.

O. Alarms Indication: DDC shall have one digital output for remote indication of an alarm condition. Possible alarms include:

1. Dirty Filter Alarm: If the outside air or return air filter differential pressure rises above the differential pressure switch set point, the microprocessor controller will activate an alarm.
2. Supply and Exhaust Air Proving Alarm: Microprocessor controller monitors proving switch on each blower and displays an alarm in case of blower failure.
3. Sensor Alarm: Microprocessor controller will send an alarm if a failed sensor is detected (temperature, pressure, relative humidity).
4. Supply Air Low Limit: If the supply air temperature drops below the supply air low limit (35°F), the microprocessor controller will de-energize the unit and activate the alarm output after a preset time delay (300s).
5. Dirty Wheel Alarm: DDC monitors pressure across the wheel and sends an alarm in the case of an increased pressure drop.
6. Wheel Rotation Alarm: Monitors wheel rotation, and sends a signal to controller (after a 15 second time delay with no rotation) that signals the DDC to activate an alarm.

P. Optional Accessories: The following accessories shall be provided to expand the functionality or usability of the controller.

1. Phase and Brown-Out Protection: Factory mounted and wired component which monitors the main power coming into the unit. If a phase drops out or exceeds the limitations, or if the incoming voltage exceeds the acceptable range, the component will turn off the unit to help protect the electrical systems.
2. Provide a factory outdoor airflow monitor with a display of airflow rate in actual CFM. Provide an analog output of the OA CFM to the BAS.

Q. Operating protocol: The DDC shall be factory-programmed for BACnet MSTP. Provide the following points list:

Points List • Modbus/BACnet®							
Type	BACnet Device Instance: 77000 (default) Analog = AV, Integer = AV, Digital = BV				Modbus Address: 1	Read Write	Description
	Instance	Name	Units		Register		
Analog	1	Outside_Air_Temp	°F		40002	R/W*	Outdoor Air Temp (###.#°F) (*To write enable point. See pg. 21)
Analog	2	Supply_Air_Temp	°F		40003	R	Supply Air Temp (###.#°F)
Analog	3	Cold_Coil_Leaving_Temp	°F		40004	R	Cold Coil Temp (###.#°F)
Analog	4	Room_Air_Temp	°F		40005	R/W*	Room AirTemp (if installed) (###.#°F) (*To write enable point. See pg. 21)
Analog	5	Outside_Humidity	percent		40006	R/W*	Outdoor Relative Humidity (###.#%) (*To write enable point. See pg. 21)
Analog	6	Room_Humidity	percent		40007	R/W*	Room Relative Humidity (###.#%) (*To write enable point. See pg. 21)
Analog	11	Temp_Set_Point	°F		40012	R/W	Temperature SetPt (read/write) (###.#F) (See Set Point Menu)
Analog	12	Active_Temp_Set_Point	°F		40013	R	Active Temperature Set Point (###.#F)
Analog	13	Dehumid_Set_Point	percent		40014	R/W	Dehumidification SetPt (read/write) (##.#F, ##.#%) (See Set Point Menu)
Integer	1001	Unit_Status_Index	no-units		45003	R	Note 1 (See below)
Integer	1002	Heating_Control_Loop	percent		45004	R	Heater output (0-100%)
Integer	1003	Cooling_Control_Loop	percent		45005	R	Cooling output (0-100%)
Integer	1004	Energy_Wheel_Speed	percent		45006	R	Energy recovery wheel speed (0-100%)
Integer	1005	Reheat_Control_Loop	percent		45007	R	Hot gas reheat output (0-100%)
Integer	1006	CO2_Level	ppm		45008	R	CO2 Levels (ppm)
Integer	1007	CO2_Set_Point	ppm		45009	R/W	CO2 Set Point (ppm)
Integer	1008	Supply_VFD_Speed	percent		45010	R	Supply Fan VFD Speed (0-100%)
Integer	1009	Supply_VFD_SetPt	percent		45011	R/W	Supply Fan VFD Set Point (0-100%)
Integer	1010	Exhaust_VFD_Speed	percent		45012	R	Exhaust Fan VFD Speed (0-100%)
Integer	1011	Exhaust_VFD_SetPt	percent		45013	R/W	Exhaust Fan VFD Set Point (0-100%)
Integer	1012	OA_Damper_Position	percent		45014	R	Outdoor Damper Position (0-100%)
Integer	1013	OA_Damper_SetPt	percent		45015	R/W	Minimum OA Damper Position (0-100%)
Integer	1014	Duct_Pressure	no-units		45016	R	Supply Duct Pressure (value/100=#.##" WC)
Integer	1015	Duct_Pressure_SetPt	no-units		45017	R/W	Supply Duct Pressure Set Point (value/100=#.##" WC)
Integer	1016	Building_Pressure	no-units		45018	R	Building Pressure (value/1000 = 0.###" WC)
Integer	1017	Building_Pressure_SetPt	no-units		45019	R/W	Building Pressure Set Point (value/1000 = 0.###" WC)
Integer	1018	Occupied_Unoccupied	no-units		45020	R/W	Occupied/unoccupied command (0=occupied, 1-unoccupied, 2-MWU)
Integer	1019	IG_Alarm	no-units		45021	R	IG Alarm - For alarm detail, Convert to binary (See IG Alarm chart below)
			Inactive_Text	Active_Text			
Digital	1	On_Off_Stat	Off	On	10002	R	Unit ON/OFF status
Digital	2	Supply_Fan_Status	Off	On	10003	R	Supply fan status
Digital	3	Exhaust_Fan_Status	Off	On	10004	R	Exhaust fan status
Digital	4	Occupancy_Status	Unoccupied	Occupied	10005	R	Occupancy Status (0=Unoccupied, 1=Occupied)
Digital	5	Stage_Compressor1_Status	Off	On	10006	R	Stage Compressor #1 status
Digital	6	Stage_Compressor2_Status	Off	On	10007	R	Stage Compressor #2 status
Digital	7	Defrost_Mode	Off	On	10008	R	Defrost mode status
Digital	8	Digital_Scroll_Status	Off	On	10009	R	Digital Scroll status
Digital	10	Unit_Start_Stop	Stop	Start	10011	R/W	Unit start/stop command
Digital	11	Reset_Alarms	Don't Reset	Reset Alarms	10012	R/W	Reset alarms command
Digital	13	Stage_Compressor3_Status	Off	On	10014	R	Stage Compressor #3 status
Digital	14	Stage_Compressor4_Status	Off	On	10015	R	Stage Compressor #4 status
Digital	20	Global_Alarm	Off	Alarm	10021	R	Global alarm indication (active when there is at least one alarm)
Digital	21	Supply_air_proving	Off	Alarm	10022	R	Supply airflow proving alarm
Digital	22	High_Wheel_Pressure	Off	Alarm	10023	R	High wheel pressure (high airflow or dirty wheel)
Digital	23	Wheel_Rotation	Off	Alarm	10024	R	Wheel rotation alarm
Digital	24	Exhaust_air_proving	Off	Alarm	10025	R	Exhaust airflow proving alarm
Digital	25	Dirty_filter	Off	Alarm	10026	R	Dirty filter alarm
Digital	26	Compressor_trip	Off	Alarm	10027	R	Compressor trip alarm
Digital	27	Supply_air_low_limit	Off	Alarm	10028	R	Supply air temperature low limit alarm
Digital	28	Sensor1_out_of_range	Off	Alarm	10029	R	Sensor#1 out of range (outside air temperature)
Digital	29	Sensor2_out_of_range	Off	Alarm	10030	R	Sensor#2 out of range (supply air temperature)
Digital	30	Sensor3_out_of_range	Off	Alarm	10031	R	Sensor#3 out of range (cold coil leaving air temperature)
Digital	31	Sensor4_out_of_range	Off	Alarm	10032	R	Sensor#4 out of range (room temperature)
Digital	32	Sensor5_out_of_range	Off	Alarm	10033	R	Sensor#5 out of range (room humidity)
Digital	33	Sensor6_out_of_range	Off	Alarm	10034	R	Sensor#6 out of range (outdoor humidity)
Digital	34	Sensor7_out_of_range	Off	Alarm	10035	R	Sensor#7 out of range (building pressure sensor)
Digital	35	Sensor8_out_of_range	Off	Alarm	10036	R	Sensor#8 out of range (duct pressure sensor)
Digital	36	Sensor9_out_of_range	Off	Alarm	10037	R	Sensor#9 out of range (CO2 sensor)
Digital	37	Sensor10_out_of_range	Off	Alarm	10038	R	Sensor#10 out of range (auxiliary temp)

If pCOe is present, see Points List on next pages.

R. Roof Curbs

1. Curb assembly made of 14 gauge galvanized steel shall be provided by the factory for assembly and installation as part of this division.
2. The curb assembly shall provide perimeter support of the entire unit and shall have duct adapters for supply air and return air. Curb assembly shall enclose the underside of the unit and shall be sized to fit into a recess in the bottom of the unit.

3. Contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly
4. Curb shall be insulated, 2” thick curb walls and insulation.
5. Curb height: 24”.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine casing insulation materials and filter media before air-to-air energy recovery equipment installation. Reject insulation materials and filter media that are wet, moisture damaged, or mold damaged.

C. Examine roughing-in for electrical services to verify actual locations of connections before installation.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Roof Curbs:
1. Provide on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."
2. Coordinate roof penetrations and flashing with roof construction specified in Division 7. See curb detail on Sheet A1.4.
3. Secure equipment to upper curb rail, and secure curb base to roof framing with anchor bolts.

B. Install units with clearances for service and maintenance.

C. Install new filters at completion of equipment installation and before testing, adjusting, and balancing.

3.03 CONNECTIONS

A. Provide condensate drain, minimum connection size, with trap per manufacturer’s recommendations.

B. Install piping adjacent to machine to allow service and maintenance.

C. Comply with requirements for ductwork specified in Division 23 Section "Ductwork." Drawings indicate the general arrangement of ducts. The following are specific connection requirements:

1. Install ducts to termination at top of roof curb.
2. Remove roof decking only as required for passage of ducts. Do not cut out decking under entire roof curb.

3. Duct connections to and from units should allow straight, smooth airflow transitions. Avoid any abrupt change in duct size and sharp turns in the fan discharge. Avoid turns opposed to wheel rotation since they generate air turbulence and result in unwanted sound.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust components, assemblies, and equipment installations, including connections.

B. Pre-Start-Up Checklist

1. Disconnect and lock-out all power switches.
2. Remove any foreign objects that are located in the unit.
3. Check all fasteners, set-screws, and locking collars on the fans, bearings, drives, motor bases and accessories for tightness.
4. Rotate the fan wheels and energy recovery wheels by hand and ensure no parts are rubbing.
5. Filters can load up with dirt during building construction. Replace any dirty pleated filters and clean the aluminum mesh filters in the intake hood.
6. Verify that dampers open and close properly.
7. Check the tightness of all factory wiring connections.
8. Verify control wire gauge.
9. Verify diameter seal settings on the energy recovery wheel.
10. Verify proper drain trap installation.
11. Look over the piping system.
12. Inspect all coils within the unit. Fins may get damaged in transit or during construction. Carefully straighten fins with a fin comb.
13. This unit contains a crankcase heater for each compressor which needs power supplied to it 24 hours prior to start-up. If start-up is scheduled in 24 hours, unlock the disconnect power and energize unit.

C. Perform tests and inspections: Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, and to assist in testing.

D. Tests and Inspections:

1. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation.
2. Adjust seals and purge.
3. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.
4. Set initial temperature and humidity set points.
5. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

E. Air-to-air energy recovery equipment will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

3.05 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

SECTION 23 74 23

DIRECT-FIRED MAKEUP-AIR UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes direct-fired heating and ventilating units.

1.03 ACTION SUBMITTALS

A. Product Data: For each type or model include the following:

1. Complete fan performance curves for Supply Air, with system operating conditions indicated, as tested on an AMCA Certified Chamber.
2. Sound performance data for Supply Air, as tested on an AMCA Certified chamber.
3. Motor ratings, electrical characteristics and motor and fan accessories.
4. Dimensioned drawings for each type of installation, showing isometric and plan views, to include location of attached ductwork and service clearance requirements.
5. Estimated gross weight of each installed unit.
6. Installation, Operating and Maintenance manual (IOM) for each model.
7. Network interface Controller specifications to include available options and operating protocols. Include complete data on all factory-supplied input devices.
8. Coils shall be Recognized Components per UL 1995, CAN / CSA C22.2 No 236.05. Coil performance shall be calculated in accordance with AHRI 410.

1.04 INFORMATIONAL SUBMITTALS

A. Startup service reports.

B. Sample Warranty: For manufacturer's special warranty.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For direct-fired heating and ventilating units to include in emergency, operation, and maintenance manuals.

1.06 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Filters: One set for each unit.

1.07 QUALITY ASSURANCE

A. Comply with NFPA 70.

B. ASHRAE Compliance: Applicable requirements in ASHRAE 62.1, Section 5 - "Systems and Equipment" and Section 7 - "Construction and Startup."

C. ASHRAE/IES 90.1 Compliance: Applicable requirements in ASHRAE/IES 90.1, Section 6 - "Heating, Ventilating, and Air-Conditioning."

D. Entire unit shall be ETL Certified per ANSI Z83.4 or ANSI Z83.18 and bear an ETL mark.

E. Coils shall be Recognized Components per UL 1995, CAN / CSA C22.2 No 236.05. Coil performance shall be calculated in accordance with AHRI 410.

1.08 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace components of direct-fired heating and ventilating units that fail in materials or workmanship within specified warranty period.

1. Warranty Period for Heat Exchangers: Manufacturer's standard, but not less than ten (10) years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Greenheck
2. Captive-Air Systems, Inc
3. Hastings Industries
4. Jackson & Church
5. Reznor
6. Trane
7. Weather-Rite, Inc.

2.02 SYSTEM DESCRIPTION

A. Unit with Integral Heating shall be fully assembled at the factory and consist of components as indicated.

2.03 CABINET

A. Materials: Formed, single wall metal cabinet with fiberglass duct liner insulation, fabricated to permit access to internal components for maintenance.

B. Outdoor Units Outside casing: Pre-painted components as supplied by the factory shall have polyester urethane paint on 18 gauge G60 galvaneal steel. Base rail is 12 gauge, galvanized (G90) steel.

1. Provide a painted finish using 4-6 mils thick Hi-Pro Polyester powder coating that meets or exceeds the performance characteristics of Air Dry Heresite and Heresite Baked Phenolic. It has been formulated for exterior durability, color and gloss retention. This coating is resistant to salt water, chemical fumes and moisture in more corrosive atmospheres. It has superior chemical resistance, excellent abrasion and outdoor UV protection.
2. Custom color shall be as selected by the Architect.

C. Indoor Units Outside casing: 18 gauge G60 galvaneal steel. Base rail is 12 gauge, galvanized (G90) steel.

D. Internal assemblies: 24 gauge, galvanized (G90) steel except for motor supports which shall be minimum14 gauge galvanized (G90) steel.

E. Cabinet Insulation: Comply with NFPA 90A and NFPA 90B and erosion requirements of UL 181. Provide double-wall construction.

1. Materials: Fiberglass insulation.
2. Thickness: 1 inch
3. Fire Hazard Classification: Maximum flame spread of 25 and smoke developed of 50, when tested in accordance with ASTM C 411.
4. Location and application: Floor of each unit shall be insulated with fiberglass insulation. Full interior coverage of entire cabinet.

F. Access panels: Unit shall be equipped with insulated, hinged access panels to provide easy access to all major components.

G. Outdoor Units: Provide an intake hood with aluminum mesh filters.

H. Unit shall have 2” thick MERV8 following the outdoor air intake in a V-bank arrangement and shall be accessible from the exterior of the unit.

I. Direct Drive Plenum Fan:

1. Provide direct-drive fans: Assembly shall be mounted on heavy gauge galvanized steel rails and further mounted on 1.125 inch thick neoprene vibration isolators. Blower motor(s) shall be capable of continuous speed modulation and controlled by a factory supplied VFD.
2. Blower assemblies: Shall be statically and dynamically balanced and designed for continuous operation at maximum rated fan speed and horsepower and must have neoprene vibration isolation devices, minimum of 1 – 1/8 inches thick
3. Fan: Plenum fan statically and dynamically balanced, AMCA certified for air and sound performance.
4. Blower section motor source quality control: Blower performance shall be factory tested for flow rate, pressure, power, air density, rotation speed and efficiency. Ratings are to be established in accordance with AMCA 210, “Laboratory Methods of Testing Fans for Rating.”
5. Proceed with installation only after all unsatisfactory conditions have been corrected.
6. Blower motors greater than ¾ horsepower shall be “NEMA Premium™” unless otherwise indicated. Compliance with EPAct minimum energy-efficiency standards for single speed ODP and TE enclosures is not acceptable. Motors shall be heavy-duty, permanently

lubricated type to match the fan load and furnished at the specified voltage, phase and enclosure.

J. Control center / connections: unit shall have an electrical control center where all high and low voltage connections are made.

1. 24 volt control voltage
2. Supply fan VFD
3. Control transformer
4. Disconnect switch
5. Distribution terminal strip
6. UL Listed, Recognized, or Classified electrical components
7. Factory prewired for single point power connection.

K. Direct Gas-Fired Burner:

1. Unit shall be factory assembled, piped and wired. Direct gas-fired system will be 92% efficient while supplying a burner that is capable of providing 30:1 turndown. Unit will utilize a draw through design and incorporate adjustable burner baffles plates for filed adjustments. Unit will have a direct-spark ignition system.
2. Burner construction shall consist of a cast aluminum burner manifold and 400 series stainless steel mixing plates. No air from the inside space shall be allowed to pass across the burner at any time. A flame safeguard display shall be included. Burner control shall have a digital coded fault indicator capable of storing the last five faults.
3. Shall be equipped for operation on fuel gas (as scheduled) with a maximum rated inlet gas pressure of 1/2 psi. An External Gas pressure regulator shall be provided by the factory.
4. Burner control: External signal for burner modulation with integral discharge temperature limits using an external 2 - 10 VDC or 4 - 20 mA signal.
5. Shall include the following safety controls:

    a. Manual Reset, High Limit Switch: Main gas valve closes if high-limit temperature is exceeded.
    b. Dual safety shutoff valves shall be that do not exceed 120 VAC control signals.
    c. High and low Gas Pressure Switches: Main gas valve closes if high or low pressure switch faults.
    d. Visual indication: Clear visual signal demonstrating the position of the main gas safety shutoff valves. Visual indication provides a clear visual signal that demonstrates the position of the main safety shutoff valves.
    e. Low gas pressure switch automatically shuts down the burner if the inlet gas pressure is too low for the burner to safely light or operate.
    f. The flame safeguard display shall interface with the flame safeguard. It displays a detailed history of the faults that have occurred as well as the current status of the Make-up Air unit.

L. Motorized Inlet Air Damper: Shall be of insulated low leakage type and shall be factory installed.

M. Roof Curbs

1. Curb assembly made of 14 gauge galvanized steel shall be provided by the factory for assembly and installation as part of this division.
2. The curb assembly shall provide perimeter support of the entire unit and shall have duct adapters for supply air. Curb assembly shall enclose the underside of the unit and shall be sized to fit into a recess in the bottom of the unit.

3. Contractor shall be responsible for coordinating with roofing contractor to ensure curb unit is properly flashed to provide protection against weather/moisture penetration. Contractor shall provide and install appropriate insulation for the curb assembly
4. Curb shall be insulated, 2" thick curb walls and insulation.
5. Curb height: 24".

2.04 UNIT CONTROLS

A. The unit shall be constructed so that it can function as a stand-alone heating system controlled by a factory-supplied remote panel, thermostats and sensors or it can be operated as a heating system controlled by a Building Automation System (BAS). This unit shall be controlled by a factory-installed Network interface controller that is connected to various optional sensors.

B. This unit shall be controlled by a factory-installed Network interface controller that is connected to various optional sensors. Unit shall incorporate a Network interface controller with integral LCD screen that provides text readouts of status, operating settings and alarm conditions. Network interface controller shall have a built-in keypad to permit operator to access read-out screens and change settings without the use of ancillary equipment, devices or software. DDC controllers that require the use of equipment or software that is not factory-installed in the unit are not acceptable. Alarm readouts consisting of flashing light codes are not acceptable]

C. The Network interface controller shall be supplied with a protocol card for BACnet MSTP for monitoring of the unit's status and control of the unit's functions through the BAS. Provide the following points list:

Greenheck Network Interface v1.10 Modbus/BACnet Points List								
Modbus-RTU/TCP/IP Network Address: 1	BACnet IP/Ethernet BACnet MSTP Device Instance: 77000(default)				Type	Read (R) Write (W)	Description	Included
Address	Address	Name	Units					
40002	1	Outside_Air_Temp	degree F		Analog	R	Outdoor Air Temp (###.# F)	X
40003	2	Supply_Air_Temp	degree F		Analog	R	Supply Air Temp (###.# F)	X
40004	3	Cold_Coil_Leaving_Temp	degree F		Analog	R	Cold Coil Temp (###.# F)	
40005	4	Return_Air_Temp	degree F		Analog	R	Return Air Temp (###.# F)	
40006	5	Exhaust_Discharge_Temp	degree F		Analog	R	Exhaust Discharge Temp (###.# F)	
40007	6	OA_After_Wheel_Temp	degree F		Analog	R	Outdoor Air After Wheel Temp (###.# F)	
40008	7	Room_Temp	degree F		Analog	R	Room Temp (###.# F)	
40011	10	Heat_Output	percent		Analog	R/W	Heater Output (0-100%)	X
40012	11	Cool_Output	percent		Analog	R/W	Cooling Output (0-100%)	
40013	12	VFD_Supply_Output	percent		Analog	R/W	VFD Supply Fan Output (0-100%)	X
40014	13	VFD_Exhaust_Output	percent		Analog	R/W	VFD Exhaust Fan Output (0-100%)	
40015	14	VFD_Wheel_Output	percent		Analog	R/W	VFD Wheel Output (0-100%)	
40016	15	RA_Damper_Output	percent		Analog	R/W	Return Air Damper Output (0-100%)	
40018	17	Supply_VFD_Monitor	volts		Analog	R	Supply VFD Monitor Signal (Vdc)	
40019	18	Exhaust_VFD_Monitor	volts		Analog	R	Exhaust VFD Monitor Signal (Vdc)	
40031	30	User_Define_Y4_AO	no-units		Analog	R/W	User Define Y4 Analog Input	
40216	1007	CO2_Level	ppm		Integer	R	CO2 Levels (ppm)	
			Inactive_Text	Active_Text				
10011	10	Unit_Start_Stop	Stop	Start	Digital	R/W	Unit Start/Stop Command	X
10012	11	Reset_Alarms	Don't Reset	Reset Alarms	Digital	R/W	Reset Alarms Command	X
10015	14	Cooling_Stg1_Command	Off	On	Digital	R/W	Cooling Stage 1 Command	
10016	15	Cooling_Stg2_Command	Off	On	Digital	R/W	Cooling Stage 2 Command	
10017	16	Heat_Stg1_Command	Off	On	Digital	R/W	Heating Stage 1 Command	X
10018	17	Occ_Unocc_Command	Off	On	Digital	R/W	Occupied/Unoccupied Command	
10019	18	Remote_Exh_Fan_Command	Off	On	Digital	R/W	Remote Exhaust Fan Command	
10020	19	HGRH_Command	Off	On	Digital	R/W	Hot Gas Reheat Command	
10021	20	Global_Alarm	Off	Alarm	Digital	R	Global Alarm Indication (active when there is at least one alarm)	X
10022	21	Frost_Status	Off	On	Digital	R	Frost Status	
10023	22	Econ_Status	Off	On	Digital	R	Econ Status	
10024	23	Fan_Proving_Status	Off	On	Digital	R	Fan Proving Status	X
10026	25	Dirty_Filter_Status	Clean	Dirty	Digital	R	Dirty Filter Status	X
10027	26	Wheel_Status	Ok	Not Ok	Digital	R	Wheel Status (Not OK = wheel not running when commanded on)	
10028	27	Supply_air_low_limit	Off	Alarm	Digital	R	Supply Air Temperature Low Limit Alarm	X
10029	28	Sensor_B1_out_of_range	Off	Alarm	Digital	R	Sensor B1 Out of Range	
10030	29	Sensor_B2_out_of_range	Off	Alarm	Digital	R	Sensor B2 Out of Range	
10031	30	Sensor_B3_out_of_range	Off	Alarm	Digital	R	Sensor B3 Out of Range	X
10032	31	Sensor_B4_out_of_range	Off	Alarm	Digital	R	Sensor B4 Out of Range	
10033	32	Sensor_B5_out_of_range	Off	Alarm	Digital	R	Sensor B5 Out of Range	
10034	33	Sensor_B6_out_of_range	Off	Alarm	Digital	R	Sensor B6 Out of Range	
10035	34	B5_User_Alarm	No Alarm	Alarm	Digital	R	B5 User Input Alarm	
10036	35	B6_User_Alarm	No Alarm	Alarm	Digital	R	B6 User Input Alarm	
10039	38	User_Define_B5_DI	Open	Closed	Digital	R	User Define B5 Digital Input	
10040	39	User_Define_B6_DI	Open	Closed	Digital	R	User Define B6 Digital Input	
10041	40	User_Define_NO1_DO	Off	On	Digital	R/W	User Define NO1 Digital Output	
10042	41	User_Define_NO2_DO	Off	On	Digital	R/W	User Define NO2 Digital Output	
10043	42	User_Define_ID2_DI	Open	Closed	Digital	R	User Define ID2 Digital Input	

D. Variable Frequency Drive (VFD): Unit shall have factory installed variable frequency drives for modulation of the blower motors. The VFDs shall be factory-programmed for unit-specific requirements and shall not require additional field programming to operate.

E. Provide a dirty filter sensor.

F. Provide an adjustable temperature sensing capillary tube which will disable the fan motor at 35ºF.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine roughing-in for piping, ducts, and electrical systems to verify actual locations of piping and electrical connections before equipment installation.

C. Verify cleanliness of airflow path to include inner-casing surfaces, filters, coils, turning vanes, fan wheels, and other components.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install gas-fired units according to NFPA 58.

B. Install controls and equipment shipped by manufacturer for field installation with direct-fired heating and ventilating units.

A. Roof Curbs:

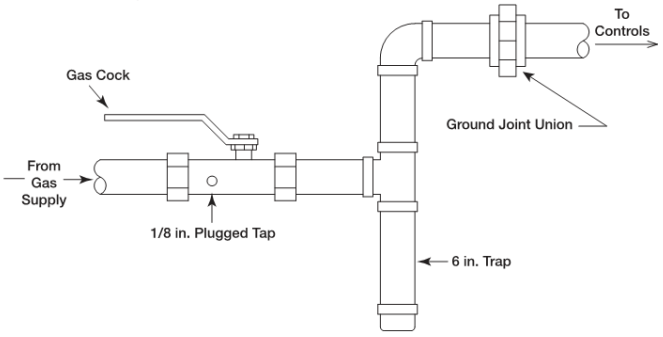
1. Provide on roof structure, level and secure, according to NRCA's "Low-Slope Membrane Roofing Construction Details Manual," Illustration "Raised Curb Detail for Rooftop Air Handling Units and Ducts."
2. Coordinate roof penetrations and flashing with roof construction specified in Division 7. See curb detail on Sheet A1.4.
3. Secure equipment to upper curb rail, and secure curb base to roof framing with anchor bolts.

3.03 CONNECTIONS

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

B. Gas Piping: Comply with requirements in Section 23 11 23 "Facility Fuel-Gas Piping." Connect gas piping with shutoff valve and union, and with sufficient clearance for burner removal and service. Make final connections of gas piping to unit with corrugated, stainless-steel tubing flexible connectors complying with ANSI LC 1/CSA 6.26 equipment connections.

A manual shut off valve (gas cock), 1/8 in. plugged test port and 6 in. drip leg must be installed prior to the gas train. The valve and the test port must be accessible for the connection of a test gauge. Supply gas connections must be made by a qualified installer and are not furnished by manufacturer.



Supply Gas Line

C. Drain: Provide per manufacturers recommendations.

D. Duct Connections: Connect supply ducts to direct-fired heating and ventilating units with flexible duct connectors. Comply with requirements in Section 23 31 13 "Ductwork" for flexible duct connectors.

E. Ground equipment according to Division 26.

F. Connect wiring according to Division 26.

3.04 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative.

C. Units will be considered defective if they do not pass tests and inspections.

D. Prepare test and inspection reports.

3.05 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 and perform the following:

1. Inspect for visible damage to burner combustion chamber.
2. Inspect casing insulation for integrity, moisture content, and adhesion.
3. Verify that clearances have been provided for servicing.
4. Verify that controls are connected and operable.
5. Verify that filters are installed.
6. Purge gas line.
7. Inspect and adjust vibration isolators.
8. Verify bearing lubrication.
9. Inspect fan-wheel rotation for movement in correct direction without vibration and binding.

C. Start unit according to manufacturer's written instructions.

1. Complete startup sheets and attach copy with Contractor's startup report.
2. Inspect and record performance of interlocks and protective devices; verify sequences.
3. Operate unit for run-in period recommended by manufacturer.
4. Perform the following operations for both minimum and maximum firing, and adjust burner for peak efficiency:

    a. Measure gas pressure at manifold.
    b. Measure combustion-air temperature at inlet to combustion chamber.
    c. Measure supply-air temperature and volume when burner is at maximum firing rate and when burner is off. Calculate useful heat to supply air.

5. Calibrate thermostats.
6. Adjust and inspect high-temperature limits.

7. Inspect dampers, if any, for proper stroke and interlock with return-air dampers.
8. Inspect controls for correct sequencing of heating, mixing dampers, refrigeration, and normal and emergency shutdown.
9. Measure and record airflow. Plot fan volumes on fan curve.
10. Verify operation of remote panel, including pilot-operation and failure modes. Inspect the following:

    a. High-limit heat.
    b. Alarms.

11. After startup and performance testing, change filters, and verify bearing lubrication.
12. Verify drain-pan performance.
13. Verify outdoor-air damper operation.

3.06 ADJUSTING

A. Adjust initial temperature set points.

B. Set field-adjustable switches and circuit-breaker trip ranges as indicated.

C. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.07 DEMONSTRATION

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

END OF SECTION

SECTION 23 81 30

DUCTLESS SPLIT-SYSTEM AIR-CONDITIONING UNITS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Division 23 Section “Common Work Results for HVAC”

1.02 SUMMARY

A. This Section includes ductless split AC units designed for year-round cooling down to -20F.

1.03 SUBMITTALS

A. Product Data: Include rated capacities, furnished specialties, and accessories for each type of product indicated. Include performance data in terms of capacities, outlet velocities, static pressures, sound power characteristics, motor requirements, and electrical characteristics.

B. Operation and Maintenance Data: For split-system air-conditioning units to include in emergency, operation, and maintenance manuals.

C. Warranty: Special warranty specified in this Section.

1.04 QUALITY ASSURANCE

A. Product Options: Drawings indicate size, profiles, and dimensional requirements of split-system units and are based on the specific system indicated. Refer to Division 1 Section "Product Requirements."

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Energy-Efficiency Ratio: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

D. Coefficient of Performance: Equal to or greater than prescribed by ASHRAE 90.1, "Energy Efficient Design of New Buildings except Low-Rise Residential Buildings."

E. A dry air holding charge shall be provided in the indoor section.

F. The outdoor unit shall be pre-charged with R-410a refrigerant for 70 feet of refrigerant tubing.

1.05 COORDINATION

A. Provide equipment supports and roof penetrations in accordance with Division 7.

1.06 WARRANTY

A. The units shall have a manufacturer's parts and defects warranty for a period five (5) years from date of installation. The compressor shall have an extended warranty of seven (7) years from date of installation. If, during this period, any part should fail to function properly due to defects in workmanship or material, it shall be replaced or repaired at the discretion of the manufacturer. This warranty will not include labor.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Mitsubishi
2. Daikin
3. Fujitsu
4. Trane
5. Samsung

2.02 DUCTLESS SPLITS

A. Indoor Unit, Mitsubishi Model PKA:

1. The indoor unit cabinet shall be wall mounted by means of a factory supplied mounting plate. The cabinet shall be formed from high strength molded plastic with front panel access for filter. Cabinet color shall be white. The indoor unit shall be factory assembled, wired and tested. Contained within the unit shall be all factory wiring and internal piping, control circuit board and fan motor.
2. The unit in conjunction with the wired, wall mounted controller shall have a self-diagnostic function, 3-minute time delay mechanism, an auto restart function, and a test run switch. Indoor unit and refrigerant pipes shall be purged with dry nitrogen before shipment from the factory.
3. The evaporator fan shall be high performance, double inlet, forward curve, direct drive sirocco fan. The fans shall be statically and dynamically balanced and run on a motor with permanently lubricated bearings. There shall be a motorized horizontal vane to automatically direct air flow in a horizontal and downward direction for uniform air distribution. The horizontal vane shall significantly decrease downward air resistance for lower noise levels, and shall close the outlet port when operation is stopped. There shall also be a set of vertical vanes to provide horizontal swing airflow movement selected by remote control.
4. Return air shall be filtered by means of an easily removable washable filter.
5. The evaporator coil shall be of nonferrous construction with pre-coated aluminum strake fins on copper tubing. The multi-angled heat exchanger shall have a modified fin shape that reduces air resistance for a smoother, quieter airflow. All tube joints shall be brazed

with PhosCopper or silver alloy. The coils shall be pressure tested at the factory. A condensate pan and drain shall be provided under the coil.

6. The electrical power of the unit shall be 208 volts or 230 volts, 1 phase, 60 hertz as scheduled. The system shall be capable of satisfactory operation within voltage limits of 198 volts to 253 volts. The power to the indoor unit shall have an option of being supplied from the outdoor unit, using Mitsubishi Electric A-Control system or separate power source for indoor and outdoor units.
7. The control system shall consist of two (2) microprocessors, one on each indoor and outdoor unit, interconnected by a single non-polar two-wire cable. Field wiring shall run directly from the indoor unit to the wall mounted controller with no splices. For A-Control, a three (3) conductor 14 ga. AWG wire with ground shall provide power feed and bi-directional control transmission between the outdoor and indoor units. Where separate power is supplied to the indoor and outdoor units, a two (2) 20 ga. AWG wire shall be run between the units to provide forbid-directional control communication..
8. The system shall be capable of automatic restart when power is restored after power interruption. The system shall have self-diagnostics ability, including total hours of compressor run time. Diagnostics codes for indoor and outdoor units shall be displayed on the wired controller panel.
9. The microprocessor located in the indoor unit shall have the capability of monitoring return air temperature and indoor coil temperature, receiving and processing commands from the wired controller, providing emergency operation and controlling the outdoor unit.
10. The indoor unit shall be connected to a wall mounted wired controller to perform input functions necessary to operate the system. The wired controller shall have a large multi-language DOT liquid crystal display (LCD). There shall be a built-in weekly timer with up to eight pattern settings per day. The controller shall consist of an On/Off button, Increase/Decrease Set Temperature buttons, a Cool/Dry/Fan mode selector, a Timer Menu button, a Timer On/Off button, Set Time buttons, a Fan Speed selector, a Vane Position selector, a Louver Swing button, a Ventilation button, a Test Run button, and a Check Mode button. The controller shall have a built-in temperature sensor. Temperature changes shall be by increments of 1°F with a range of 67°F to 87°F.
11. The wired controller shall display operating conditions such as set temperature, room temperature, pipe temperatures (i.e. liquid, discharge, indoor and outdoor), compressor operating conditions (including running current, frequency, input voltage, On/Off status and operating time), LEV opening pulses, sub cooling and discharge super heat.
12. Normal operation of the wired controller shall provide individual system control in which one wired controller and one indoor unit are installed in the same room. The controller shall have the capability of controlling up to a maximum of sixteen systems at a maximum developed control cable distance of 1,500 feet.
13. The control voltage from the wired controller to the indoor unit shall be 12 volts, DC. The control signal between the indoor and outdoor unit shall be pulse signal 24 volts DC. Up to two wired controllers shall be able to be used to control one unit.
14. Control system shall control the continued operation of the air sweep louvers, as well as provide On/Off and mode switching. The controller shall have the capability to provide sequential starting with up to fifty seconds delay.

B. Outdoor Unit

1. The connected indoor unit must be of the same capacity as the outdoor unit. The outdoor unit shall be equipped with a control board that interfaces with the indoor unit to perform all necessary operation functions.
2. Low ambient cooling down to -20ºF providing 100% capacity. Provide optional wind baffle.
3. The outdoor unit shall be able to operate with a maximum height difference of 100 feet indoor unit to outdoor unit,

4. System shall have a maximum refrigerant tubing length of 100 feet for the 12,000 and 18,000 and 165 feet for the 24,000, 30,000 and 36,000 between indoor and outdoor units without the need for line size changes, traps or additional oil.
5. Unit shall be pre-charged for a maximum of 70 feet of refrigerant tubing. The outdoor unit shall be completely factory assembled, piped, and wired. Each unit must be test run at the factory.
6. The casing shall be constructed from galvanized steel plate, coated with a finished with an electrostatically applied, thermally fused acrylic or polyester powder coating for corrosion protection. The fan grille shall be of ABS plastic.
7. The fan motor shall be of aerodynamic design for quiet operation, and the fan motor bearings shall be permanently lubricated. The outdoor unit shall have horizontal discharge airflow. The fan shall be mounted in front of the coil, pulling air across it from the rear and dispelling it through the front. The fan shall be provided with a raised guard to prevent contact with moving parts.
8. The L shaped condenser coil shall be of copper tubing with flat aluminum fins to reduce debris build up. The coil shall be protected with an integral metal guard. Refrigerant flow from the condenser shall be controlled by means of linear expansion valve (LEV) metering orifice. The LEV shall be control by a microprocessor controlled step motor.
9. There shall be a DC rotary compressor with Variable Compressor Speed Inverter Technology. The compressor shall be driven by inverter circuit to control compressor speed. The compressor speed shall dynamically vary to match the room load for significantly increasing the efficiency of the system which results in vast energy savings. To prevent liquid from accumulating in the compressor during the off cycle, a minimal amount of current shall be intermittently applied to the compressor motor to maintain enough heat. The outdoor unit shall have an accumulator and high pressure safety switch. The compressor shall be mounted to avoid the transmission of vibration.
10. The outdoor unit shall be controlled by the microprocessor located in the indoor unit.
11. Fast restart due to bypass valve make it ideal for equipment cooling applications, such as data centers.
12. The control signal between the indoor unit and the outdoor unit shall be pulse signal 24 volts DC. The unit shall have Pulse Amplitude Modulation circuit to utilize 98% of input power supply.

C. Provide Accessories:

1. 3-pole disconnect switch
2. Provide thermostat interface that is compatible with a temperature sensor provided by the BAS contractor. Mitsubishi PAC-US444CN-1 or similar.

2.03 OUTDOOR UNIT SUPPORT STANDS

A. Provide support standsd that provide year round operation.

B. Quick-Sling Model QSMS, or approved equal.

1. 14 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. Securely fasten to roof sleepers with corrosion resistant fasteners.
4. Adjustable in height up to 1.25"
5. 50 durometer pads on each foot
6. Max capacity 400 lbs.
7. 4 points of anti-vibration isolation washers

8. 2 additional support arms included
9. Provide all required hardware.

C. Provide roof sleepers, attach stands.

2.04 LINE SETS

A. PDM Preinsulated Pipes; “Gelcopper”, Mitsubishi Diamondback Linesets; or approved equal.

B. Polyethylene closed cell foam: assures thermal insulation from surroundings.

1. ASTM C 1427-07 compliant
2. Type I (tubular)
3. Grade I (insulation material for use on typical commercial system non-crosslinked).
4. Low-density polyethylene foam: closed cells foam, CFC and HCFC gas free
5. Water vapor permeability: ASTM E96-00 compliant
6. Working temperature: ASTM C 1427-07 compliant
7. Wall thickness: 1/2" and 3/4”
8. Surface burning characteristics: UL 94, top rated – UL 723,
9. ASTM E84 (25/50) compliant, flame and Spread Index less than 25 and Smoke Development Index less than 50 as tested according to UL 723.
10. R-Value: between 6.0 and 3.0 (depending on pipe diameter)

C. Copper: Manufactured according to ASTM B280; No. C122200 DHP (phosphorous deoxidized, high residual phosphorous), 99.90%. R410a approved.

D. Outer Jacket: Additional white polyethylene jacket cover protects foam insulation from tearing during installation process. Marking: insulation incrementally marked by every foot to ensure accurate initial unit charge. UV resistant. Paintable: The insulation can be painted to match the surroundings.

E. Line Set Covers: Mitsubishi, Rectorseal, or approved equal. Precision engineered system of prefabricated PVC duct and fittings which conceals and protects exposed refrigeration line sets, wiring, and drain pipes. Made from extruded PVC duct with a full range of injection molded Polypropylene fittings, all of which meet the requirements of the current UL -94V-0 specification. Color: white. Provide stainless steel screws, retainer clips, wall covers, sleeves, fittings, and hardware for a neat, finished installation.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Install units level and plumb.

B. Install evaporator-fan components using manufacturer's standard mounting devices securely fastened to building structure.

C. Provide roof sleepers. Coordinate work with roofing contractor.

D. Anchor units to supports with removable, cadmium-plated fasteners.

E. Install and connect pre-charged refrigerant tubing to component's quick-connect fittings. Install tubing to allow access to unit.

3.02 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties.

B. Install piping adjacent to unit to allow service and maintenance.

C. Coordinate locations of indoor units with structure, ceiling grid, and other trades – must maintain heat pump manufacturer's recommended service clearances.

D. Provide insulated refrigerant piping per heat pump manufacturer's recommendations. Provide and connect pre-charged refrigerant tubing to component's quick-connect fittings. Provide tubing to allow access to unit. Test and inspect refrigerant piping according to ASME B31.5, Chapter VI.

E. Exterior piping and wiring shall be enclosed in line set covers.

F. Route indoor unit condensate drains to sink traps, floor drains, plumbing code compliant, or other locations as indicated.

G. Electrical Connections: Comply with requirements in Electrical Specification Sections for power wiring, switches, and motor controls.

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect, test, and adjust field-assembled components and equipment installation, including connections. Report results in writing.

B. Perform the following field tests and inspections and prepare test reports:

1. Leak Test: After installation, charge system and test for leaks. Repair leaks and retest until no leaks exist.
2. 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. Remove and replace malfunctioning units and retest as specified above.

3.04 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service. Complete installation and startup checks according to manufacturer's written instructions.

3.05 DEMONSTRATION

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

B. Refer to Division 1 for further requirements.

END OF SECTION

SECTION 23 82 16

DUCT MOUNTED HOT WATER HEATING COILS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 23 Section "Common Work Results for HVAC"

1.02 SUMMARY

A. This Section includes HW heating air coils that are not an integral part of air-handling units.

1.03 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for each air coil. Include rated capacity and pressure drop for each air coil.

B. Operation and Maintenance Data: For air coils to include in operation and maintenance manuals.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. ASHRAE Compliance: Comply with ASHRAE 33 for methods of testing heating coils.

PART 2 - PRODUCTS

2.01 WATER COILS

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

1. Trane.
2. McQuay
3. Aerofin Corporation.
4. Carrier Corporation.
5. Coil Company, LLC.

6. Dunham-Bush, Inc.
7. Greenheck
8. Super Radiator Coils.
9. USA Coil & Air.

B. Performance Ratings: Tested and rated according to ARI 410 and ASHRAE 33.

C. Minimum Working-Pressure/Temperature Ratings: 200 psig, 325 deg F.

D. Source Quality Control: Factory tested to 300 psig.

E. Construction

1. Tubes: ASTM B 743 copper, minimum 0.024 inch thick.
2. Fins: Aluminum, minimum 0.006 inch thick.
3. Headers: Seamless copper tube with brazed joints, prime coated.
4. Frames: Galvanized-steel channel frame, minimum 0.052 inch thick for slip-in mounting.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine ducts, plenums, and casings to receive air coils for compliance with requirements for installation tolerances and other conditions affecting coil performance.

B. Examine roughing-in for piping systems to verify actual locations of piping connections before coil installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install coils level and plumb.

B. Install coils in metal ducts and casings constructed according to SMACNA's "HVAC Duct Construction Standards, Metal and Flexible."

C. Straighten bent fins on air coils. Clean coils using materials and methods recommended in writing by manufacturers, and clean inside of casings and enclosures to remove dust and debris.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Division 23 Sections. Drawings indicate general arrangement of piping, fittings, and specialties. Install piping adjacent to coils to allow service and maintenance.

B. Connect water piping with unions and shutoff valves to allow coils to be disconnected without draining piping.

END OF SECTION

SECTION 23 82 39

UNIT HEATERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

B. Related Sections include the following:

1. Division 23 Section “Common Work Results for Mechanical”

1.02 SUMMARY

A. This Section includes hydronic unit heaters.

1.03 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.

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

1.05 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.

PART 2 - PRODUCTS

2.01 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

2.02 UNIT HEATERS

A. Description: An assembly including casing, coil, fan, and motor in the following configurations as scheduled:

B. Casing: Galvanized steel, with removable panels.

C. Cabinet Finish: Bonderize, phosphatized, and flow-coat with baked-on primer and manufacturer's standard paint applied to factory-assembled and -tested propeller unit heater before shipping.

D. Hot-Water Coil: Copper tube, 0.031-inch wall thickness, with mechanically bonded aluminum fins spaced no closer than 0.1 inch and rated for a minimum working pressure of 200 psig and a maximum entering water temperature of 325 deg F, with manual air vent. Test for leaks to 375 psig underwater.

E. Propeller with aluminum blades directly connected to motor.

F. Fan Motors: shaded-pole or permanent-split capacitor, with integral thermal-overload protection.

G. Units mounted shall be equipped with an OSHA fan guard. Fan guards shall be welded steel, zinc plated or painted.

H. Provide Accessories

1. Disconnect Switch.
2. Starter.

2.03 SOURCE QUALITY CONTROL

A. Test unit heater coils according to ASHRAE 33.

PART 3 - EXECUTION

3.01 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.

3.02 INSTALLATION

A. Install unit heaters level and plumb.

B. Install unit heaters to comply with NFPA 90A.

3.03 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.

3.04 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.

3.05 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.

END OF SECTION

SECTION 23 83 16

RADIANT-HEATING HYDRONIC PIPING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes radiant-heating piping, consisting of pipes, fittings, and piping specialties.

B. Distribution manifolds and compatible fittings.

C. Fasteners approved by manufacturer.

D. Mixing assemblies.

E. Controls.

1.03 DEFINITIONS

A. CWP: Cold working pressure.

B. PEX: Crosslinked polyethylene.

C. PTFE: Polytetrafluoroethylene plastic.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include data for piping, fittings, manifolds, specialties, and controls; include pressure and temperature ratings, oxygen-barrier performance, fire-performance characteristics, and water-flow and pressure-drop characteristics.

B. Shop Drawings: Show piping layout and details drawn to scale, including valves, manifolds, controls, and support assemblies, and their attachments to building structure.

1. Shop Drawing Scale: 1/4 inch = 1 foot.
2. Shop drawings and calculation reports with the following information.

a. Submit circuit layout that shows manifold location, pipe spacing, pipe size, circuit length, flow rates, head loss, supply water temperatures for heating, and supply water temperatures for cooling if applicable.

b. Provide calculation reports that show output of the heating/cooling system to include any excess or shortages of heating or cooling, heating/cooling entering the space, flow rates, head loss, back losses of heating/cooling, floor covering resistance, and floor surface temperatures.
c. Submit floor cross section details with fastener(s) being used, fastener spacing, insulation requirements, thermal mass thickness (if required), and intended floor covering.
d. Submit details of manifold, manifold cabinets, valves, and fittings either in a flush mounted installation or a recessed location.
e. Submit details of slab penetrations.

1.05 CLOSEOUT SUBMITTALS

A. Technical Data Sheets.

B. Design Calculation Reports.

1.06 WARRANTY

A. Manufacturer warranty shall include the following:

1. In the event that manufacturer determines that the failure or leak and any resulting damages were the result of a manufacturing defect in the products covered by the warranty and occurred during the first ten years of the time period covered by the warranty, the manufacturer will reimburse the property owner for reasonable repair or replacement charges resulting from the failure or leak and, additionally will reimburse damages to personal property resulting from the failure or leak.
2. Radiant heat pipe manufacturer shall warranty the tubing under normal conditions of use and properly maintained, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation, when properly installed by contractors trained by manufacturer.
3. PEX Press fittings, when installed with ViegaPEX Barrier and FostaPEX tubing, will be free from failure caused by manufacturing defect for a period of thirty (30) years from date of installation. This also includes protected PEX Press fitting in a slab.
4. Manifolds and panels used in the system will be free from manufacturing defect for a period of five (5) years.
5. Controls, mixing stations, or electrical components sold by manufacturer shall be free from manufacturing defect for a period of two (2) years from date of installation.

PART 2 - PRODUCTS

2.01 PEX PIPE AND FITTINGS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Viega LLC; or comparable product by one of the following:

1. Viega LLC
2. Watts Radiant
3. Uponor

B. Pipe Material:

1. PEX tubing and fittings shall maintain a quality control program in accordance with ISO 9001 or NSF International in the manufacturing plant to assure that the tubing and fittings are continually being produced to the required standard.
2. Tubing shall be silane cross-linked high density polyethylene as per ASTM F876/F877 and CSA B137.5.
3. Tubing includes four layers.

    a. First layer: Cross-linked, high density polyethylene.
    b. Second layer: Adhesive.
    c. Third layer: Ethylene vinyl alcohol layer (EVOH oxygen barrier).
    d. Fourth layer: Polyethylene to protect the EVOH layer from damage.

4. Certified to NSF 14 and 61.
5. Tubing will have 6 month UV protection.
6. Certified to UL 263 ULC S101 for floor and wall assemblies.
7. Certified to ASTM E84 and ULC S102.2 Flame Spread (FS)/Smoke Developed (SD) (25/50).

C. Oxygen Barrier: Limit oxygen diffusion through the tube to maximum 0.10 mg per cu. m/day at 104°F according to DIN 4726.

D. Bronze Fittings: PEX Press Fittings manufactured from UNS C83600 copper alloy, meeting the requirements of ASTM F 877 tested as a system with ViegaPEX Barrier tubing.

1. PEX Press Sleeve: Manufactured out of a 304 grade or better stainless steel, and have three view holes with an attached sleeve to ensure proper PEX tubing insertion.
2. Attached sleeve fitting will incorporate a tool locator ring that shall be in place while making a proper press connection.
3. PEX Press connection shall be made with a Viega supplied ratcheting PEX Press hand tool or PEX Press power tool.

E. Pressure/Temperature Rating: ViegaPEX Barrier High-Density Cross-linked polyethylene tubing shall meet the standard grade hydrostatic pressure ratings from the Plastic Pipe Institute in accordance with TR-4/03. The following three ratings are required:

1. 200 deg F at 80 psi.
2. 180 deg F at 100 psi.
3. 73.4 deg F at 160 psi.

2.02 DISTRIBUTION MANIFOLDS

A. Stainless Manifold with Balancing Valves and Flow Meters: Minimum NPS 1 1/4.

1. Manifolds shall be made of 304 Stainless Steel with nickel-plate valve necks on select models.
2. Flow meters, balancing valves, and shut off valves are integrated on manifold.
3. Air bleeders and two purge valves are to be integrated on manifold.
4. Manifolds have 1 inch NPT removable end caps and 1 1/4 inch Union connections.
5. Galvanized steel bracket supplied by Viega.
6. Select manifold cabinet based on manifolds, accessories and fittings added.
7. Accept optional powerheads for individual zone control.
8. Manifold is suitable to receive all SVC connections.

9. Flow Meters for Stainless Manifolds:

    a. Visual Flow Indicator: Visible indication in a clear plastic cap at top of valve.
    b. Body Brass: Nickel plated.
    c. Internal Parts: Plastic, EPDM.
    d. Inlet Connection: NPS 1/2, 1/2 inch with O-ring.
    e. Measure Range: 0 - 2 gpm.
    f. Handle Style: Rotating ring with lockable cap, no memory stop to retain set position if used for shut off.
    g. CWP Rating: 100 psi.

10. Thermometers:

    a. Mount on connection.
    b. Case: Stainless steel, 2 inch diameter.
    c. Element: Bimetal coil element.
    d. Movement: Mechanical, connecting element and pointer.
    e. Dial: White aluminum, black lettering.
    f. Pointer: Aluminum, black.
    g. Window: Instrument glass, NS 33 polycarbonate.
    h. Connector: Rigid, back type.
    i. Accuracy: Plus or minus 2 percent of range.

11. Maximum Operating Pressure: 100 psi.
12. Maximum Operating Temperature: 180°F.

B. Balancing Valves for Stainless Manifolds:

1. Body: Brass, nickel plated.
2. Valve Spindle: Brass, EPDM.
3. Inlet Connection: NPS 1/2, 1/2 inch with O-ring.
4. Operator: Allen Wrench - 5 mm.
5. CWP Rating: 145 psi.
6. Maximum Operating Pressure: 100 psi
7. Maximum Operating Temperature: 180°F

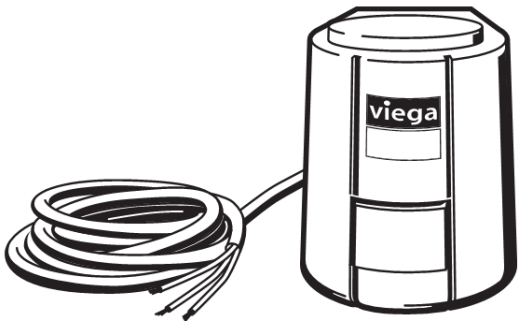
C. Main Shutoff Valves for Stainless Manifolds:

1. Field installed on supply and return connections.
2. Two-piece body.
3. Body: Brass nickel-plated body.
4. Ball: Full port chrome-plated brass.
5. Seals: PTFE.
6. Stem: Brass with 2 Buna-N O-rings and blowout proof assembly.
7. CWP Rating: 100 psig.
8. Maximum Operating Temperature: 180°F

D. Powerheads for Stainless Manifolds (0-10VDC):

1. Voltage: 24 VAC 50/60 Hz.
2. Control Voltage: 0-10 VDC.
3. Maximum Inrush Current: <320 mA for 2 minutes maximum.
4. Operating Power: 1 watt.
5. Actuating Force: 21 lbs.
6. Stroke: 0.16 inch.

7. Fluid Temperature: 32 to 212 deg F.
8. Maximum Pressure Differential: 50 psi.
9. Connecting Cable Length: 3 feet.



E. Manifold Cabinets: Provide appropriately size cabinets to house the manifolds.
1. Recess mount
2. Adjustable wall depth (4½"-6")
3. 20 Gauge galvanized sheet metal construction
4. Provide shop-primed finished for field painting by Division 9.
5. Open-bottom to make tubing connections easy
6. Provide lock and key
7. Adjustable legs (0-7")

Manifold Cabinet Dimensions

Part Number	Outside Dimension W x H x D	Inside Dimension W x H x D
15800	22⅝" x 28" x 4½"	21" x 28" x 4½"
15801	28⅝" x 28" x 4½"	27" x 28" x 4½"
15802	46" x 28" x 4½"	45" x 28" x 4½"

8. Cabinets not needed for exposed manifolds in unfinished spaces
   a. Mechanical Room
   b. Water Entry Room
   Above ceilings

2.03 PIPING SPECIALTIES

A. Viega RapidGrid Insulation Board: Provided by Division 7. Coordinate with supplier, the insulation board must be compatible with the furnished piping.



2.04 CONTROLS

A. Temperature-control devices and sequence of operations are specified in Section 23 09 23 "Direct-Digital Control (DDC) System for HVAC" and Section 23 09 93.11 "Sequence of Operations for HVAC DDC."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine surfaces and substrates to receive radiant-heating piping for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

1. Ensure that surfaces and pipes in contact with radiant-heating piping are free of burrs and sharp protrusions.
2. Ensure that surfaces and substrates are level and plumb.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Refer to manufacturer's most current installation instructions.

B. Drawing plans, schematics, and diagrams indicate general location and arrangement of piping systems. Indicate piping locations and arrangements if such were used to size pipe and calculate friction loss, expansion, pump sizing, and other design considerations. Install piping as indicated unless deviations to layout are approved on Shop Drawings or coordination drawings.

C. Install ViegaPEX Barrier at least 4 inches from edge of slabs, walls or other permanent objects.

D. Install ViegaPEX Barrier continuous from the manifold through the heated panel and back to the manifold without piping joints in heated panels. If coupling is required, use Viega PEX Press fitting and wrap in Viega's Coupling Repair Tape.

E. Avoid crossing tubing in slab unless minimum concrete thickness is met.

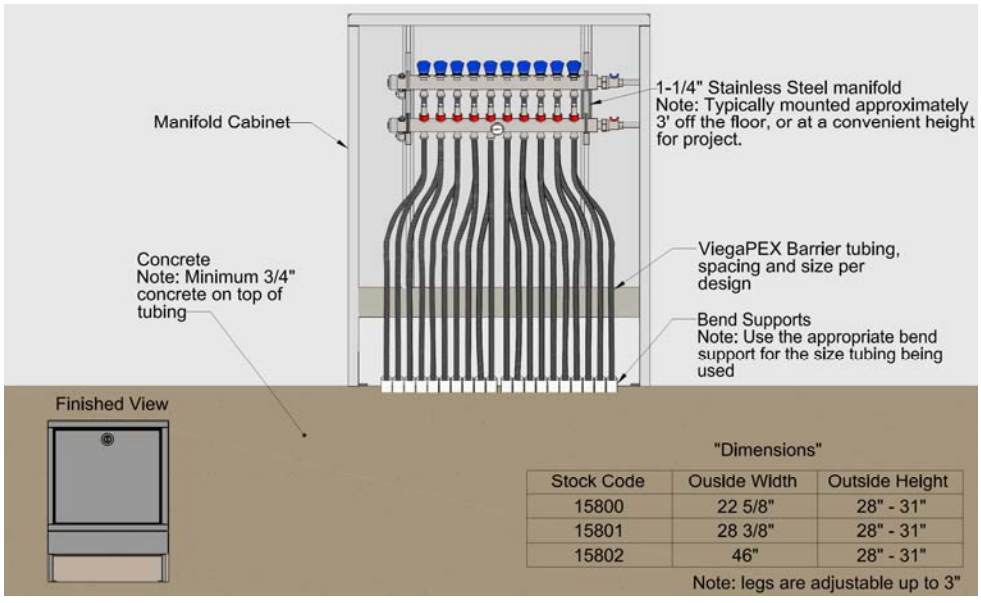
F. Square off ViegaPEX Barrier or FostaPEX with approved PEX Cutters.

G. Connect ViegaPEX Barrier or FostaPEX to manifold using approved Viega Manifold Adapters.

H. Use bend supports for pipe entering and exiting the slab.

I. Do not bend pipe in radii smaller than manufacturer's minimum bend radius.

J. Manifolds should be installed with brackets supplied by Viega LLC.



K. Install manifolds in accessible locations, or install access panels to provide maintenance access as required in Division 8.

L. Comply with requirements in Section 23 21 13 "Hydronic Piping" and Section 23 21 16 Hydronic Piping Specialties" for pipes and connections to hydronic systems and for glycol-solution fill requirements.

M. Fire- and Smoke-Barrier Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at pipe penetrations. Seal pipe penetrations with firestop materials according to Section 07 84 13 "Penetration Firestopping."

N. Piping in Concrete:

1. Secure piping by attaching pipes to reinforcement using approved fasteners from manufacturer.
2. Space fasteners a maximum of 24 inches o.c. and at center of turns and bends.
3. Maintain 2 inches minimum cover.
4. Install a sleeve of 3/8 inch thick, foam type insulation or PE pipe around tubing and extending for a minimum of 12 inches on each side of slab expansion joints to protect the tubing passing through expansion joints. Anchor sleeve to slab form at expansion joints to provide maximum clearance for saw cut.
5. Install vapor barrier and insulation as per the radiant design. Ensure compression rating is suitable for structural engineer.
6. If pipe is being secured to insulation space fasteners a maximum of 24 inches and at center of turns and bends.
7. Maintain pressure test of a minimum 100 psig or 1.5 times system working pressure.
8. After initial pressurization, ensure pressure has not dropped after 20 minutes. Fluctuations may occur due to temperature fluctuations and tubing expansion. If a drop has occurred add pressure to the system. Carry out testing for a minimum of 1 hour.
9. Maintain pressure in piping during concrete installation and continue for 24 hours after placement.

O. Revise locations and elevations from those indicated as required to suit field conditions and ensure integrity of piping and as approved by Architect.

P. After system balancing has been completed, mark balancing valves to permanently indicate final position per design.

Q. Perform the following adjustments before operating the system:

1. Open valves to fully open position.
2. Check operation of automatic valves.
3. Set temperature controls so all zones call for full flow.
4. Purge air from piping.

R. After concrete has cured as recommended by concrete supplier, operate radiant-heating system as follows:

1. Start warm up after concrete has reached its final set (curing complete).
2. Set supply water temperature to 77°F for the first three days.
3. Increase supply water temperature to the set point in gradual increments for the next 4 days. Maximum of a 50°F increase in a period of 24 hours.
4. For freeze protection, operate at a minimum of 60°F supply-water temperature or provide adequate antifreeze protection.

3.03 FIELD QUALITY CONTROL

A. Prepare radiant-heating piping for testing as follows:

1. Open all isolation valves and close bypass valves.
2. Open and verify operation of zone control valves.

3. Flush with clean water and clean strainers.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Leak Test: After installation, charge system and test for leaks. Subject piping to hydrostatic test pressure that is not less than 1.5 times the design pressure but not more than 100 psig. Repair leaks and retest until no leaks exist.
2. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

C. Radiant-heating piping will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

E. Protect hydronic piping system from damage during construction.

END OF SECTION

SECTION 26 01 00

BASIC ELECTRICAL REQUIREMENTS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. General requirements applicable to all Division 26 sections.
2. Allowances for Utility Construction Charges

B. The work included for Division 27 and Division 28 shall be included under Division 26.

1.03 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.

1.04 ALLOWANCES FOR UTILITY CONSTRUCTION CHARGES

A. Provide a $60,000 allowance as specified in Division 01 for utility company construction charges associated with the electric, phone, and CATV services.

1.05 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 2011 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.

1.06 EFFICIENCY MAINE

A. This project intends to pursue Maine Advanced Buildings 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 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

1.07 COORDINATION

A. Provide coordination drawings in accordance with Section 01 00 00 “General Requirements”.

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

SECTION 26 05 19

LOW-VOLTAGE ELECTRICAL POWER CONDUCTORS AND CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Building wires and cables rated 600 V and less.
2. Connectors, splices, and terminations rated 600 V and less.

1.03 DEFINITIONS

A. VFC: Variable frequency controller.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

PART 2 - PRODUCTS

2.01 CONDUCTORS AND CABLES

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. Alpha Wire.
2. Belden Inc.
3. Encore Wire Corporation.
4. General Cable Technologies Corporation.
5. Southwire Incorporated.

B. Aluminum and Copper Conductors: Comply with NEMA WC 70/ICEA S-95-658.

C. Conductor Insulation: Comply with NEMA WC 70/ICEA S-95-658 for Type THHN-2-THWN-2, Type XHHW-2, and Type SO.

D. Multiconductor Cable: Comply with NEMA WC 70/ICEA S-95-658 for metal-clad cable, Type MC and type SO with ground wire.

2.02 CONNECTORS AND SPLICES

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 Power Systems, Inc.
2. Ideal Industries, Inc.
3. Ilsco; a branch of Bardes Corporation.
4. NSi Industries LLC.
5. O-Z/Gedney; a brand of the EGS Electrical Group.
6. 3M; Electrical Markets Division.

B. Description: Factory-fabricated connectors and splices of size, ampacity rating, material, type, and class for application and service indicated.

2.03 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 NFPA 70.

PART 3 - EXECUTION

3.01 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. Compression pin terminal adapters shall be used at terminations for aluminum conductors.

B. Branch Circuits: Copper. Solid or stranded for No. 10 AWG and smaller; stranded for No. 8 AWG and larger.

3.02 CONDUCTOR INSULATION AND MULTICONDUCTOR CABLE APPLICATIONS AND WIRING METHODS

A. Service Entrance: Type THHN-2-THWN-2, single conductors in raceway.

B. Exposed Feeders: Type THHN-2-THWN-2, single conductors in raceway.

C. Feeders Concealed in Ceilings, Walls, Partitions, and Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.

D. Feeders Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.

E. Exposed Branch Circuits, Including in Crawlspaces: Type THHN-2-THWN-2, single conductors in raceway.

F. Branch Circuits Concealed in Ceilings, Walls, and Partitions:

1. Shall be MC cabling or shall be Type THHN-2-THWN-2 single conductors in raceway. Where infrastructure is exposed in areas without ceilings, MC cabling shall not be used.

G. Branch Circuits Concealed in Concrete, below Slabs-on-Grade, and Underground: Type THHN-2-THWN-2, single conductors in raceway.

H. Cord Drops and Portable Appliance Connections: Type SO, hard service cord with stainless-steel, wire-mesh, strain relief device at terminations to suit application.

I. VFC Output Circuits: Type XHHW-2 in metal conduit.

3.03 INSTALLATION OF CONDUCTORS AND CABLES

A. Conceal cables in finished walls, ceilings, and floors unless otherwise indicated.

B. Complete raceway installation between conductor and cable termination points according to Section 26 05 33 "Raceways and Boxes for Electrical Systems" prior to pulling conductors and cables.

C. 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.

D. Use pulling means, including fish tape, cable, rope, and basket-weave wire/cable grips, that will not damage cables or raceway.

E. Support cables according to Section 26 05 29 "Hangers and Supports for Electrical Systems."

3.04 CONNECTIONS

A. Tighten electrical connectors and terminals according to manufacturer's published torque-tightening values. If manufacturer's torque values are not indicated, use those specified in UL 486A-486B.

B. Make splices, terminations, and taps that are compatible with conductor material and that possess equivalent or better mechanical strength and insulation ratings than unspliced conductors.

C. Wiring at Outlets: Install conductor at each outlet, with at least 6 inches (150 mm) of slack.

3.05 IDENTIFICATION

A. Identify and color-code conductors and cables according to Section 26 05 53 "Identification for Electrical Systems."

B. Identify each spare conductor at each end with identity number and location of other end of conductor, and identify as spare conductor.

3.06 SLEEVE AND SLEEVE-SEAL INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Install sleeves and sleeve seals at penetrations of exterior floor and wall assemblies. Comply with requirements in Section 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

3.07 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly using materials listed for that purpose and installed according to their listing.

3.08 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. After installing conductors and cables and before electrical circuitry has been energized, test service entrance and emergency system feeder conductors for compliance with requirements.
2. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.

B. Test and Inspection Reports: Prepare a written report to record the following:

1. Procedures used.
2. Results that comply with requirements.
3. Results that do not comply with requirements and corrective action taken to achieve compliance with requirements.

C. Cables will be considered defective if they do not pass tests and inspections.

END OF SECTION

SECTION 26 05 23

CONTROL-VOLTAGE ELECTRICAL POWER CABLES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. RS-485 cabling.
2. Low-voltage control cabling.
3. Control-circuit conductors.
4. Identification products.

1.03 DEFINITIONS

A. EMI: Electromagnetic interference.

B. 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.

C. Plenum: A space forming part of the air distribution system to which one or more air ducts are connected. An air duct is a passageway, other than a plenum, for transporting air to or from heating, ventilating, or air-conditioning equipment.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

B. Source quality-control reports.

C. Field quality-control reports.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

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

2.02 PERFORMANCE REQUIREMENTS

A. Flame Travel and Smoke Density in Plenums: As determined by testing identical products according to NFPA 262 by a qualified testing agency. Identify products for installation in plenums with appropriate markings of applicable testing agency.

1. Flame Travel Distance: 60 inches (1520 mm) or less.
2. Peak Optical Smoke Density: 0.5 or less.
3. Average Optical Smoke Density: 0.15 or less.

B. Flame Travel and Smoke Density for Riser Cables in Non-Plenum Building Spaces: As determined by testing identical products according to UL 1666.

C. Flame Travel and Smoke Density for Cables in Non-Riser Applications and Non-Plenum Building Spaces: As determined by testing identical products according to UL 1685.

2.03 RS-485 CABLE

A. Standard Cable: NFPA 70, Type CMR.

1. Paired, two pairs, twisted, No. 22 AWG, stranded (7x30) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

2.04 LOW-VOLTAGE CONTROL CABLE

A. Paired Cable: NFPA 70, Type CMR.

1. Multi-pair, twisted, No. 16 AWG, stranded (19x29) tinned-copper conductors.
2. PVC insulation.
3. Unshielded.
4. PVC jacket.
5. Flame Resistance: Comply with UL 1685.

2.05 CONTROL-CIRCUIT CONDUCTORS

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

1. Encore Wire Corporation.
2. General Cable Technologies Corporation.

3. Southwire Company.

B. Class 1 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

C. Class 2 Control Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway, complying with UL 83.

D. Class 3 Remote-Control and Signal Circuits: Stranded copper, Type THHN-2-THWN-2, in raceway complying with UL 83.

E. Class 2 Control Circuits and Class 3 Remote-Control and Signal Circuits That Supply Critical Circuits: Circuit Integrity (CI) cable.

1. Smoke control signaling and control circuits.

PART 3 - EXECUTION

3.01 INSTALLATION OF RACEWAYS AND BOXES

A. Comply with requirements in Section 26 05 33 "Raceways and Boxes for Electrical Systems" for raceway selection and installation requirements for boxes, conduits, and wireways as supplemented or modified in this Section.

1. 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.

B. Comply with TIA-569-B for pull-box sizing and length of conduit and number of bends between pull points.

C. Install manufactured conduit sweeps and long-radius elbows if possible.

3.02 INSTALLATION OF CONDUCTORS AND CABLES

A. Comply with NECA 1 and NFPA 70.

B. General Requirements for Cabling:

1. Terminate all conductors and optical fibers; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, and cross-connect and patch panels.
2. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems".
5. 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.

6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Do not use heat lamps for heating.
7. Pulling Cable: Comply with BICSI ITSIMM, Ch. 5, "Copper Structured Cabling Systems". Monitor cable pull tensions.

C. Installation of Control-Circuit Conductors:

1. Install wiring in raceways except at cable trays and telecommunications racks. Comply with requirements specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

D. Open-Cable Installation at cable trays and telecommunications racks:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.

E. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA-569-B recommendations for separating unshielded copper voice and data communications cable from potential EMI sources including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 12 inches (305 mm).
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 24 inches (600 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 12 inches (305 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment or Circuit Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment or Circuit Rating between 2 and 5 kVA: A minimum of 3 inches (75 mm).
    c. Electrical Equipment or Circuit Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or 5 HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.03 CONTROL-CIRCUIT CONDUCTORS

A. Minimum Conductor Sizes:

1. Class 1 remote-control and signal circuits; No 14 AWG.
2. Class 2 low-energy, remote-control, and signal circuits; No. 16 AWG.
3. Class 3 low-energy, remote-control, alarm, and signal circuits; No 12 AWG.

3.04 FIRESTOPPING

A. Comply with requirements in Division 07.

3.05 GROUNDING

A. For low-voltage control wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.06 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.07 FIELD QUALITY CONTROL

A. Perform the following 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 direct-current loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not after cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA-568-C.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

B. 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.

C. End-to-end cabling will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

SECTION 26 05 26

GROUNDING AND BONDING FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes methods and materials for grounding systems and equipment.

1.03 SUBMITTALS

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

1.04 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with UL 467 for grounding and bonding materials and equipment.

PART 2 - PRODUCTS

2.01 CONDUCTORS

A. Insulated Conductors: Copper 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: Rectangular bars of annealed copper, 1/4 by 2 inches (6 by 50 mm) in cross section, unless otherwise indicated; with insulators.

2.02 CONNECTORS

A. Listed and labeled by a nationally recognized testing laboratory acceptable to authorities having jurisdiction for applications in which used, and for specific types, sizes, and combinations of conductors and other items connected.

B. Bolted Connectors for Conductors and Pipes: Copper or copper alloy, bolted pressure-type, with at least two bolts.

1. Pipe Connectors: Clamp type, sized for pipe.

C. Welded Connectors: Exothermic-welding kits of types recommended by kit manufacturer for materials being joined and installation conditions.

2.03 GROUNDING ELECTRODES

A. Ground Rods: Copper-clad steel; 3/4 inch by 10 feet (19 mm by 3 m).

PART 3 - EXECUTION

3.01 APPLICATIONS

A. Conductors: Install solid conductor for No. 10 AWG and smaller, and stranded conductors for No. 8 AWG and larger, unless otherwise indicated.

B. Underground Grounding Conductors: Install bare copper conductor, No. 2/0 AWG minimum unless noted otherwise.

1. Bury at least 24 inches (600 mm) below grade.

C. Grounding Bus: Install in electrical and telephone equipment rooms, in rooms housing service equipment, and elsewhere as indicated.

1. Install bus on insulated spacers 1 inch (25 mm), minimum, from wall 6 inches (150 mm) above finished floor, unless otherwise indicated.
2. Where indicated on both sides of doorways, route bus up to top of door frame, across top of doorway, down to specified height above floor, and connect to horizontal bus.

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.

3.02 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 Anti-frost 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. Signal and Communication Equipment: For telephone, alarm, voice and data, and other communication equipment, provide No. 4 AWG minimum insulated grounding conductor in raceway from grounding electrode system to each service location, terminal cabinet, wiring closet, and central equipment location.

1. Service and Central Equipment Locations and Wiring Closets: Terminate grounding conductor on a 1/4-by-2-by-12-inch (6-by-50-by-300-mm) grounding bus.
2. Terminal Cabinets: Terminate grounding conductor on cabinet grounding terminal.

3.03 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.

3.01 GROUNDING SEPARATELY DERIVED SYSTEMS

A. Install grounding electrode(s) at the transformer or other separately derived source location. The electrode shall be connected to the equipment grounding conductor and to the frame of the separately derived source equipment.

3.01 GROUNDING UNDERGROUND DISTRIBUTION SYSTEM COMPONENTS

A. Comply with IEEE C2 grounding requirements.

B. Pad-Mounted Transformers and Switches: Comply with utility company requirements. Install two ground rods and ground ring around the pad. Ground pad-mounted equipment and noncurrent-carrying metal items associated with substations by connecting them to underground cable and grounding electrodes. Install tinned-copper conductor not less than No. 2 AWG for ground ring and for taps to equipment grounding terminals. Bury ground ring not less than 6 inches (150 mm) from the foundation.

3.02 INSTALLATION

A. Grounding Conductors: Route along shortest and straightest paths possible, unless otherwise indicated or required by Code. Avoid obstructing access or placing conductors where they may be subjected to strain, impact, or damage.

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. Use exothermic welds for all below-grade connections.
3. 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 so vibration is not transmitted to rigidly mounted equipment.
3. Use exothermic-welded connectors for outdoor locations, but if a disconnect-type connection is required, use a bolted clamp.

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, using a bolted clamp connector or by bolting a lug-type connector to a pipe flange, using one of the lug bolts of the flange. Where a dielectric main water fitting is installed, connect grounding conductor on street side of fitting. Bond metal grounding conductor conduit or sleeve to conductor at each end.
2. Water Meter Piping: Use braided-type bonding jumpers to electrically bypass water meters. Connect to pipe with a bolted connector.
3. Bond each aboveground portion of gas piping system downstream from equipment shutoff valve.

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): Fabricate according to NFPA 70; use a minimum of 20 feet (6 m) of bare copper conductor not smaller than No. 4 AWG.

1. If concrete foundation is less than 20 feet (6 m) long, coil excess conductor within base of foundation.
2. Bond grounding conductor to reinforcing steel in at least four locations and to anchor bolts. Extend grounding conductor below grade and connect to building's grounding grid or to grounding electrode external to concrete.

I. 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.

J. Connections: Make connections so possibility of galvanic action or electrolysis is minimized. Select connectors, connection hardware, conductors, and connection methods so metals in direct contact are galvanically compatible.

1. Use electroplated or hot-tin-coated materials to ensure high conductivity and to make contact points closer in order of galvanic series.
2. Make connections with clean, bare metal at points of contact.
3. Make aluminum-to-steel connections with stainless-steel separators and mechanical clamps.
4. Make aluminum-to-galvanized-steel connections with tin-plated copper jumpers and mechanical clamps.
5. Coat and seal connections having dissimilar metals with inert material to prevent future penetration of moisture to contact surfaces.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and inspections and prepare test reports:

1. After installing grounding system but before permanent electrical circuits have been energized, test for compliance with requirements.
2. Test completed grounding system at each location where a maximum ground-resistance level is specified. Make tests at ground rods before any conductors are connected.

a. Measure ground resistance not less than two full days after last trace of precipitation and without soil being moistened by any means other than natural drainage or seepage and without chemical treatment or other artificial means of reducing natural ground resistance.
b. Perform tests by fall-of-potential method according to IEEE 81.

3. 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.

B. Report measured ground resistances that exceed the following values:

1. Power and Lighting Equipment or System with Capacity 500 kVA and Less: 10 ohms.
2. Power and Lighting Equipment or System with Capacity 500 to 1000 kVA: 5 ohms.

C. Excessive Ground Resistance: If resistance to ground exceeds specified values, notify Architect promptly and include recommendations to reduce ground resistance.

END OF SECTION

SECTION 26 05 29

HANGERS AND SUPPORTS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:

1. Hangers and supports for electrical equipment and systems.
2. Construction requirements for concrete bases.

1.03 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. IMC: Intermediate metal conduit.

C. RMC: Rigid metal conduit.

1.04 PERFORMANCE REQUIREMENTS

A. Delegated Design: Design supports for multiple raceways, including comprehensive engineering analysis by a qualified professional engineer, using performance requirements and design criteria indicated.

B. Design supports for multiple raceways capable of supporting combined weight of supported systems and its contents.

C. Design equipment supports capable of supporting combined operating weight of supported equipment and connected systems and components.

D. Rated Strength: Adequate in tension, shear, and pullout force to resist maximum loads calculated or imposed for this Project, with a minimum structural safety factor of five times the applied force.

1.05 ACTION SUBMITTALS

A. Product Data: For the following:

1. Steel slotted support systems.

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

1. Trapeze hangers. Include Product Data for components.
2. Steel slotted channel systems. Include Product Data for components.
3. Equipment supports.

1.06 QUALITY ASSURANCE

A. Comply with NFPA 70.

1.07 COORDINATION

A. Coordinate size and location of concrete bases. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified together with concrete Specifications.

B. Coordinate installation of roof curbs, equipment supports, and roof penetrations. These items are specified in Division 07.

PART 2 - PRODUCTS

2.01 SUPPORT, ANCHORAGE, AND ATTACHMENT COMPONENTS

A. Steel Slotted Support Systems: Comply with MFMA-4, factory-fabricated components for field assembly.

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

a. Cooper B-Line, Inc.; a division of Cooper Industries.
b. ERICO International Corporation.
c. Thomas & Betts Corporation.
d. Unistrut; Tyco International, Ltd.

2. Metallic Coatings: Hot-dip galvanized after fabrication and applied according to MFMA-4.
3. Channel Dimensions: Selected for applicable load criteria.

B. Raceway and Cable Supports: As described in NECA 1 and NECA 101.

C. Conduit and Cable Support Devices: Steel and malleable-iron hangers, clamps, and associated fittings, designed for types and sizes of raceway or cable to be supported.

D. Structural Steel for Fabricated Supports and Restraints: ASTM A 36/A 36M, steel plates, shapes, and bars; black and galvanized.

E. Mounting, Anchoring, and Attachment Components: Items for fastening electrical items or their supports to building surfaces include the following:

1. Mechanical-Expansion Anchors: Insert-wedge-type, zinc-coated or stainless steel, for use in hardened portland cement concrete with tension, shear, and pullout capacities appropriate for supported loads and building materials in which used.

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

        1) Cooper B-Line, Inc.; a division of Cooper Industries.
        2) Empire Tool and Manufacturing Co., Inc.
        3) Hilti Inc.
        4) ITW Ramset/Red Head; a division of Illinois Tool Works, Inc.
        5) MKT Fastening, LLC.

2. Concrete Inserts: Steel or malleable-iron, slotted support system units similar to MSS Type 18; complying with MFMA-4 or MSS SP-58.
3. Clamps for Attachment to Steel Structural Elements: MSS SP-58, type suitable for attached structural element.
4. Through Bolts: Structural type, hex head, and high strength. Comply with ASTM A 325.
5. Toggle Bolts: All-steel springhead type.
6. Hanger Rods: Threaded steel.

2.02 FABRICATED METAL EQUIPMENT SUPPORT ASSEMBLIES

A. Description: Welded or bolted, structural-steel shapes, shop or field fabricated to fit dimensions of supported equipment.

B. Materials: Comply with requirements in Division 05 for steel shapes and plates.

PART 3 - EXECUTION

3.01 APPLICATION

A. Comply with NECA 1 and NECA 101 for application of hangers and supports for electrical equipment and systems except if requirements in this Section are stricter.

B. Maximum Support Spacing and Minimum Hanger Rod Size for Raceway: Space supports for EMT, IMC, and RMC as scheduled in NECA 1, where its Table 1 lists maximum spacings less than stated in 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 slottedsupport 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 or single-bolt conduit clamps using spring friction action for retention in support channel.

3.02 SUPPORT INSTALLATION

A. Comply with NECA 1 and NECA 101 for installation requirements except as specified in this Article.

B. Raceway Support Methods: In addition to methods described in NECA 1, EMT, IMC, and RMC may be supported by openings through structure members, as permitted in NFPA 70.

C. Strength of Support Assemblies: Where not indicated, select sizes of components so strength will be adequate to carry present and future static loads within specified loading limits. Minimum static design load used for strength determination shall be weight of supported components plus 200 lb (90 kg).

D. Mounting and Anchorage of Surface-Mounted Equipment and Components: Anchor and fasten electrical items and their supports to building structural elements by the following methods unless otherwise indicated by code:

1. To Wood: Fasten with lag screws or through bolts.
2. To New Concrete: Bolt to concrete inserts.
3. To Masonry: Approved toggle-type bolts on hollow masonry units and expansion anchor fasteners on solid masonry units.
4. To Existing Concrete: Expansion anchor fasteners.
5. To Steel: Beam clamps (MSS Type 19, 21, 23, 25, or 27) complying with MSS SP-69.
6. To Light Steel: Sheet metal screws.
7. Items Mounted on Hollow Walls and Nonstructural Building Surfaces: Mount cabinets, panelboards, disconnect switches, control enclosures, pull and junction boxes, transformers, and other devices on slotted-channel racks attached to substrate by means that meet seismic-restraint strength and anchorage requirements.

E. Drill holes for expansion anchors in concrete at locations and to depths that avoid reinforcing bars.

3.03 INSTALLATION OF FABRICATED METAL SUPPORTS

A. Cut, fit, and place miscellaneous metal supports accurately in location, alignment, and elevation to support and anchor electrical materials and equipment.

3.04 CONCRETE BASES

A. Construct concrete bases of dimensions indicated but not less than 4 inches (100 mm) larger in both directions than supported unit, and so anchors will be a minimum of 10 bolt diameters from edge of the base.

B. Use 3000-psi (20.7-MPa), 28-day compressive-strength concrete.

C. Anchor equipment to concrete base.

1. Place and secure anchorage devices. Use supported equipment manufacturer's setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
2. Install anchor bolts to elevations required for proper attachment to supported equipment.
3. Install anchor bolts according to anchor-bolt manufacturer's written instructions.

3.05 PAINTING

A. Touchup: Clean field welds and abraded areas of shop paint. Paint exposed areas immediately after erecting hangers and supports. Use same materials as used for shop painting. Comply with SSPC-PA 1 requirements for touching up field-painted surfaces.

1. Apply paint by brush or spray to provide minimum dry film thickness of 2.0 mils (0.05 mm).

B. Galvanized Surfaces: Clean welds, bolted connections, and abraded areas and apply galvanizing-repair paint to comply with ASTM A 780.

END OF SECTION

SECTION 26 05 33

RACEWAY AND BOXES FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes raceways, fittings, boxes, enclosures, and cabinets for electrical wiring.

B. Related Sections include the following:

1. Division 26 Section "Underground Ducts and Raceways for Electrical Systems" for exterior ductbanks, manholes, and underground utility construction.

1.03 DEFINITIONS

A. EMT: Electrical metallic tubing.

B. ENT: Electrical nonmetallic tubing.

C. EPDM: Ethylene-propylene-diene terpolymer rubber.

D. FMC: Flexible metal conduit.

E. IMC: Intermediate metal conduit.

F. LFMC: Liquidtight flexible metal conduit.

G. NBR: Acrylonitrile-butadiene rubber.

H. RNC: Rigid nonmetallic conduit.

1.04 SUBMITTALS

A. Product Data: For surface raceways, wireways and fittings, floor boxes, hinged-cover enclosures, and cabinets.

B. Shop Drawings: For the following raceway components. Include plans, elevations, sections, details, and attachments to other work.

1. Custom enclosures and cabinets.
2. For handholes and boxes for underground wiring, including the following:

a. Duct entry provisions, including locations and duct sizes.
b. Frame and cover design.
c. Grounding details.
d. Dimensioned locations of cable rack inserts, and pulling-in and lifting irons.
e. Joint details.

C. Manufacturer Seismic Qualification Certification: Submit certification that enclosures and cabinets and their mounting provisions, including those for internal components, will withstand seismic forces defined in Division 26 Section "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. The term "withstand" means "the cabinet or enclosure will remain in place without separation of any parts when subjected to the seismic forces specified and the unit will retain its enclosure characteristics, including its interior accessibility, after the seismic event."

1.05 QUALITY ASSURANCE

A. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

B. Comply with NFPA 70.

PART 2 - PRODUCTS

2.01 METAL CONDUIT AND TUBING

A. 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. AFC Cable Systems, Inc.
2. Alflex Inc.
3. Allied Tube & Conduit; a Tyco International Ltd. Co.
4. O-Z Gedney; a unit of General Signal.
5. Wheatland Tube Company.

B. Rigid Steel Conduit: ANSI C80.1.

C. Aluminum Rigid Conduit: ANSI C80.5.

D. IMC: ANSI C80.6.

E. PVC-Coated Steel Conduit: PVC-coated rigid steel conduit

1. Comply with NEMA RN 1.
2. Coating Thickness: 0.040 inch (1 mm), minimum.

F. EMT: ANSI C80.3.

G. FMC: Zinc-coated steel.

H. LFMC: Flexible steel conduit with PVC jacket.

I. Fittings for Conduit (Including all Types and Flexible and Liquidtight), EMT, and Cable: NEMA FB 1; listed for type and size raceway with which used, and for application and environment in which installed.

1. Conduit Fittings for Hazardous (Classified) Locations: Comply with UL 886.
2. Fittings for EMT: Steel set-screw type.
3. Coating for Fittings for PVC-Coated Conduit: Minimum thickness, 0.040 inch (1 mm), with overlapping sleeves protecting threaded joints.

J. Joint Compound for Rigid Steel Conduit or IMC: Listed for use in cable connector assemblies, and compounded for use to lubricate and protect threaded raceway joints from corrosion and enhance their conductivity.

2.02 NONMETALLIC CONDUIT AND TUBING

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. AFC Cable Systems, Inc.
2. Anamet Electrical, Inc.; Anaconda Metal Hose.
3. Arnco Corporation.
4. CANTEX Inc.
5. Carlon Electrical Products.
6. RACO; a Hubbell Company.
7. Thomas & Betts Corporation.

B. RNC: NEMA TC 2, Type EPC-40-PVC, unless otherwise indicated.

C. Fittings and RNC: NEMA TC 3; match to conduit or tubing type and material.

2.03 OPTICAL FIBER/COMMUNICATIONS CABLE RACEWAY AND FITTINGS

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

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

1. Arnco Corporation.
2. Endot Industries Inc.
3. IPEX Inc.
4. Lamson & Sessions; Carlon Electrical Products.

C. Description: Comply with UL 2024; flexible type, approved for plenum installation.

2.04 METAL WIREWAYS

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. Cooper B-Line, Inc.
2. Hoffman.
3. Square D; Schneider Electric.

B. Description: Sheet metal sized and shaped as indicated, NEMA 250, Type 1, unless otherwise indicated.

C. Fittings and Accessories: Include couplings, offsets, elbows, expansion joints, adapters, hold-down straps, end caps, and other fittings to match and mate with wireways as required for complete system.

D. Wireway Covers: Hinged type.

E. Finish: Manufacturer's standard enamel finish.

2.05 SURFACE RACEWAYS

A. Surface Metal Raceways: Galvanized steel with snap-on covers.

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

a. Thomas & Betts Corporation.
b. Walker Systems, Inc.; Wiremold Company (The).
c. Wiremold Company (The); Electrical Sales Division.

2. Shall only be used where specifically indicated on drawings.

2.06 BOXES, ENCLOSURES, AND CABINETS

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

1. Cooper Crouse-Hinds; Div. of Cooper Industries, Inc.
2. EGS/Appleton Electric.
3. Erickson Electrical Equipment Company.
4. Hoffman.
5. Hubbell Incorporated; Killark Electric Manufacturing Co. Division.
6. O-Z/Gedney; a unit of General Signal.
7. RACO; a Hubbell Company.
8. Thomas & Betts Corporation.
9. Walker Systems, Inc.; Wiremold Company (The).

B. Sheet Metal Outlet and Device Boxes: NEMA OS 1.

C. Cast-Metal Outlet and Device Boxes: NEMA FB 1, ferrous alloy, Type FD, with gasketed cover.

D. Nonmetallic Outlet and Device Boxes: NEMA OS 2.

E. Metal Floor Boxes: Cast metal, rectangular. Basis of Design is FSR, Inc. FL-500P series.

1. Provide with pour pan for grade-level application where required.
2. Provide with cover and trim as applicable to finished flooring.
3. Trim and cover color as selected by Architect from manufacturers standard.
4. Provide complete with all components required to create configurations indicated or scheduled on the drawings. Where empty floor boxes are indicated, provide blank internal device plates.

F. Small Sheet Metal Pull and Junction Boxes: NEMA OS 1.

G. Cast-Metal Access, Pull, and Junction Boxes: NEMA FB 1, cast aluminum with gasketed cover.

H. Hinged-Cover Enclosures: NEMA 250, Type 1, with continuous-hinge cover with flush latch, unless otherwise indicated.

1. Metal Enclosures: Steel, finished inside and out with manufacturer's standard enamel.
2. Nonmetallic Enclosures: Plastic finished inside with radio-frequency-resistant paint.

I. Cabinets:

1. NEMA 250, Type 1, galvanized-steel box with removable interior panel and removable front, finished inside and out with manufacturer's standard enamel.
2. Hinged door in front cover with flush latch and concealed hinge.
3. Key latch to match panelboards.
4. Metal barriers to separate wiring of different systems and voltage.
5. Accessory feet where required for freestanding equipment.

2.07 SLEEVES FOR RACEWAYS

A. Steel Pipe Sleeves: ASTM A 53/A 53M, Type E, Grade B, Schedule 40, galvanized steel, plain ends.

B. Cast-Iron Pipe Sleeves: Cast or fabricated "wall pipe," equivalent to ductile-iron pressure pipe, with plain ends and integral waterstop, unless otherwise indicated.

C. Sleeves for Rectangular Openings: Galvanized sheet steel with minimum 0.052- or 0.138-inch (1.3- or 3.5-mm) thickness as indicated and of length to suit application.

D. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07 Section "Penetration Firestopping."

PART 3 - EXECUTION

3.01 RACEWAY APPLICATION

A. Outdoors: Apply raceway products as specified below, unless otherwise indicated:

1. Exposed Conduit: Rigid steel conduit.
2. Concealed Conduit, Aboveground: Rigid steel conduit.
3. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): LFMC

4. Boxes and Enclosures, Aboveground: NEMA 250, Type 3R
5. Conduits installed under concrete slabs: RNC with rigid steel elbows for bends greater and 10 degrees. Use Schedule 80 RNC for emergency system wiring that is not encased in concrete.

B. Comply with the following indoor applications, unless otherwise indicated:

1. Exposed, Not Subject to Physical Damage: EMT.
2. Exposed, Not Subject to Severe Physical Damage: EMT.
3. Exposed and Subject to Severe Physical Damage: Rigid steel conduit. Includes raceways in the following locations:

   a. Vehicle storage, service and traffic areas.

4. Concealed in Ceilings and Interior Walls and Partitions: EMT.
5. Connection to Vibrating Equipment (Including Transformers and Hydraulic, Pneumatic, Electric Solenoid, or Motor-Driven Equipment): FMC, except use LFMC in damp or wet locations.
6. Damp or Wet Locations: Rigid steel conduit
7. Raceways for Optical Fiber or Communications Cable Risers in Vertical Shafts: EMT.
8. Boxes and Enclosures: NEMA 250, Type 1, except use NEMA 250, Type 4, in damp or wet locations.

C. Minimum Raceway Size: ¾ inch trade size.

D. Raceway Fittings: Compatible with raceways and suitable for use and location.

1. Rigid and Intermediate Steel Conduit: Use threaded rigid steel conduit fittings, unless otherwise indicated.
2. PVC Externally Coated, Rigid Steel Conduits: Use only fittings listed for use with that material. Patch and seal all joints, nicks, and scrapes in PVC coating after installing conduits and fittings. Use sealant recommended by fitting manufacturer.

E. Install nonferrous conduit or tubing for circuits operating above 60 Hz. Where aluminum raceways are installed for such circuits and pass through concrete, install in nonmetallic sleeve.

F. Do not install aluminum conduits in contact with concrete.

3.02 INSTALLATION

A. Comply with NECA 1 for installation requirements applicable to products specified in Part 2 except where requirements on Drawings or in this Article are stricter.

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. Support raceways as specified in Division 26 Section "Hangers and Supports for Electrical Systems."

E. Arrange stub-ups so curved portions of bends are not visible above the finished slab.

F. Install no more than the equivalent of three 90-degree bends in any conduit run except for communications conduits, for which fewer bends are allowed.

G. Conceal conduit and EMT within finished walls, ceilings, and floors, unless otherwise indicated.

H. Raceways Embedded in Slabs:

1. Run conduit larger than 1-inch (27-mm) trade size, parallel or at right angles to main reinforcement. Where at right angles to reinforcement, place conduit close to slab support.
2. Arrange raceways to cross building expansion joints at right angles with expansion fittings.
3. Change from RNC to rigid steel conduit, or IMC before rising above the floor.

I. 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.

J. Raceway Terminations at Locations Subject to Moisture or Vibration: Use insulating bushings to protect conductors, including conductors smaller than No. 4 AWG.

K. 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.

L. Raceways for Optical Fiber and Communications Cable: Install raceways, metallic and nonmetallic, rigid and flexible, as follows:

1. 3/4-Inch (19-mm) Trade Size and Smaller: Install raceways in maximum lengths of 50 feet (15 m).
2. 1-Inch (25-mm) Trade Size and Larger: Install raceways in maximum lengths of 75 feet (23 m).
3. Install with a maximum of two 90-degree bends or equivalent for each length of raceway unless Drawings show stricter requirements. Separate lengths with pull or junction boxes or terminations at distribution frames or cabinets where necessary to comply with these requirements.

M. Install raceway sealing fittings at suitable, approved, and accessible locations and fill them with listed sealing compound. For concealed raceways, install each fitting in a flush steel box with a blank cover plate having a finish similar to that of adjacent plates or surfaces. Install raceway sealing fittings at the following points:

1. Where conduits pass from warm to cold locations, such as boundaries of refrigerated spaces.
2. Where otherwise required by NFPA 70.

N. Expansion-Joint Fittings for RNC: Install in each run of aboveground conduit 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).

1. Install expansion-joint fittings for each of the following locations, and provide type and quantity of fittings that accommodate temperature change listed for location:

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 the Outdoors without Physical Separation: **125 deg F (70 deg C)** temperature change.

2. 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.
3. Install each expansion-joint fitting with position, mounting, and piston setting selected according to manufacturer's written instructions for conditions at specific location at the time of installation.

O. Recessed Boxes in Masonry Walls: Saw-cut opening for box in center of cell of masonry block, and install box flush with surface of wall.

P. Set metal floor boxes level and flush with finished floor surface.

3.03 SLEEVE INSTALLATION FOR ELECTRICAL PENETRATIONS

A. Coordinate sleeve selection and application with selection and application of firestopping specified in Division 07.

B. Concrete Slabs and Walls: Install sleeves for penetrations unless core-drilled holes or formed openings are used. Install sleeves during erection of slabs and walls.

C. Use pipe sleeves unless penetration arrangement requires rectangular sleeved opening.

D. Rectangular Sleeve Minimum Metal Thickness:

1. For sleeve cross-section rectangle perimeter less than 50 inches (1270 mm) and no side greater than 16 inches (400 mm), thickness shall be 0.052 inch (1.3 mm).
2. For sleeve cross-section rectangle perimeter equal to, or greater than, 50 inches (1270 mm) and 1 or more sides equal to, or greater than, 16 inches (400 mm), thickness shall be 0.138 inch (3.5 mm).

E. Fire-Rated Assemblies: Install sleeves for penetrations of fire-rated floor and wall assemblies unless openings compatible with firestop system used are fabricated during construction of floor or wall.

F. Cut sleeves to length for mounting flush with both surfaces of walls.

G. Extend sleeves installed in floors 6 inches (50 mm) above finished floor level unless noted otherwise.

H. Size pipe sleeves to provide 1/4-inch (6.4-mm) annular clear space between sleeve and raceway unless sleeve seal is to be installed.

I. Seal space outside of sleeves with grout for penetrations of concrete and masonry.

J. Interior Penetrations of Non-Fire-Rated Walls and Floors: Seal annular space between sleeve and raceway, using joint sealant appropriate for size, depth, and location of joint. Refer to Division 07 Section "Joint Sealants" for materials and installation.

K. Fire-Rated-Assembly Penetrations: Maintain indicated fire rating of walls, partitions, ceilings, and floors at raceway penetrations. Install sleeves and seal with firestop materials. Comply with Division 07 Section "Penetration Firestopping."

L. Roof-Penetration Sleeves: Seal penetration of individual raceways with flexible, boot-type flashing units applied in coordination with roofing work.

M. Aboveground, Exterior-Wall Penetrations: Seal penetrations using sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

N. Underground, Exterior-Wall Penetrations: Install cast-iron "wall pipes" for sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway and sleeve for installing mechanical sleeve seals.

3.04 SLEEVE-SEAL INSTALLATION

A. Install to seal underground, exterior wall penetrations.

B. Use type and number of sealing elements recommended by manufacturer for raceway material and size. Position raceway in center of sleeve. Assemble mechanical sleeve seals and install in annular space between raceway and sleeve. Tighten bolts against pressure plates that cause sealing elements to expand and make watertight seal.

3.05 FIRESTOPPING

A. Apply firestopping to electrical penetrations of fire-rated floor and wall assemblies to restore original fire-resistance rating of assembly. Firestopping materials and installation requirements are specified in Division 07 Section "Penetration Firestopping."

3.06 PROTECTION

A. Provide final protection and maintain conditions that ensure coatings, finishes, and cabinets are without damage or deterioration at time of Substantial Completion.

1. Repair damage to galvanized finishes with zinc-rich paint recommended by manufacturer.
2. Repair damage to PVC or paint finishes with matching touchup coating recommended by manufacturer.

END OF SECTION

SECTION 26 05 43

UNDERGROUND DUCTS AND RACEWAYS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:

1. Conduit, ducts, and duct accessories for direct-buried and concrete-encased duct banks, and in single duct runs.
2. Handholes and boxes.
3. Manholes.

1.03 DEFINITION

A. RNC: Rigid nonmetallic conduit.

1.04 ACTION SUBMITTALS

A. Product Data: For the following:

1. Duct-bank materials, including separators and miscellaneous components.
2. Ducts and conduits and their accessories, including elbows, end bells, bends, fittings, and solvent cement.
3. Accessories for manholes, handholes, boxes.
4. Warning tape.

B. Shop Drawings for Precast or Factory-Fabricated Underground Utility Structures: Include plans, elevations, sections, details, attachments to other work, and accessories, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Reinforcement details.
3. Frame and cover design and manhole frame support rings.
4. Ladder details.
5. Grounding details.
6. Dimensioned locations of cable rack inserts, pulling-in and lifting irons, and sumps.
7. Joint details.

C. Shop Drawings for Factory-Fabricated Handholes and Boxes Other Than Precast Concrete: Include dimensioned plans, sections, and elevations, and fabrication and installation details, including the following:

1. Duct entry provisions, including locations and duct sizes.
2. Cover design.
3. Grounding details.

1.05 INFORMATIONAL SUBMITTALS

A. Duct-Bank Coordination Drawings: Show duct profiles and coordination with other utilities and underground structures.

1. Include plans and sections, drawn to scale, and show bends and locations of expansion fittings.
2. Drawings shall be signed and sealed by a qualified professional engineer.

B. Product Certificates: For concrete and steel used in precast concrete manholes and handholes, as required by ASTM C 858.

C. Qualification Data: For professional engineer and testing agency.

D. Source quality-control test reports.

E. Field quality-control test reports.

1.06 QUALITY ASSURANCE

A. Testing Agency Qualifications: Qualified according to ASTM E 329 for testing indicated.

B. Comply with ANSI C2.

C. Comply with NFPA 70.

1.07 DELIVERY, STORAGE, AND HANDLING

A. Deliver ducts to Project site with ends capped. Store nonmetallic ducts with supports to prevent bending, warping, and deforming.

B. Store precast concrete and other factory-fabricated underground utility structures at Project site as recommended by manufacturer to prevent physical damage. Arrange so identification markings are visible.

C. Lift and support precast concrete units only at designated lifting or supporting points.

1.08 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.

1.09 COORDINATION

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.

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 from those indicated as required to suit field conditions and to ensure that duct runs drain to manholes and handholes, and as approved by Architect.

PART 2 - PRODUCTS

2.01 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 by same manufacturer as the conduit, complying with NEMA TC 3 and UL 514B.

2.02 PRECAST CONCRETE HANDHOLES AND BOXES

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. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.

B. Comply with ASTM C 858 for design and manufacturing processes.

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 open bottom, unless otherwise indicated.
5. Extensions: Designed to mate with bottom of enclosure. Same material as enclosure.

    a. Extension shall provide increased depth of 12 inches (300 mm).

6. 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.

2.03 HANDHOLES AND BOXES OTHER THAN PRECAST CONCRETE

A. Description: Comply with SCTE 77.

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.
6. Handholes 12 inches wide by 24 inches long (300 mm wide by 600 mm long) and larger shall have factory-installed inserts for cable racks and pulling-in irons.

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

a. Armorcast Products Company.
b. Carson Industries LLC.
c. CDR Systems Corporation.
d. NewBasis.

2.04 PRECAST MANHOLES

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. Carder Concrete Products.
2. Christy Concrete Products.
3. Elmhurst-Chicago Stone Co.
4. Oldcastle Precast Group.
5. Riverton Concrete Products; a division of Cretex Companies, Inc.
6. Utility Concrete Products, LLC.
7. Utility Vault Co.
8. Wausau Tile, Inc.

B. Comply with ASTM C 858, with structural design loading as specified in Part 3 "Underground Enclosure Application" Article and with interlocking mating sections, complete with accessories, hardware, and features.

1. 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 roofs of manholes, 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. 4 steel reinforcing bars in concrete around each opening.

C. Concrete Knockout Panels: 1-1/2 to 2 inches (38 to 50 mm) thick, for future conduit entrance and sleeve for ground rod.

D. 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.

2.05 UTILITY STRUCTURE ACCESSORIES

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. Bilco Company (The).
2. Campbell Foundry Company.
3. McKinley Iron Works, Inc.
4. NewBasis.
5. Oldcastle Precast Group.
6. Riverton Concrete Products; a division of Cretex Companies, Inc..
7. Strongwell Corporation; Lenoir City Division.
8. Underground Devices, Inc.
9. Utility Concrete Products, LLC.

B. 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, 26 inches (660 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.
c. Legend: "SIGNAL" for communications, data, and telephone duct systems.

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.

C. Manhole Sump Frame and Grate: ASTM A 48/A 48M, Class 30B, gray cast iron.

D. 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.

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 (32 mm) minimum at base.

1. Tested Ultimate Pullout Strength: 12,000 lbf (53 kN) minimum.

G. 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.

H. Cable Rack Assembly: Steel, hot-dip galvanized, except insulators.

1. Stanchions: T-section or channel; 2-1/4-inch (57-mm) nominal size; punched with 14 holes on 1-1/2-inch (38-mm) centers for cable-arm attachment.
2. Arms: 1-1/2 inches (38 mm) wide, lengths ranging from 3 inches (75 mm) with 450-lb (204-kg) minimum capacity to 18 inches (460 mm) with 250-lb (114-kg) minimum capacity. Arms shall have slots along full length for cable ties and be arranged for secure mounting in horizontal position at any vertical location on stanchions.
3. Insulators: High-glaze, wet-process porcelain arranged for mounting on cable arms.

I. Duct-Sealing Compound: Non hardening, 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.

J. Fixed Manhole Ladders: Arranged for attachment to wall of manhole. Ladder and mounting brackets and braces shall be fabricated from hot-dip galvanized steel.

K. Cover Hooks: Heavy duty, designed for lifts 60 lbf (270 N) and greater. Two required.

2.06 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 manholes and boxes for compliance with SCTE 77. Strength tests shall be for specified tier ratings of products supplied.

1. Tests of materials shall be performed by a independent testing agency.
2. Strength tests of complete boxes and covers shall be by either an independent testing agency or the manufacturer. A qualified registered professional engineer shall certify tests by manufacturer.

3. Testing machine pressure gages shall have current calibration certification complying with ISO 9000 and ISO 10012, and traceable to NIST standards.

PART 3 - EXECUTION

3.01 GENERAL

A. Comply with utility company specifications and requirements for ducts, raceways, and enclosures for use by utility companies.

3.02 UNDERGROUND DUCT APPLICATION

A. Ducts for Electrical Cables Over 600 V: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

B. Ducts for Electrical Feeders 600 V and Less: RNC, NEMA Type EPC-40-PVC for normal feeders and EPC-80-PVC for emergency feeders, in direct-buried duct bank where not under paved driveways or roadways, unless otherwise indicated. Duct banks shall be concrete encased where installed under paved driveways or roadways.

C. Ducts for Electrical Branch Circuits: RNC, NEMA Type EPC-40-PVC, in direct-buried duct bank, unless otherwise indicated. Emergency system conduits shall be Type EPC-80-PVC.

D. Underground Ducts for Telephone, Communications, or Data Utility Service Cables: RNC, NEMA Type EPC-40-PVC, in concrete-encased duct bank, unless otherwise indicated.

E. Underground Ducts Crossing Paved Paths, Walks, Driveways, and Roadways: RNC, NEMA Type EPC-40-PVC, encased in reinforced concrete.

3.03 UNDERGROUND ENCLOSURE APPLICATION

A. Handholes and Boxes for 600 V and Less, Including Telephone, Communications, and Data Wiring:

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: Precast concrete, AASHTO HB 17, H-20 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.

B. Manholes: Precast or cast-in-place 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.

3.04 EARTHWORK

A. Excavation and Backfill: Provided by Division 31 in accordance with Division 31 requirements, but do not use heavy-duty, hydraulic-operated, compaction equipment.

B. Restore surface features at areas disturbed by excavation and reestablish 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.

3.05 DUCT INSTALLATION

A. 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.

B. Curves and Bends: Use 5-degree angle couplings for small changes in direction. Use manufactured long sweep rigid steel bends with a minimum radius of 48 inches (1220 mm), both horizontally and vertically, at other locations, unless otherwise indicated.

C. 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.

D. 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.
3. Grout end bells into structure walls from both sides to provide watertight entrances.

E. 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 26 05 44 "Sleeves and Sleeve Seals for Electrical Raceways and Cabling."

F. 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.

G. Pulling Cord: Install 100-lbf- (445-N-) test nylon cord in ducts, including spares.

H. Concrete-Encased Ducts: Support ducts on duct separators.

1. Separator Installation: Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 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.
2. 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.
    b. If more than one pour is necessary, terminate each pour in a vertical plane and install 3/4-inch (19-mm) reinforcing rod dowels extending 18 inches (450 mm) into concrete on both sides of joint near corners of envelope.

3. Pouring Concrete: Spade concrete carefully during pours to prevent voids under and between conduits and at exterior surface of envelope. Do not allow a heavy mass of concrete to fall directly onto ducts. Use a plank to direct concrete down sides of bank assembly to trench bottom. Allow concrete to flow to center of bank and rise up in middle, uniformly filling all open spaces. Do not use power-driven agitating equipment unless specifically designed for duct-bank application.
4. 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.
5. 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.
6. Depth: Install top of duct bank at least 24 inches (600 mm) below finished grade in areas not subject to deliberate traffic, and at least 30 inches (750 mm) below finished grade in deliberate traffic paths for vehicles, unless otherwise indicated.
7. Stub-Ups: Use manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    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 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.

8. Warning Tape: Bury warning tape approximately 12 inches (300 mm) above all concrete-encased ducts and duct banks. Align tape parallel to and within 3 inches (75 mm) of the centerline of duct bank. Provide an additional warning tape for each 12-inch (300-mm) increment of duct-bank width over a nominal 18 inches (450 mm). Space additional tapes 12 inches (300 mm) apart, horizontally.

I. Direct-Buried Duct Banks:

1. Support ducts on duct separators coordinated with duct size, duct spacing, and outdoor temperature.
2. Space separators close enough to prevent sagging and deforming of ducts, with not less than 5 spacers per 20 feet (6 m) of duct. Secure separators to earth and to ducts to prevent displacement during backfill and yet permit linear duct movement due to

expansion and contraction as temperature changes. Stagger spacers approximately 6 inches (150 mm) between tiers.

3. 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.
4. Install backfill as specified in Division 31.
5. After installing first tier of ducts, backfill and compact. Start at tie-in point and work toward end of duct run, leaving ducts at end of run free to move with expansion and contraction as temperature changes during this process. Repeat procedure after placing each tier. After placing last tier, hand-place backfill to 4 inches (100 mm) over ducts and hand tamp. Firmly tamp backfill around ducts to provide maximum supporting strength. Use hand tamper only. After placing controlled backfill over final tier, make final duct connections at end of run and complete backfilling with normal compaction as specified in Division 31.
6. Depth: Install top of duct bank at least 36 inches (900 mm) below finished grade, unless otherwise indicated.
7. Set elevation of bottom of duct bank below the frost line.
8. Install manufactured rigid steel conduit elbows for stub-ups at poles and equipment and at building entrances through the floor.

    a. Couple steel conduits to ducts with adapters designed for this purpose, and encase coupling with 3 inches (75 mm) of concrete.
    b. For equipment mounted on outdoor concrete bases, extend steel conduit horizontally a minimum of 60 inches (1500 mm) from edge of equipment pad or foundation. Install insulated grounding bushings on terminations at equipment.

3.06 INSTALLATION OF CONCRETE MANHOLES, HANDHOLES, AND BOXES

A. Cast-in-Place Manhole Installation:

1. Finish interior surfaces with a smooth-troweled finish.
2. Windows for Future Duct Connections: Form and pour concrete knockout panels 1-1/2 to 2 inches (38 to 50 mm) thick, arranged as indicated.
3. Cast-in-place concrete, formwork, and reinforcement are specified in Division 03.

B. 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.

C. Elevations:

1. Manhole Roof: Install with rooftop at least 15 inches (380 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 the 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.

D. Drainage: Install drains in bottom of manholes where indicated. Coordinate with drainage provisions indicated.

E. Manhole Access: Circular opening in manhole roof; sized to match cover size.

1. Manholes with Fixed Ladders: Offset access opening from manhole centerlines to align with ladder.
2. Install chimney, constructed of precast concrete collars and rings to support frame and cover and to connect cover with manhole roof opening. Provide moisture-tight masonry joints and waterproof grouting for cast-iron frame to chimney.

F. Waterproofing: Apply waterproofing to exterior surfaces of manholes 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.

G. Hardware: 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.

H. Fixed Manhole Ladders: Arrange to provide for safe entry with maximum clearance from cables and other items in manholes.

I. Field-Installed Bolting Anchors in Manholes and Concrete Handholes: Do not drill deeper than 3-7/8 inches (98 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.

J. Warning Sign: Install "Confined Space Hazard" warning sign on the inside surface of each manhole cover.

3.07 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 the manufacturer.

B. Unless otherwise indicated, support units on a level bed of crushed stone or gravel, graded from 1/2-inch (12.7-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 so cover surface will be flush with finished grade. Set covers of other handholes 1 inch (25 mm) above finished grade.

D. Install handholes and boxes with bottom below the frost line, below grade.

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 the 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, form and pour a concrete ring encircling, and in contact with, enclosure and with top surface screeded to top of box cover frame. Bottom of ring shall rest on compacted earth.

1. Concrete: 3000 psi (20 kPa), 28-day strength, complying with Division 03, with a troweled finish.
2. Dimensions: 10 inches wide by 12 inches deep (250 mm wide by 300 mm deep).

3.08 GROUNDING

A. Ground underground ducts and utility structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.09 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 aluminum or wood test mandrel through duct to prove joint integrity and test for out-of-round duct. Provide mandrel equal to 80 percent fill of duct. If obstructions are indicated, remove obstructions and retest.
3. Test manhole grounding to ensure electrical continuity of grounding and bonding connections. Measure and report ground resistance as specified in Section 26 05 26 "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

SECTION 26 05 44

SLEEVES AND SLEEVE SEALS FOR ELECTRICAL RACEWAYS AND CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Sleeves for cable penetration of non-fire-rated construction walls and floors.
2. Sleeve-seal systems.
3. Sleeve-seal fittings.
4. Grout.
5. Silicone sealants.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

PART 2 - PRODUCTS

2.01 SLEEVES

A. Wall Sleeves:

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

B. 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).

2.02 SLEEVE-SEAL SYSTEMS

A. Description: Modular sealing device, designed for field assembly, to fill annular space between sleeve and raceway or cable.

1. Manufacturers: Subject to compliance with requirements, available manufacturers offering products that may be incorporated into the Work include, but are not limited to, the following:

a. Advance Products & Systems, Inc.
b. CALPICO, Inc.
c. Metraflex 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 or Stainless steel of length required to secure pressure plates to sealing elements.

2.03 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.

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. Presealed Systems.

2.04 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.

2.05 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.

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

3.01 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 Cables 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 cable, using joint sealant appropriate for size, depth, and location of joint. Comply with requirements in Division 07.
   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 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 Cables 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. Aboveground, Exterior-Wall Penetrations: Seal penetrations using steel or cast-iron pipe sleeves and mechanical sleeve seals. Select sleeve size to allow for 1-inch (25-mm) annular clear space between pipe and sleeve for installing mechanical sleeve seals.

F. Underground, Exterior-Wall and Floor Penetrations: Install cast-iron pipe sleeves. Size sleeves to allow for 1-inch (25-mm) annular clear space between raceway or cable and sleeve for installing sleeve-seal system.

3.02 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.

3.03 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

SECTION 26 05 48

VIBRATION AND SEISMIC CONTROLS FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following:

1. 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 26 05 29 "Hangers and Supports for Electrical Systems" for commonly used electrical supports and installation requirements.

1.03 DEFINITIONS

A. The IBC: International Building Code.

B. ICC-ES: ICC-Evaluation Service.

1.04 PERFORMANCE REQUIREMENTS

A. Seismic restraints shall be designed in accordance with seismic force levels as shown on the structural plans.

B. Importance Factor (Ip): 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 Ip= 1.5:

1. Fire alarm system
2. Generator and emergency power distribution system.

1.05 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).

1.06 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.

1.07 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

2.01 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.

2.02 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.

2.03 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

3.01 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.

3.02 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: Sselect sizes of components so strength will be adequate to carry present and future static and seismic loads within specified loading limits.

3.03 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.

3.04 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.

3.05 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.

3.06 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

SECTION 26 05 53

IDENTIFICATION FOR ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Identification for conductors.
2. Underground-line warning tape.
3. Warning labels and signs.
4. Equipment identification labels.
5. Miscellaneous identification products.

1.03 ACTION SUBMITTALS

A. Product Data: For each electrical identification product indicated.

1.04 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.

1.05 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

2.01 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, Self-Laminating Polyester Labels: Preprinted, 3-mil- (0.08-mm-) thick flexible label with acrylic pressure-sensitive adhesive that provides a clear, weather- and chemical-resistant, self-laminating, protective shield over the legend. Labels sized to fit the conductor diameter such that the clear shield overlaps the entire printed legend.

C. Snap-Around Labels: Slit, pretensioned, flexible, preprinted, color-coded acrylic sleeve, with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.

D. Snap-Around, Color-Coding Bands: Slit, pretensioned, flexible, solid-colored acrylic sleeve with diameter sized to suit diameter of conductor it identifies and to stay in place by gripping action.

E. Marker Tapes: Vinyl or vinyl-cloth, self-adhesive wraparound type, with circuit identification legend machine printed by thermal transfer or equivalent process.

F. Write-On Tags: Polyester tag, 0.015 inch (0.38 mm) thick, with corrosion-resistant grommet and cable tie for attachment to conductor or cable.

1. Labels for Tags: Self-adhesive label, machine-printed with permanent, waterproof, black ink recommended by printer manufacturer, sized for attachment to tag.

2.02 UNDERGROUND-LINE WARNING TAPE

A. Tape:

1. Recommended by manufacturer for the method of installation and suitable to identify and locate underground electrical and communications utility lines.
2. Printing on tape shall be permanent and shall not be damaged by burial operations.
3. Tape material and ink shall be chemically inert, and not subject to degrading when exposed to acids, alkalis, and other destructive substances commonly found in soils.
4. Pigmented polyolefin, bright-colored, continuous-printed on one side with the inscription of the utility, compounded for direct-burial service.
5. Thickness: 4 mils (0.1 mm).
6. Weight: 18.5 lb/1000 sq. ft. (9.0 kg/100 sq. m).
7. 3-Inch (75-mm) Tensile According to ASTM D 882: 30 lbf (133.4 N), and 2500 psi (17.2 MPa).

B. Color and Printing:

1. Comply with ANSI Z535.1 through ANSI Z535.5.
2. Inscriptions for Red-Colored Tapes: ELECTRIC LINE, HIGH VOLTAGE,.

3. Inscriptions for Orange-Colored Tapes: TELEPHONE CABLE, CATV CABLE, COMMUNICATIONS CABLE, OPTICAL FIBER CABLE,.

2.03 WARNING LABELS AND SIGNS

A. Comply with NFPA 70 and 29 CFR 1910.145.

B. Self-Adhesive Warning Labels: Factory-printed, multicolor, pressure-sensitive adhesive labels, configured for display on front cover, door, or other access to equipment unless otherwise indicated.

C. Baked-Enamel Warning Signs:

1. Preprinted aluminum signs, punched or drilled for fasteners, with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 7 by 10 inches (180 by 250 mm).

D. Metal-Backed, Butyrate Warning Signs:

1. Weather-resistant, nonfading, preprinted, cellulose-acetate butyrate signs with 0.0396-inch (1-mm) galvanized-steel backing; and with colors, legend, and size required for application.
2. 1/4-inch (6.4-mm) grommets in corners for mounting.
3. Nominal size, 10 by 14 inches (250 by 360 mm).

E. Warning label and sign shall include, but are not limited to, the following legends:

1. Multiple Power Source Warning: "DANGER - ELECTRICAL SHOCK HAZARD."

2.04 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.

B. Adhesive Film Label: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm).

C. Adhesive Film Label with Clear Protective Overlay: Machine printed, in black, by thermal transfer or equivalent process. Minimum letter height shall be 3/8 inch (10 mm). Overlay shall provide a weatherproof and UV-resistant seal for label.

2.05 EQUIPMENT IDENTIFICATION LABELS

A. Self-Adhesive, Engraved, Laminated Acrylic or Melamine Label: Adhesive backed, with white letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

B. Engraved, Laminated Acrylic or Melamine Label: Punched or drilled for screw mounting. White letters on a dark-gray background. Minimum letter height shall be 3/8 inch (10 mm).

2.06 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.

2.07 MISCELLANEOUS IDENTIFICATION PRODUCTS

A. 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

3.01 INSTALLATION

A. Verify identity of each item before installing identification products.

B. Location: Install identification materials and devices at locations for most convenient viewing without interference with operation and maintenance of equipment.

C. Apply identification devices to surfaces that require finish after completing finish work.

D. Self-Adhesive Identification Products: Clean surfaces before application, using materials and methods recommended by manufacturer of identification device.

E. Attach signs and plastic labels that are not self-adhesive type with mechanical fasteners appropriate to the location and substrate.

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. Underground-Line Warning Tape: During backfilling of trenches install continuous underground-line warning tape directly above line at 6 to 8 inches (150 to 200 mm) below finished grade. Use multiple tapes where width of multiple lines installed in a common trench or concrete envelope exceeds 16 inches (400 mm) overall.

3.02 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 Phase and Voltage Level Identification, 600 V or Less: Use colors listed below for ungrounded service, feeder, and branch-circuit conductors.

a. Color shall be factory applied or field applied for sizes larger than No. 8 AWG, if authorities having jurisdiction permit.
b. Colors for 208/120-V Circuits:

1) Phase A: Black.
2) Phase B: Red.
3) Phase C: Blue.

c. Colors for 480/277-V Circuits:

1) Phase A: Brown.
2) Phase B: Orange.
3) Phase C: Yellow.

d. Field-Applied, Color-Coding Conductor Tape: Apply in half-lapped turns for a minimum distance of 6 inches (150 mm) from terminal points and in boxes where splices or taps are made. Apply last two turns of tape with no tension to prevent possible unwinding. Locate bands to avoid obscuring factory cable markings.

B. Power-Circuit Conductor Identification, More than 600 V: For conductors in vaults, pull and junction boxes, manholes, and handholes, use nonmetallic plastic tag holder with adhesive-backed phase tags, and a separate tag with the circuit designation.

C. Install instructional sign including the color-code for grounded and ungrounded conductors using adhesive-film-type labels.

D. Control-Circuit Conductor Identification: For conductors and cables in pull and junction boxes, manholes, and handholes, self-adhesive, self-laminating polyester labels with the conductor or cable designation, origin, and destination.

E. Control-Circuit Conductor Termination Identification: For identification at terminations provide self-adhesive, self-laminating polyester labels with the conductor designation.

F. Conductors to Be Extended in the Future: Attach marker tape to conductors and list source.

G. Locations of Underground Lines: Identify with underground-line warning tape for power, lighting, communication, and control wiring and optical fiber cable.

1. Install underground-line warning tape for both direct-buried cables and cables in raceway.

H. Operating Instruction Signs: Install instruction signs to facilitate proper operation and maintenance of electrical systems and items to which they connect. Install instruction signs with approved legend where instructions are needed for system or equipment operation.

I. Equipment Identification Labels: On each unit of equipment, install unique designation label that is consistent with wiring diagrams, schedules, and the Operation and Maintenance Manual.

Apply labels to disconnect switches and protection equipment, central or master units, control panels, control stations, terminal cabinets, and racks of each system. Systems include power, lighting, control, communication, signal, monitoring, and alarm systems unless equipment is provided with its own identification.

1. Labeling Instructions:

   a. Indoor Equipment: Self-adhesive, engraved, laminated acrylic or melamine label. Unless otherwise indicated, provide a single line of text with 1/2-inch- (13-mm-) high letters on 1-1/2-inch- (38-mm-) high label; where two lines of text are required, use labels 2 inches (50 mm) high.
   b. Outdoor Equipment: Engraved, laminated acrylic or melamine label.
   c. Unless provided with self-adhesive means of attachment, fasten labels with appropriate mechanical fasteners that do not change the NEMA or NRTL rating of the enclosure.

2. Equipment to Be Labeled:

   a. Panelboards: Typewritten directory of circuits in the location provided by panelboard manufacturer. Panelboard identification shall be self-adhesive, engraved, laminated acrylic or melamine label.
   b. Enclosures and electrical cabinets.
   c. Access doors and panels for concealed electrical items.
   d. Transformers: Label that includes tag designation shown on Drawings for the transformer, feeder, and panelboards or equipment supplied by the secondary.
   e. Enclosed switches.
   f.
   g. Enclosed circuit breakers.
   h. Enclosed controllers.

END OF SECTION

SECTION 26 05 72

OVERCURRENT PROTECTIVE DEVICE SHORT-CIRCUIT STUDY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes a computer-based, fault-current study to determine the minimum interrupting capacity of circuit protective devices.

1.03 DEFINITIONS

A. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

B. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

C. SCCR: Short-circuit current rating.

D. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals may be in digital form.

1. Short-circuit study input data, including completed computer program input data sheets.
2. Short-circuit study and equipment evaluation report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.
    b. Revised single-line diagram, reflecting field investigation results and results of short-circuit study.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Short-Circuit Study Specialist

B. Product Certificates: For short-circuit study software, certifying compliance with IEEE 399.

1.06 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Short-Circuit Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE

A. Software Developers: Subject to compliance with requirements, provide software by one of the following:

1. ESA Inc
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 399 and IEEE 551.

C. Analytical features of fault-current-study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output.

2.02 SHORT-CIRCUIT STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Comments and recommendations for system improvements, where needed.

E. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Tabulations of circuit breaker, fuse, and other protective device ratings versus calculated short-circuit duties.
3. For 600-V overcurrent protective devices, ensure that interrupting ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.
4. For devices and equipment rated for asymmetrical fault current, apply multiplication factors listed in the standards to 1/2-cycle symmetrical fault current.
5. Verify adequacy of phase conductors at maximum three-phase bolted fault currents; verify adequacy of equipment grounding conductors and grounding electrode conductors at maximum ground-fault currents. Ensure that short-circuit withstand ratings are equal to or higher than calculated 1/2-cycle symmetrical fault current.

F. Short-Circuit Study Input Data: As described in "Power System Data" Article in the Evaluations.

G. Short-Circuit Study Output:

1. Low-Voltage Fault Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Equivalent impedance.

2. Momentary Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. Calculated asymmetrical fault currents:

        1) Based on fault-point X/R ratio.
        2) Based on calculated symmetrical value multiplied by 1.6.
        3) Based on calculated symmetrical value multiplied by 2.7.

3. Interrupting Duty Report: Three-phase and unbalanced fault calculations, showing the following for each overcurrent device location:

    a. Voltage.
    b. Calculated symmetrical fault-current magnitude and angle.
    c. Fault-point X/R ratio.
    d. No AC Decrement (NACD) ratio.
    e. Equivalent impedance.
    f. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a symmetrical basis.
    g. Multiplying factors for 2-, 3-, 5-, and 8-cycle circuit breakers rated on a total basis.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Obtain all data necessary for the conduct of the study.

1. Verify completeness of data supplied on the one-line diagram. Call any discrepancies to the attention of Architect.
2. For equipment provided that is Work of this Project, use characteristics submitted under the provisions of action submittals and information submittals for this Project.

B. Gather and tabulate the following input data to support the short-circuit study. Comply with recommendations in IEEE 551 as to the amount of detail that is required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for Project's overcurrent protective devices involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Obtain electrical power utility impedance at the service.
3. Power sources and ties.
4. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
5. For reactors, provide manufacturer and model designation, voltage rating, and impedance.
6. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip, SCCR, current rating, and breaker settings.
7. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.
8. Busway manufacturer and model designation, current rating, impedance, lengths, and conductor material.
9. Motor horsepower and NEMA MG 1 code letter designation.
10. Cable sizes, lengths, number, conductor material and conduit material (magnetic or nonmagnetic).

3.02 SHORT-CIRCUIT STUDY

A. Perform study following the general study procedures contained in IEEE 399.

B. Calculate short-circuit currents according to IEEE 551.

C. Base study on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin short-circuit current analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.
2. Exclude equipment rated 240-V ac or less when supplied by a single transformer rated less than 125 kVA.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

H. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault at each of the following:

1. Electric utility's supply termination point.
2. Incoming switchgear.
3. Unit substation primary and secondary terminals.
4. Low-voltage switchgear.
5. Motor-control centers.
6. Control panels.
7. Standby generators and automatic transfer switches.
8. Branch circuit panelboards.
9. Disconnect switches.

3.03 ADJUSTING

A. Make minor modifications to equipment as required to accomplish compliance with short-circuit study.

3.04 DEMONSTRATION

A. Train Owner's operating and maintenance personnel in the use of study results.

END OF SECTION

SECTION 26 05 73

OVERCURRENT PROTECTIVE DEVICE COORDINATION STUDY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes computer-based, overcurrent protective device coordination studies to determine overcurrent protective devices and to determine overcurrent protective device settings for selective tripping.

1.03 DEFINITIONS

A. Existing to Remain: Existing items of construction that are not to be removed and that are not otherwise indicated to be removed, removed and salvaged, or removed and reinstalled.

B. One-Line Diagram: A diagram which shows, by means of single lines and graphic symbols, the course of an electric circuit or system of circuits and the component devices or parts used therein.

C. Protective Device: A device that senses when an abnormal current flow exists and then removes the affected portion from the system.

D. SCCR: Short-circuit current rating.

E. Service: The conductors and equipment for delivering electric energy from the serving utility to the wiring system of the premises served.

1.04 ACTION SUBMITTALS

A. Product Data: For computer software program to be used for studies.

B. Other Action Submittals: Submit the following after the approval of system protective devices submittals. Submittals shall be in digital form.

1. Coordination-study input data, including completed computer program input data sheets.
2. Study and equipment evaluation reports.
3. Overcurrent protective device coordination study report; signed, dated, and sealed by a qualified professional engineer.

    a. Submit study report for action prior to receiving final approval of the distribution equipment submittals. If formal completion of studies will cause delay in equipment manufacturing, obtain approval from Architect for preliminary submittal

of sufficient study data to ensure that the selection of devices and associated characteristics is satisfactory.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Coordination Study Software Developer Coordination Study Specialist.

B. Product Certificates: For overcurrent protective device coordination study software, certifying compliance with IEEE 399.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For the overcurrent protective devices to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01, include the following:

a. The following parts from the Protective Device Coordination Study Report:

1) One-line diagram.
2) Protective device coordination study.
3) Time-current coordination curves.

b. Power system data.

1.07 QUALITY ASSURANCE

A. Studies shall use computer programs that are distributed nationally and are in wide use. Software algorithms shall comply with requirements of standards and guides specified in this Section. Manual calculations are unacceptable.

B. Coordination Study Software Developer Qualifications: An entity that owns and markets computer software used for studies, having performed successful studies of similar magnitude on electrical distribution systems using similar devices.

1. The computer program shall be developed under the charge of a licensed professional engineer who holds IEEE Computer Society's Certified Software Development Professional certification.

C. Coordination Study Specialist Qualifications: Professional engineer in charge of performing the study and documenting recommendations, licensed in the state where Project is located. All elements of the study shall be performed under the direct supervision and control of this professional engineer.

PART 2 - PRODUCTS

2.01 COMPUTER SOFTWARE DEVELOPERS

A. Software Developers: Subject to compliance with requirements, available software developers offering software that may be used for the Work include, but are not limited to, the following:

1. ESA Inc.
2. Operation Technology, Inc.
3. Power Analytics, Corporation.
4. SKM Systems Analysis, Inc.

B. Comply with IEEE 242 and IEEE 399.

C. Analytical features of device coordination study computer software program shall have the capability to calculate "mandatory," "very desirable," and "desirable" features as listed in IEEE 399.

D. Computer software program shall be capable of plotting and diagramming time-current-characteristic curves as part of its output. Computer software program shall report device settings and ratings of all overcurrent protective devices and shall demonstrate selective coordination by computer-generated, time-current coordination plots.

1. Optional Features:

a. Arcing faults.
b. Simultaneous faults.
c. Explicit negative sequence.
d. Mutual coupling in zero sequence.

2.02 PROTECTIVE DEVICE COORDINATION STUDY REPORT CONTENTS

A. Executive summary.

B. Study descriptions, purpose, basis and scope. Include case descriptions, definition of terms and guide for interpretation of the computer printout.

C. One-line diagram, showing the following:

1. Protective device designations and ampere ratings.
2. Cable size and lengths.
3. Transformer kilovolt ampere (kVA) and voltage ratings.
4. Motor and generator designations and kVA ratings.
5. Switchgear, switchboard, motor-control center, and panelboard designations.

D. Study Input Data: As described in "Power System Data" Article.

E. Short-Circuit Study – Refer to Section 26 05 72 – “Overcurrent Protective Device Short-Circuit Study”.

F. Protective Device Coordination Study:

1. Report recommended settings of protective devices, ready to be applied in the field. Use manufacturer's data sheets for recording the recommended setting of overcurrent protective devices when available.

   a. Phase and Ground Relays:

      1) Device tag.
      2) Relay current transformer ratio and tap, time dial, and instantaneous pickup value.
      3) Recommendations on improved relaying systems, if applicable.

   b. Circuit Breakers:

      1) Adjustable pickups and time delays (long time, short time, ground).
      2) Adjustable time-current characteristic.
      3) Adjustable instantaneous pickup.
      4) Recommendations on improved trip systems, if applicable.

   c. Fuses: Show current rating, voltage, and class.

G. Time-Current Coordination Curves: Determine settings of overcurrent protective devices to achieve selective coordination. Graphically illustrate that adequate time separation exists between devices installed in series, including power utility company's upstream devices. Prepare separate sets of curves for the switching schemes and for emergency periods where the power source is local generation. Show the following information:

1. Device tag and title, one-line diagram with legend identifying the portion of the system covered.
2. Terminate device characteristic curves at a point reflecting maximum symmetrical or asymmetrical fault current to which the device is exposed.
3. Identify the device associated with each curve by manufacturer type, function, and, if applicable, tap, time delay, and instantaneous settings recommended.
4. Plot the following listed characteristic curves, as applicable:

   a. Power utility's overcurrent protective device.
   b. Medium- and low-voltage fuses including manufacturer's minimum melt, total clearing, tolerance, and damage bands.
   c. Low-voltage equipment circuit-breaker trip devices, including manufacturer's tolerance bands.
   d. Transformer full-load current, magnetizing inrush current, and ANSI through-fault protection curves.
   e. Cables and conductors damage curves.
   f. Ground-fault protective devices.
   g. Motor-starting characteristics and motor damage points.
   h. Generator short-circuit decrement curve and generator damage point.
   i. The largest feeder circuit breaker in each motor-control center and panelboard.

5. Provide adequate time margins between device characteristics such that selective operation is achieved.
6. Comments and recommendations for system improvements.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine Project overcurrent protective device submittals for compliance with electrical distribution system coordination requirements and other conditions affecting performance. Devices to be coordinated are indicated on Drawings.

1. Proceed with coordination study only after relevant equipment submittals have been assembled. Overcurrent protective devices that have not been submitted and approved prior to coordination study may not be used in study.

3.02 PROTECTIVE DEVICE COORDINATION STUDY

A. Comply with IEEE 242 for calculating short-circuit currents and determining coordination time intervals.

B. Comply with IEEE 399 for general study procedures.

C. The study shall be based on the device characteristics supplied by device manufacturer.

D. The extent of the electrical power system to be studied is indicated on Drawings.

E. Begin analysis at the service, extending down to the system overcurrent protective devices as follows:

1. To normal system low-voltage load buses where fault current is 10 kA or less.

F. Study electrical distribution system from normal and alternate power sources throughout electrical distribution system for Project. Study all cases of system-switching configurations and alternate operations that could result in maximum fault conditions.

G. Motor Protection:

1. Select protection for low-voltage motors according to IEEE 242 and NFPA 70.
2. Select protection for motors served at voltages more than 600 V according to IEEE 620.

H. Conductor Protection: Protect cables against damage from fault currents according to ICEA P-32-382, ICEA P-45-482, and protection recommendations in IEEE 242. Demonstrate that equipment withstands the maximum short-circuit current for a time equivalent to the tripping time of the primary relay protection or total clearing time of the fuse. To determine temperatures that damage insulation, use curves from cable manufacturers or from listed standards indicating conductor size and short-circuit current.

I. Generator Protection: Select protection according to manufacturer's written recommendations and to IEEE 242.

J. The calculations shall include the ac fault-current decay from induction motors, synchronous motors, and asynchronous generators and shall apply to low- and medium-voltage, three-phase ac systems. The calculations shall also account for the fault-current dc decrement, to address the asymmetrical requirements of the interrupting equipment.

1. For grounded systems, provide a bolted line-to-ground fault-current study for areas as defined for the three-phase bolted fault short-circuit study.

K. Calculate short-circuit momentary and interrupting duties for a three-phase bolted fault and single line-to-ground fault at each of the following:

1. Electric utility's supply termination point.
2. Low-voltage Switchboards.
3. Standby generators and automatic transfer switches.
4. Branch circuit panelboards.

L. Protective Device Evaluation:

1. Evaluate equipment and protective devices and compare to short-circuit ratings.
2. Adequacy of switchgear, motor-control centers, and panelboard bus bars to withstand short-circuit stresses.
3. Any application of series-rated devices shall be recertified, complying with requirements in NFPA 70.

3.03 POWER SYSTEM DATA

A. Obtain all data necessary for the conduct of the overcurrent protective device study.

1. Verify completeness of data supplied in the one-line diagram on Drawings. Call discrepancies to the attention of Architect.
2. For new equipment, use characteristics submitted under the provisions of action submittals and information submittals for this Project.
3. For existing equipment, whether or not relocated obtain required electrical distribution system data by field investigation and surveys, conducted by qualified technicians and engineers. The qualifications of technicians and engineers shall be qualified as defined by NFPA 70E.

B. Gather and tabulate the following input data to support coordination study. The list below is a guide. Comply with recommendations in IEEE 241 and IEEE 551 for the amount of detail required to be acquired in the field. Field data gathering shall be under the direct supervision and control of the engineer in charge of performing the study, and shall be by the engineer or its representative who holds NETA ETT Level III certification or NICET Electrical Power Testing Level III certification.

1. Product Data for overcurrent protective devices specified in other Sections and involved in overcurrent protective device coordination studies. Use equipment designation tags that are consistent with electrical distribution system diagrams, overcurrent protective device submittals, input and output data, and recommended device settings.
2. Electrical power utility impedance at the service.
3. Power sources and ties.
4. Short-circuit current at each system bus, three phase and line-to-ground.
5. Voltage level at each bus.
6. For transformers, include kVA, primary and secondary voltages, connection type, impedance, X/R ratio, taps measured in percent, and phase shift.
7. For circuit breakers and fuses, provide manufacturer and model designation. List type of breaker, type of trip and available range of settings, SCCR, current rating, and breaker settings.
8. Generator short-circuit current contribution data, including short-circuit reactance, rated kVA, rated voltage, and X/R ratio.

9. Motor horsepower and NEMA MG 1 code letter designation.
10. Low-voltage cable sizes, lengths, number, conductor material, and conduit material (magnetic or nonmagnetic).
11. Medium-voltage cable sizes, lengths, conductor material, and cable construction and metallic shield performance parameters.
12. Data sheets to supplement electrical distribution system diagram, cross-referenced with tag numbers on diagram, showing the following:

    a. Special load considerations, including starting inrush currents and frequent starting and stopping.
    b. Transformer characteristics, including primary protective device, magnetic inrush current, and overload capability.
    c. Motor full-load current, locked rotor current, service factor, starting time, type of start, and thermal-damage curve.
    d. Generator thermal-damage curve.
    e. Ratings, types, and settings of utility company's overcurrent protective devices.
    f. Special overcurrent protective device settings or types stipulated by utility company.
    g. Time-current-characteristic curves of devices indicated to be coordinated.
    h. Manufacturer, frame size, interrupting rating in amperes rms symmetrical, ampere or current sensor rating, long-time adjustment range, short-time adjustment range, and instantaneous adjustment range for circuit breakers.
    i. Manufacturer and type, ampere-tap adjustment range, time-delay adjustment range, instantaneous attachment adjustment range, and current transformer ratio for overcurrent relays.
    j. Panelboards, switchboards, motor-control center ampacity, and SCCR in amperes rms symmetrical.
    k. Identify series-rated interrupting devices for a condition where the available fault current is greater than the interrupting rating of the downstream equipment. Obtain device data details to allow verification that series application of these devices complies with NFPA 70 and UL 489 requirements.

3.04 FIELD ADJUSTING

A. Adjust relay and protective device settings according to the recommended settings provided by the coordination study. Field adjustments shall be completed by the engineering service division of the equipment manufacturer under the Startup and Acceptance Testing contract portion.

B. Make modifications to equipment as required to accomplish compliance with short-circuit and protective device coordination studies.

1. Perform each visual and mechanical inspection and electrical test stated in NETA Acceptance Testing Specification. Certify compliance with test parameters. Perform NETA tests and inspections for all adjustable overcurrent protective devices.

3.05 DEMONSTRATION

A. Engage the Coordination Study Specialist to train Owner's maintenance personnel in the following:

1. Acquaint personnel in the fundamentals of operating the power system in normal and emergency modes.

2. Hand-out and explain the objectives of the coordination study, study descriptions, purpose, basis, and scope. Include case descriptions, definition of terms, and guide for interpreting the time-current coordination curves.
3. Adjust, operate, and maintain overcurrent protective device settings.

END OF SECTION

SECTION 26 08 00

COMMISSIONING OF ELECTRICAL SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section describes the requirements for start-up and commissioning for Division 26 installed work, including but not limited to:

1. Lighting system
2. Lighting control devices
3. Network Lighting Controls

B. Related Sections:

1. Section 01 91 13 "General Commissioning Requirements" for general commissioning process requirements.

1.03 DEFINITIONS

A. Commissioning Plan: A document that outlines the organization, schedule, allocation of resources, and documentation requirements of the commissioning process.

B. Commissioning: A systematic process confirming that building systems have been installed, properly started, and consistently operated in strict accordance with the Contract Documents, that all systems are complete and functioning in accordance with the Contract Documents at Substantial Completion, and that Contractor has provided Owner adequate system documentation and training. Commissioning includes deferred and/or seasonal tests as approved by Owner.

C. CxA: Commissioning Authority.

D. Deferred Tests: Functional Performance or Integrated System Tests performed after Substantial Completion due to partial occupancy, partial equipment acceptance, seasonal requirements, design, or other Site conditions that prohibit the test from being performed prior to Substantial Completion.

E. Deficiency: Condition of a component, piece of equipment or system that is not in compliance with Contract Documents.

F. Factory Testing: Testing of equipment at the factory, by factory personnel with an Owner's representative present if deemed necessary by Owner.

G. Functional Performance Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configuration and steps required to determine if the system is performing and functioning properly. Contractor prepares these procedures to document Functional Performance Tests.

H. Functional Performance Test (FPT): Test of dynamic function and operation of equipment and systems executed by Contractor. Systems are tested under various modes, such as during low cooling or heating loads, high loads, component failures, unoccupied, varying outside air temperatures, life safety conditions, power failure, etc. Systems are run through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Functional Performance Tests are executed after start-ups and Prefunctional Checklists are complete.

I. Integrated System Test: Test of dynamic function and operation of multiple systems. Integrated System Tests are tested under various modes, such as fire alarm and emergency situations, life safety conditions, power failure, etc. Systems are integrally operated through all specified sequences of operation. Components are verified to be responding in accordance with Contract Documents. Integrated System Tests are executed after Functional Performance Tests are complete and prior to Substantial Completion. Integrated System Tests provide verification that the integrated systems will properly function according to the Contract Documents.

J. Integrated System Test Procedures: Commissioning protocols and detailed test procedures and instructions in tabular and script-type format that fully describe system configurations and steps required to determine if the interacting systems are performing and functioning properly. Contractor prepares these procedures to document Integrated System Tests.

K. Lighting Systems: Interior and exterior lighting control systems including occupancy sensors, time clocks, photocells and BAS interface.

L. Prefunctional Checklist: A list of static inspections and material or component tests that verify proper installation of equipment (e.g., belt tension, oil levels, labels affixed, gages in place, sensors calibrated, etc.). The word Prefunctional refers to before Functional tests. Prefunctional Checklists must include the manufacturer's Start-up checklist(s). Contractor shall sign Prefunctional Checklists as complete and submit with the Request for Start-up/Functional Performance Test Form.

M. Start-up: The activities where equipment is initially energized, tested, and operated. Start-up is completed prior to Functional Performance Tests.

N. Test Requirements: Requirements specifying what systems, modes and functions, etc. must be tested. Test requirements are not detailed test procedures. Test requirements and acceptance criteria are specified in the Contract Documents.

1.04 INFORMATIONAL SUBMITTALS

A. Submittals shall comply with the requirements of the Construction Contract Clauses, Section 01 33 00 "Submittal Procedures" and the individual sections specifying the work.

B. Prefunctional Checklists of readiness.

C. Prefunctional Checklists of completion of installation, prestart, and startup activities.

1.05 CONTRACTOR'S RESPONSIBILITIES

A. Perform commissioning tests at the direction of the CxA.

B. Attend construction phase coordination meeting.

C. Attend testing, adjusting, and balancing review and coordination meeting.

D. Participate in Lighting systems, assemblies, equipment, and component maintenance orientation and inspection as directed by the CxA.

E. Provide information requested by the CxA for final commissioning documentation.

F. Provide measuring instruments and logging devices to record test data, and provide data acquisition equipment to record data for the complete range of testing for the required test period.

1.06 CxA'S RESPONSIBILITIES

A. Provide Project-specific construction checklists and commissioning process test procedures for Lighting systems, assemblies, equipment, and components to be furnished and installed as part of the construction contract.

B. Direct commissioning testing.

C. Verify testing, adjusting, and balancing of Work are complete.

D. Provide test data, inspection reports, and certificates in Systems Manual.

1.07 COMMISSIONING DOCUMENTATION

A. Provide the following information to the CxA for inclusion in the commissioning plan:

1. Plan for delivery and review of submittals, systems manuals, and other documents and reports.
2. Identification of installed systems, assemblies, equipment, and components including design changes that occurred during the construction phase.
3. Process and schedule for completing construction checklists and manufacturer's prestart and startup checklists for Lighting systems, assemblies, equipment, and components to be verified and tested.
4. Prefunctional Checklists certifying that installation, prestart checks, and startup procedures have been completed.
5. Prefunctional Checklists certifying that Lighting systems, subsystems, equipment, and associated controls are ready for testing.
6. Test and inspection reports and certificates.
7. Corrective action documents.
8. Verification of testing and adjusting reports.

PART 2 - PRODUCTS (Not Used)

PART 3 - EXECUTION

3.01 TESTING PREPARATION

A. Certify that Lighting systems, subsystems, and equipment have been installed, calibrated, and started and are operating according to the Contract Documents.

B. Certify that lighting instrumentation and control systems have been completed and calibrated, that they are operating according to the Contract Documents, and that pretest set points have been recorded.

C. Certify that testing and adjusting procedures have been completed and that testing and adjusting reports have been submitted, discrepancies corrected, and corrective work approved.

D. Set systems, subsystems, and equipment into operating mode to be tested (e.g., normal shutdown, normal auto position, normal manual position, emergency power, and alarm conditions).

E. Inspect and verify the position of each device and interlock identified on checklists.

F. Check safety cutouts and interlocks during each mode of operation.

G. Testing Instrumentation: Install measuring instruments and logging devices to record test data as directed by the CxA.

3.02 GENERAL TESTING REQUIREMENTS

A. Provide technicians, instrumentation, and tools to perform commissioning test at the direction of the CxA.

B. Scope of lighting control system testing shall include lighting system installation for all interior spaces and exterior.

C. Test all operating modes, interlocks, control responses, and responses to abnormal or emergency conditions, and verify proper response.

D. The CxA in cooperation with the Lighting Controls Contractor shall prepare detailed testing plans, procedures, and checklists for lighting controls systems, subsystems, and equipment.

E. Tests will be performed using design conditions whenever possible.

F. Simulated conditions may need to be imposed using an artificial load when it is not practical to test under design conditions. Before simulating conditions, calibrate testing instruments. Provide equipment to simulate loads. Set simulated conditions as directed by the CxA and document simulated conditions and methods of simulation. After tests, return settings to normal operating conditions.

G. The CxA may direct that set points be altered when simulating conditions is not practical.

H. The CxA may direct that sensor values be altered with a signal generator when design or simulating conditions and altering set points are not practical.

I. If tests cannot be completed because of a deficiency outside the scope of the lighting control system, document the deficiency and report it to the Owner. After deficiencies are resolved, reschedule tests.

3.03 LIGHTING AND LIGHTING CONTROL SYSTEM COMMISSIONING

A. Perform commissioning work after equipment is installed and system ready for operation.

B. Perform commissioning work in accordance with equipment manufacturer's standard procedures and check lists.

3.04 CHECKLIST

1. Prior to Functional Performance Test:

    a. System in place, including all components indicated, and tested.
    b. Connected to facility power system on a permanent basis.

2. Personnel to be present or assist as required to Perform Functional Performance Test:

    a. Electrical Contractor, sub-contractors and specialty contractors as required.
    b. Owner’s Representative's Project Manager/Representative and/or Inspector of Record (I.O.R.).
    c. Owner’s maintenance staff, as desired.
    d. Design Engineer.

3. Functional Performance Test: Demonstrate operation of normal power distribution system per specifications including the following:

    a. Verify performance meets the specified design intent.

4. Results:

    a. If specified equipment performance is not verified, the contractor shall have corrections made and reschedule Functional performance Test as soon as possible after corrective work is completed.

3.05 DOCUMENTATION

1. Documentation:

    a. All prefunctional and functional testing documentation as well as a final commissioning report shall be prepared and delivered to the owner per the commissioning contract.

END OF SECTION

SECTION 26 09 23

LIGHTING CONTROL DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Standalone daylight-harvesting dimming controls.
2. Indoor occupancy sensors.
3. Switchbox-mounted occupancy sensors.

B. Related Requirements:

1. Section 26 27 26 "Wiring Devices" for wall-box dimmers, and manual light switches.

1.03 MANDATORY PROGRAMMING MEETING

A. 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.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings:

1. Show installation details for the following:

a. Occupancy sensors.

2. Interconnection diagrams showing field-installed wiring.
3. Include diagrams for power, signal, and control wiring.

C. Field quality-control reports.

D. Sample Warranty: For manufacturer's warranties.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of lighting control device to include in operation and maintenance manuals.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer and Installer agree to repair or replace lighting control devices that fail(s) in materials or workmanship within specified warranty period.

1. Failures include, but are not limited to, the following:
   a. Faulty operation of lighting control devices.

2. Warranty Period: 2 year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS

A. Electrical Components, Devices, and Accessories:

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application

2.02 DAYLIGHT-HARVESTING SENSORS AND DIMMING CONTROLS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Greengate Room Controller series or comparable product by one of the following:

1. Hubbell Building Automation
2. Acuity Brands.
3. Philips.

B. System Description: Sensing daylight lighting levels, the system adjusts the indoor electrical lighting levels. As daylight increases, the lights are dimmed.

1. Daylight Zones – Sidelit and toplit areas within an enclosed space shall be controlled separately and automatically by multi-level photocontrol devices.
2. Provide continuous daylight dimming for control groups indicated on drawings. Daylight dimming shall adjust electric lighting based on daylight conditions to maintain at least the illumination level provided by the electric lighting in each daylit area without daylight contritbution.
3. Provide the ability to adjust the high end and low end trim of the dimmers.
4. Provide the ability for the dimmers and the relays to function separately.
5. Occupancy requirements – Provide occupancy sensors with Manual On/ Automatic Off or Automatic On/ Automatic Off functionality as indicated for each space.

C. Ceiling mounted occupancy sensors

1. Product: Basis of design is Eaton OAC-DT-2000R.
2. Provide all necessary mounting hardware and instructions.
3. Sensors shall be Class 2 devices.
4. Connect to Room Controller via Click & Go cable to eliminate wiring errors.

a. Room Controller accessory is used to allow any standard occupancy/vacancy sensor to utilize Click & Go cable connections.
b. Two RJ45 connection ports for connection to Room Controller.
c. Occupancy Sensor and Daylight sensor shall be capable of a daisy chain connection to the Room Controller.

5. Device calibration and features:

a. Sensitivity – 0-100% in 10% increments.
b. Time delay – 1-30, self-adjusts to 10 min based on room occupancy.
c. Test mode – Fifteen second time delay.
d. Detection technology – Dual Technology

6. Device Status LEDs including:

a. PIR Detection
b. Ultrasonic detection

7. Occupancy sensors are pre-defined to specific loads within the room without wiring or special tools for maximum energy savings.
8. Manual override of controlled loads.
9. Multiple occupancy sensors may be installed in a room by simply daisy-chaining them together to the Room Controller via Click & Go cable. No additional configuration will be required.

D. Wall/corner mounted occupancy sensors

1. Product: OAWC-DT-120W-R
2. Provide all necessary mounting hardware and instructions.
3. Sensors shall be Class 2 devices.
4. Connect to Room Controller via Click & Go cable to eliminate wiring errors.

a. Room Controller accessory is used to allow any standard occupancy/vacancy sensor to utilize Click & Go cable connections.
b. Two RJ45 connection ports for connection to Room Controller.
c. Occupancy Sensor and Daylight sensor shall be capable of a daisy chain connection to the Room Controller.

5. Device calibration and features:

a. Sensitivity – 0-100% in 10% increments.
b. Time delay – 1-30, self-adjusts to 10 min based on room occupancy.
c. Test mode – Fifteen second time delay.
d. Detection technology – Dual Technology

6. Device Status LEDs including:

a. PIR Detection
b. Ultrasonic detection

7. Occupancy sensors are pre-defined to specific loads within the room without wiring or special tools for maximum energy savings.
8. Manual override of controlled loads.
9. Multiple occupancy sensors may be installed in a room by simply daisy-chaining them together to the Room Controller via Click & Go cable. No additional configuration will be required.

E. Room Controller wall stations:

1. Low voltage momentary pushbutton switches in 2 and 4 button configuration; color shall match wiring devices; compatible with wall plates with decorator opening. Wallstations shall include the following features:
   a. Removable buttons for field replacement with engraved buttons and/or alternate color buttons. Button replacement may be completed without removing the switch from the wall.
   b. Button labeling to match application and load controls.

2. Two RJ-45 ports for connection to the Room Controller local network.
3. Multiple digital wallstations may be installed in a room by simply connecting them to the Room Controller local network. No additional configuration will be required to achieve multi-way switching.
4. Room Controller digital wallstation functions include raise, lower, and manual on/off as indicated on the drawings.

F. Daylight Photosensors

1. Basis of Design is Eaton Greengate DS-FMOIR.
2. Daylight photosensors work with Room Controllers to provide automatic daylight dimming capabilities for any load type connected to a room controller. Open loop daylight sensors measure incoming daylight in the space, and are capable of controlling up to three lighting zones. Daylight sensors shall be interchangeable without the need for rewiring. Daylight sensors shall be capable of daisy-chaining with occupancy sensors in each room.
3. Digital daylight sensors include the following features:

   a. The daylight sensor shall have three light level ranges: Low (3-300 lux), High (30-3000 lux), and Direct Sun (300-30000 lux).
   b. For dimming daylight harvesting, the daylight sensor shall provide the capability of controlling multiple (up to three) daylight zones.
   c. Infrared (IR) transceiver for daylight sensor range and daylight zone gain adjustments via handheld remote programmer.
   d. Infrared (IR) receiver for personal control and scene programming via handheld remote programmer.
   e. Red configuration LED that blinks to indicate data transmission.
   f. Green Mode status LED that blinks to indicate Daylight Commissioning Mode.
   g. Green Mode status LED that remains constant ON when daylight range is set to low for available natural light.
   h. One RJ45 port for connection to Room Controller local network.
   i. An adjustable head and a mounting bracket to accommodate multiple mounting methods and building materials. The daylight sensor may be mounted on a ceiling tile, skylight well, suspended lighting fixture or backbox.
   j. An internal photodiode that measures light in a 60 degree angle cutting off the unwanted light from the interior of the room.

2.03 INDOOR OCCUPANCY SENSORS

A. General Requirements for Sensors:

1. Wall, Ceiling or pendant-mounted, solid-state indoor occupancy sensors.
2. Dual technology.
3. Power pack.

4. Hardwired
5. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
6. Operation:

    a. Turn lights on automatically or when manually turned on as indicated on the drawings 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 30 minutes.

7. Sensor Output: Sensor is powered from the power pack**.**
8. Power Pack: Dry contacts rated for 20-A LED 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.
9. 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.

10. Indicator: Digital display, to show when motion is detected during testing and normal operation of sensor.
11. Bypass Switch: Override the "on" function in case of sensor failure.
12. Automatic Light-Level Sensor: Adjustable from 2 to 200 fc (21.5 to 2152 lux); turn lights off when selected lighting level is present.

B. Dual-Technology Type: Ceiling, pendant, or wall mounted as indicated; 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. Basis of design for wall mounted units is Greengate OAWC-DT-120W-R.
4. Basis of design for ceiling mounted units is Greengate OAC-DT-2000R.

2.04 SWITCHBOX-MOUNTED OCCUPANCY SENSORS

A. General Requirements for Sensors: Automatic-wall-switch occupancy sensor with manual on-auto off switch, suitable for mounting in a single gang switchbox.

1. Listed and labeled as defined in NFPA 70, by a qualified testing agency, and marked for intended location and application.
2. Occupancy Sensor Operation: Unless otherwise indicated, turn lights on via manual switch, and turn lights off when unoccupied; with a time delay for turning lights off, adjustable over a minimum range of 1 to 15 minutes.
3. Operating Ambient Conditions: Dry interior conditions, 32 to 120 deg F (0 to 49 deg C).
4. Switch Rating: Not less than 800-VA LED load at 120 V, 1200-VA LED load at 277 V,

B. Wall-Switch Sensor (Tag Sos or SosD)

1. Standard Range: 180-degree field of view, field adjustable from 180 to 40 degrees; with a minimum coverage area of 900 sq. ft. (84 sq. m).
2. Sensing Technology: Dual technology - PIR and ultrasonic.
3. Switch Type: SP, manual "on," automatic "off."
4. Capable of controlling load in three-way application.
5. Voltage: Match the circuit voltage.
6. Ambient-Light Override: Concealed, field-adjustable, light-level sensor from 10 to 150 fc (108 to 1600 lux). The switch prevents the lights from turning on when the light level is higher than the set point of the sensor.
7. Concealed, field-adjustable, "off" time-delay selector at up to 30 minutes.
8. Concealed, "off" time-delay selector at 30 seconds and 5, 10, and 20 minutes.
9. Adaptive Technology: Self-adjusting circuitry detects and memorizes usage patterns of the space and helps eliminate false "off" switching.
10. Color of device and plate: shall match toggle switches and plates specified in “wiring devices” specification Section 26 27 26.

2.05 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 26 05 19 "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 26 05 19 "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 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine lighting control devices before installation. Reject lighting control devices that are wet, moisture damaged, or mold damaged.

B. Examine walls and ceilings for suitable conditions where lighting control devices will be installed.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 SENSOR INSTALLATION

A. Comply with NECA 1.

B. 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.

C. 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.

D. Provide pendant, wall or ceiling mounting for daylight sensors as required to permit direct sensing of daylight from window, skylight or solatube at each sensor location.

3.03 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method: Comply with Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Minimum conduit size is 1/2 inch (13 mm).

C. Wiring within Enclosures: Comply with NECA 1. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

3.04 IDENTIFICATION

A. Identify components and power and control wiring according to Section 26 05 53 "Identification for Electrical Systems."

1. Identify controlled circuits in lighting contactors. Identify circuits or luminaires controlled by photoelectric and occupancy sensors at each sensor.

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections

1. Operational Test: After installing time 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.

3.06 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting lighting control devices 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. Align high-bay occupancy sensors using manufacturer's laser aiming tool.

3.07 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within 2 years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

3.08 DEMONSTRATION

A. Coordinate demonstration of products specified in this Section with demonstration requirements for low-voltage, programmable lighting control systems specified in Section 26 09 43 “Network Lighting Controls.

B. Train Owner's maintenance personnel to adjust, operate, and maintain lighting control devices.

END OF SECTION

SECTION 26 09 33

CENTRAL DIMMING CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes microprocessor-based central dimming controls with the following components:

1. Digital control network.
2. Master-control stations.
3. Partitioned-space master-control stations.
4. Wall stations.
5. Dimmer cabinets.
6. Manual switches and plates for controlling dimmers.

1.03 MANDATORY PROGRAMMING MEETING

A. 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.

1.04 DEFINITIONS

A. Fade Override: The ability to temporarily set fade times to zero for all lighting scenes.

B. Fade Rate: The time it takes each zone to arrive at the next scene, dependent on the degree of change in lighting level.

C. Fade Time: The time it takes all zones to fade from one lighting scene to another, with all zones arriving at the next scene at the same time.

D. Low Voltage: As defined in NFPA 70, term for circuits and equipment operating at less than 50 V or for remote-control, signaling, and power-limited circuits.

E. Scene: The lighting effect created by adjusting several zones of lighting to the desired intensity.

F. SCR: Silicon-controlled rectifier.

G. Zone: A fixture or group of fixtures controlled simultaneously as a single entity. Also known as a "channel."

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. For central dimming controls; include elevation, features, characteristics, and labels.
2. For dimmer panels; include dimensions, features, dimmer characteristics, ratings, and directories.
3. Device plates, plate color, and material.
4. Ballasts and lamp combinations compatible with dimmer controls.
5. Sound data including results of operational tests of central dimming controls.
6. Operational documentation for software and firmware.

B. Shop Drawings: Detail assemblies of standard components, custom assembled for specific application on Project. Indicate dimensions, weights, arrangement of components, and clearance and access requirements.

1. Include elevation views of front panels of control and indicating devices and control stations.
2. Include diagrams for power, signal, and control wiring.

C. Samples for Initial Selection: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.

D. Samples for Verification: For master-control stations, partitioned-space master-control stations, wall stations, dimmer cabinets, and faceplates with factory-applied color finishes and technical features.

1.06 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

B. Sample Warranty: For special warranty.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For central dimming controls with remote-mounting dimmers to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

a. Software manuals.
b. Adjustments of scene preset controls, adjustable fade rates, and fade overrides.
c. Operation of adjustable zone controls.
d. Testing and adjusting of panic and emergency power features.

1.08 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials described below, before installation begins, that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Dimmers: Full-size units equal to two percent of amount installed for each size indicated, but no fewer than two units.
2. Fuses: Two of each size installed, but no fewer than.

1.09 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace components of central dimming controls 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.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Electronic Theatre Controls, Inc.
2. Crestron Electronics, Inc.
3. Lehigh Electric Products Company

2.02 GENERAL SYSTEM REQUIREMENTS

A. Compatibility:

1. Dimming control components shall be compatible with lighting fixtures, ballasts, and transformers.

B. Line-Voltage Surge Suppression: Factory installed as an integral part of 120- and 277-V ac, solid-state dimmers and control panels.

C. Dimmers and Dimmer Modules: Comply with UL 508.

1. Audible Noise and Radio-Frequency Interference Suppression: Solid-state dimmers shall operate smoothly over their operating ranges without audible lamp or dimmer noise or radio-frequency interference. Modules shall include integral or external filters to suppress audible noise and radio-frequency interference.
2. Dimmer or Dimmer-Module Rating: Not less than 125 percent of connected load unless otherwise indicated.

2.03 SYSTEM DESCRIPTION

A. Description: Microprocessor-based, solid-state controls consisting of control stations and a separately mounted dimmer cabinet.

1. Operation: Change variable dimmer settings of indicated number of zones simultaneously from one preset scene to another when a slider, push button, or software preset is operated.
2. System control shall include master station(s), wall stations, and dimmer panels.
3. Each zone shall be configurable to control the following light sources:

    a. Line-voltage incandescent lamps.
    b. Non-dimmed loads.
    c. LED lamps.

4. Control of each zone shall interface with controls for the following accessory functions:

    a. Curtains and drapes.
    b. Blackout curtains.
    c. Projector screens.

5. Memory: Retain preset scenes and fade settings through power failures for at least 90 days by retaining physical settings of controls or by an on-board, automatically recharged battery.

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 15, Subparts A and B, for Class A digital devices.

D. Comply with NFPA 70.

2.04 CONTROL NETWORK

A. Dimmers shall receive signals from control stations that are linked to dimmer cabinet with a common network data cable.

B. Functions of network control stations shall be set up at master station that include the number and arrangement of scene presets, zones, and fade times at wall stations.

1. Control Voltage: 24- or 10-V dc.
2. Communications: Ethernet and wireless,802.11g.

2.05 WALL STATIONS

A. Functions and Features:

1. Wall stations shall function as a submaster to a master station, containing limited control of selected scenes of the master station.
2. Numbered push buttons to select scenes.
3. Off switch to turn master station off.
4. On switch turns all scenes of master station to full bright.
5. Push-button controls for accessory functions.

B. Mounting: Flush, wall box with manufacturer's standard faceplate.

C. Hand-Held Cordless Control: Scene-select and accessory function push buttons using infrared or radio-frequency transmission.

2.06 DIMMER CABINETS

A. Factory wired, with barriers to accommodate 120- and 277-V feeders and suitable to control designated lighting equipment or accessory functions.

B. Ambient Conditions:

1. Temperature: 60 to 95 deg F (15 to 35 deg C).
2. Relative Humidity: 10 to 90 percent, noncondensing.
3. Filtered air supply.

C. Dimmer Cabinet Assembly: NRTL listed and labeled.

D. Cabinet Type: Plug in, modular, and accepting dimmers of each specified type in any plug-in position.

1. Integrated Fault-Current Rating: 10,000-A RMS symmetrical.

E. Lighting Dimmers: Solid-state SCR dimmers.

1. Primary Protection: Magnetic or thermal-magnetic circuit breaker, also serving as the disconnecting means.
2. Dimmer response to control signal shall follow the "Square Law Dimming Curve" specified in IESNA's "IESNA Lighting Handbook."
3. Dimming Range: 0 to 100 percent, full output voltage not less than 98 percent of line voltage.
4. Dimmed circuits shall be filtered to provide a minimum 350-mic.sec. current-rise time at a 90-degree conduction angle and 50 percent of rated dimmer capacity. Rate of current rise shall not exceed 30 mA/mic.sec., measured from 10 to 90 percent of load-current waveform.
5. Protect controls of each dimmer with a fuse and transient voltage surge suppression.

F. Non-dim modules shall include relays with contacts rated to switch 20-A tungsten-filament load at 120-V ac and 20-A electronic ballast load at 277-V ac.

G. Accessory function control modules shall be compatible with requirement of the accessory being controlled.

H. Digital Control Network:

1. Dimmers shall receive digital signals from digital network control stations that are linked to the dimmer cabinet with a common network data cable.
2. Functions of digital network control stations shall be set up at the dimmer cabinet's electronic controls that include indicated number and arrangement of scene presets, channels, and fade times.

I. Emergency Power Transfer Switch: Comply with UL 1008; factory prewired and pretested to automatically transfer load circuits from normal to emergency power supply when normal supply fails.

1. Transfer from normal to emergency supply when normal-supply voltage drops to 55 percent or less.
2. Retransfer immediately to normal on failure of emergency supply and after an adjustable time-delay of 10 to 90 seconds on restoration of normal supply while emergency supply is available.
3. Integrated Fault-Current Rating: Same value as listed for the panel.
4. Test Switch: Simulate failure of normal supply to test controls associated with transfer scheme.
5. Fabricate and test dimmer boards to withstand seismic forces defined in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

2.07 PORTABLE COMPUTER

A. Description: As recommended by master-control-station manufacturer, to program master station and associated wall stations. Portable computer shall be laptop style with a battery runtime of at least two hours. Display shall be an 11-inch (280-mm) interactive-matrix LCD and shall have required hardware, firmware, and software to program specified control functions of master-control stations.

B. Software shall be configured and customized by master-station manufacturer.

2.08 MANUAL SWITCHES AND PLATES

A. Switches: Modular, momentary push-button, low-voltage type.

1. Color: match wiring devices unless otherwise indicated.
2. Integral Pilot Light: Indicate when circuit is on. Use where indicated.
3. Locator Light: Internal illumination.
4. Wall Plates: Comply with requirements in Section 26 27 26 "Wiring Devices" for materials, finish, and color. Use multigang plates if more than one switch is indicated at a location.
5. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.09 CONDUCTORS AND CABLES

A. Wiring to Supply Side of Remote-Control Power Sources: Not smaller than No. 12 AWG. Comply with requirements in Section 26 05 19 "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 26 05 19 "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 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

D. Unshielded, Twisted-Pair Data Cable: Category 6. Comply with requirements in Section 27 15 00 "Communications Horizontal Cabling."

PART 3 - EXECUTION

3.01 WIRING INSTALLATION

A. Comply with NECA 1.

B. Wiring Method:

1. Comply with requirements in Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."
2. Install unshielded, twisted-pair cable for control and signal transmission conductors, complying with Section 27 15 00 "Communications Horizontal Cabling."
3. Minimum conduit size shall be 1/2 inch (13 mm).

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points. Separate power-limited and nonpower-limited conductors according to conductor manufacturer's written instructions.

D. Size conductors according to lighting control device manufacturer's written instructions unless otherwise indicated.

E. Splices, Taps, and Terminations: Make connections only on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures.

F. Install dimmer cabinets for each zone.

3.02 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems" for identifying components and power and control wiring.

B. Label each dimmer module with a unique designation.

C. Label each scene control button with approved scene description.

3.03 FIELD QUALITY CONTROL

A. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Continuity tests of circuits.
2. Operational Test: Set and operate controls to demonstrate their functions and capabilities in a methodical sequence that cues and reproduces actual operating functions.

    a. Include testing of dimming control equipment under conditions that simulate actual operational conditions. Record control settings, operations, cues, and functional observations.

3. Emergency Power Transfer: Test listed functions.

B. Remove and replace malfunctioning dimming control components and retest as specified above.

C. Test Labeling: After satisfactory completion of tests and inspections, apply a label to tested components indicating test results, date, and responsible agency and representative.

D. Reports: Written reports of tests and observations. Record defective materials and workmanship and unsatisfactory test results. Record repairs and adjustments.

3.04 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, service agreement shall include software support for two years.

B. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule and access the system and to upgrade computer equipment if necessary.

3.05 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain central dimming controls. Laptop portable computer shall be used in training.

END OF SECTION

SECTION 26 09 43

NETWORK LIGHTING CONTROLS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes manually operated lighting controls with relays, time clock, photocell control, external source relays and control module.

B. Related Sections:

1. Section 26 09 23 "Lighting Control Devices" for photoelectric sensors, occupancy sensors, and multipole contactors.

1.03 MANDATORY PROGRAMMING MEETING

A. 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.

1.04 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.

1.05 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.

1.06 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.

1.07 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.

1.08 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.

1.09 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 26 24 16 "Panelboards."

1.10 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.

1.11 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

2.01 MANUFACTURERS

A. Basis-of-Design Product: Subject to compliance with requirements, provide Eaton Greengate LK series or comparable product by one of the following:

1. Hubbell Building Automation
2. Leviton Mfg. Company Inc.
3. Lightolier Controls; a division of Genlyte Group, LLC.
4. Lutron Electronics Co., Inc.

2.02 SYSTEM REQUIREMENTS

A. Expandability: System shall be capable of increasing the number of control functions in the future by 25 percent of current capacity; to include equipment ratings, housing capacities, spare relays, terminals, number of conductors in control cables, and control software.

B. 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.

2.03 CONTROL MODULE

A. Control Module Description: Comply with UL 508 (CAN/CSA C22.2, No. 14); microprocessor-based 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 and include integral astronomical time clock.

2.04 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, 277-V ac for LED
   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 26 43 13 "Transient-Voltage Suppression for Low-Voltage Electrical Power Circuits" for Category A locations.

2.05 MANUAL ANALOG SWITCHES AND PLATES

A. Push-Button : Modular, momentary-contact, low-voltage type.

1. Match color specified in Section 26 27 26 "Wiring Devices."
2. Integral green LED pilot light to indicate when circuit is on.

B. Manual, Maintained Contact, Full- or Low-Voltage Switch: Comply with Section 26 27 26 "Wiring Devices."

C. Wall Plates: Single and multi-gang plates as specified in Section 26 27 26 "Wiring Devices."

D. Legend: Engraved or permanently silk-screened on wall plate where indicated. Use designations indicated on Drawings.

2.06 CONDUCTORS AND CABLES

A. Power Wiring to Supply Side of Class 2 Power Source: Not smaller than No. 12 AWG, complying with Section 26 05 19 "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 26 05 19 "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 26 05 19 "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 6 for horizontal copper cable and with Section 27 15 00 "Communications horizontal cabling."

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

3.01 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 26 05 19 "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 26 05 23 "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 26 05 53 "Identification for Electrical Systems."

3.02 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.

3.03 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.

3.04 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.

3.05 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

SECTION 26 22 00

LOW-VOLTAGE TRANSFORMERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. This Section includes the following types of dry-type transformers rated 600 V and less, with capacities up to 1000 kVA:

1. Distribution transformers.
2. Buck-boost transformers.

1.03 ACTION SUBMITTALS

A. Product Data: Include rated nameplate data, capacities, weights, dimensions, minimum clearances, installed devices and features, and performance for each type and size of transformer indicated.

B. Shop Drawings: Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.

1. Wiring Diagrams: Power, signal, and control wiring.

1.04 INFORMATIONAL SUBMITTALS

A. Manufacturer Seismic Qualification Certification: Submit certification that transformers, accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems." Include the following:

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.

a. 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."

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.

B. Source quality-control test reports.

C. Field quality-control test reports.

1.05 CLOSEOUT SUBMITTALS

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

1.06 QUALITY ASSURANCE

A. Source Limitations: Obtain each transformer type through one source from a single manufacturer.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, Article 100, by a testing agency acceptable to authorities having jurisdiction, and marked for intended use.

C. Comply with IEEE C57.12.91, "Test Code for Dry-Type Distribution and Power Transformers."

1.07 DELIVERY, STORAGE, AND HANDLING

A. Temporary Heating: Apply temporary heat according to manufacturer's written instructions within the enclosure of each ventilated-type unit, throughout periods during which equipment is not energized and when transformer is not in a space that is continuously under normal control of temperature and humidity.

1.08 COORDINATION

A. Coordinate size and location of concrete bases with actual transformer provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

B. Coordinate installation of wall-mounting and structure-hanging supports with actual transformer provided.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. ACME Electric Corporation; Power Distribution Products Division.
2. Eaton Electrical Inc.; Cutler-Hammer Products.
3. General Electric Company.
4. Siemens Energy & Automation, Inc.
5. Sola/Hevi-Duty.
6. Square D; Schneider Electric.

2.02 GENERAL TRANSFORMER REQUIREMENTS

A. Description: Factory-assembled and -tested, air-cooled units for 60-Hz service.

B. Cores: Grain-oriented, non-aging silicon steel.

C. Coils: Continuous windings without splices except for taps.

1. Internal Coil Connections: Brazed or pressure type.
2. Coil Material: Aluminum.

2.03 DISTRIBUTION TRANSFORMERS

A. Comply with NEMA ST 20, and list and label as complying with UL 1561.

B. Provide transformers that are constructed to withstand seismic forces specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Cores: One leg per phase.

D. Enclosure: Ventilated, NEMA 250, Type 2 unless otherwise noted.

1. Core and coil shall be encapsulated within resin compound, sealing out moisture and air.

E. Transformer Enclosure Finish: Comply with NEMA 250.

1. Finish Color: Gray

F. Taps for Transformers Smaller Than 3 kVA: None

G. Taps for Transformers 7.5 to 24 kVA: One 5 percent tap above and one 5 percent tap below normal full capacity.

H. Taps for Transformers 25 kVA and Larger: Two 2.5 percent taps above and two 2.5 percent taps below normal full capacity.

I. Insulation Class: 220 deg C, UL-component-recognized insulation system with a maximum of 150 deg C rise above 40 deg C ambient temperature.

J. Energy Efficiency for Transformers Rated 15 kVA and Larger:

1. Complying with NEMA TP 1, Class 1 efficiency levels.
2. Tested according to NEMA TP 2.

K. K-Factor Rating: Transformers indicated to be K-factor rated shall comply with UL 1561 requirements for nonsinusoidal load current-handling capability to the degree defined by designated K-factor.

1. Unit shall not overheat when carrying full-load current with harmonic distortion corresponding to designated K-factor.
2. Indicate value of K-factor on transformer nameplate.

L. Electrostatic Shielding: Each winding shall have an independent, single, full-width copper electrostatic shield arranged to minimize interwinding capacitance.

1. Arrange coil leads and terminal strips to minimize capacitive coupling between input and output terminals.
2. Include special terminal for grounding the shield.
3. Shield Effectiveness:

    a. Capacitance between Primary and Secondary Windings: Not to exceed 33 picofarads over a frequency range of 20 Hz to 1 MHz.
    b. Common-Mode Noise Attenuation: Minimum of minus 120 dBA at 0.5 to 1.5 kHz; minimum of minus 65 dBA at 1.5 to 100 kHz.
    c. Normal-Mode Noise Attenuation: Minimum of minus 52 dBA at 1.5 to 10 kHz.

M. Wall Brackets: Manufacturer's standard brackets.

N. Low-Sound-Level Requirements: Maximum sound levels, when factory tested according to IEEE C57.12.91, as follows:

1. 9 kVA and Less: 37dBA.
2. 30 to 50 kVA: 42dBA.
3. 51 to 150 kVA: 47dBA.
4. 151 to 300 kVA: 52dBA.

2.04 BUCK-BOOST TRANSFORMERS

A. Description: Self-cooled, two-winding dry type, rated for continuous duty and with wiring terminals suitable for connection as autotransformer. Transformers shall comply with NEMA ST 1 and shall be listed and labeled as complying with UL 506 or UL 1561.

B. Enclosure: Ventilated, NEMA 250, Type 2.

1. Finish Color: Gray

2.05 IDENTIFICATION DEVICES

A. Nameplates: Engraved, laminated-plastic or metal nameplate for each transformer, mounted with corrosion-resistant screws. Nameplates and label products are specified in Section 26 05 53 "Identification for Electrical Systems."

2.06 SOURCE QUALITY CONTROL

A. Test and inspect transformers according to IEEE C57.12.91.

B. Factory Sound-Level Tests: Conduct sound-level tests on equipment for this Project.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine conditions for compliance with enclosure- and ambient-temperature requirements for each transformer.

B. Verify that field measurements are as needed to maintain working clearances required by NFPA 70 and manufacturer's written instructions.

C. Examine walls, floors, roofs, and concrete bases for suitable mounting conditions where transformers will be installed.

D. Verify that ground connections are in place and requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems" have been met. Maximum ground resistance shall be 5 ohms at location of transformer.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install wall-mounting transformers level and plumb with wall brackets fabricated by transformer manufacturer.

1. Brace wall-mounting transformers as specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Construct concrete bases and anchor floor-mounting transformers according to manufacturer's written instructions, seismic codes applicable to Project, and requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems."

3.03 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.04 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. Remove and replace units that do not pass tests or inspections and retest as specified above.

D. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

3.05 ADJUSTING

A. Record transformer secondary voltage at each unit for at least 48 hours of typical occupancy period. Adjust transformer taps to provide optimum voltage conditions at secondary terminals. Optimum is defined as not exceeding nameplate voltage plus 10 percent and not being lower

than nameplate voltage minus 3 percent at maximum load conditions. Submit recording and tap settings as test results.

B. Connect buck-boost transformers to provide nameplate voltage of equipment being served, plus or minus 5 percent, at secondary terminals.

C. Output Settings Report: Prepare a written report recording output voltages and tap settings.

3.06 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

END OF SECTION

SECTION 26 24 13

SWITCHBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Service and distribution switchboards rated 600 V and less.
2. Transient voltage suppression devices.
3. Disconnecting and overcurrent protective devices.
4. Instrumentation.
5. Accessory components and features.
6. Identification.

1.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Switchboards 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."

1.04 ACTION SUBMITTALS

A. Product Data: For each type of switchboard, overcurrent protective device, transient voltage suppression device, ground-fault protector, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, accessories, and finishes.

B. Shop Drawings: For each switchboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details, including required clearances and service space around equipment. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Detail short-circuit current rating of switchboards and overcurrent protective devices.
5. Include descriptive documentation of optional barriers specified for electrical insulation and isolation.

6. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
7. Include time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.05 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: Submit certification that switchboards, overcurrent protective devices, accessories, and components will withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems." Include the following:

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.

B. 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.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For switchboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Routine maintenance requirements for switchboards and all installed components.
2. Manufacturer's written instructions for testing and adjusting overcurrent protective devices.
3. Time-current coordination curves for each type and rating of overcurrent protective device included in switchboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.07 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. Potential Transformer Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
2. Control-Power Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than two of each size and type.
3. Indicating Lights: Equal to 10 percent of quantity installed for each size and type, but no fewer than one of each size and type.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An employer of workers qualified as defined in NEMA PB 2.1 and trained in electrical safety as required by NFPA 70E.

B. Source Limitations: Obtain switchboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

C. Product Selection for Restricted Space: Drawings indicate maximum dimensions for switchboards including clearances between switchboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

E. Comply with NEMA PB 2.

F. Comply with NFPA 70.

G. Comply with UL 891.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Deliver switchboards in sections or lengths that can be moved past obstructions in delivery path.

B. Remove loose packing and flammable materials from inside switchboards and install temporary electric heating (250 W per section) to prevent condensation.

C. Handle and prepare switchboards for installation according to NEMA PB 2.1.

1.10 PROJECT CONDITIONS

A. Environmental Limitations:

1. Do not deliver or install switchboards until spaces are enclosed and weathertight, wet work in spaces is complete and dry, work above switchboards is complete, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.
2. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

    a. Ambient Temperature: Not exceeding 104 deg F (40 deg C).
    b. Altitude: Not exceeding 6600 feet (2000 m).

B. Service Conditions: NEMA PB 2, usual service conditions, as follows:

1. Ambient temperatures within limits specified.
2. Altitude not exceeding 6600 feet (2000 m).

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

1. Notify Owner no fewer than seven days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of switchboards and components with other construction that penetrates walls or is supported by them, including electrical and other types of equipment, raceways, piping, encumbrances to workspace clearance requirements, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.12 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.

PART 2 - PRODUCTS

2.01 MANUFACTURED UNITS

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

1. 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. Front-Connected, Front-Accessible Switchboards:

1. Main Devices: Fixed, individually mounted.
2. Branch Devices: Panel mounted.
3. Sections rear aligned.

C. Nominal System Voltage: 480Y/277 V.

D. Main-Bus Continuous: 4000 A.

E. Seismic Requirements: Fabricate and test switchboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

F. Indoor Enclosures: Steel, NEMA 250, Type 1.

G. Enclosure Finish for Indoor Units: Factory-applied finish in manufacturer's standard gray finish over a rust-inhibiting primer on treated metal surface.

H. Barriers: Between adjacent switchboard sections.

I. Insulation and isolation for main bus of main section and main and vertical buses of feeder sections.

J. Customer Metering Compartment: A separate customer metering compartment and section with front hinged door, for indicated metering, and current transformers for each meter. Current transformer secondary wiring shall be terminated on shorting-type terminal blocks. Include potential transformers having primary and secondary fuses with disconnecting means and secondary wiring terminated on terminal blocks.

K. Bus Transition and Incoming Pull Sections: Matched and aligned with basic switchboard.

L. Hinged Front Panels: Allow access to circuit breaker, metering, accessory, and blank compartments.

M. Buses and Connections: Three phase, four wire unless otherwise indicated.

1. Phase- and Neutral-Bus Material: Hard-drawn copper of 98 percent conductivity or tin-plated, high-strength, electrical-grade aluminum alloy.
2. Ground Bus: Minimum-size required by UL 891, hard-drawn copper of 98 percent conductivity, equipped with mechanical connectors for feeder and branch-circuit ground conductors. For busway feeders, extend insulated equipment grounding cable to busway ground connection and support cable at intervals in vertical run.
3. Main Phase Buses and Equipment Ground Buses: Uniform capacity for entire length of switchboard's main and distribution sections. Provide for future extensions from branch end.
4. Neutral Buses: 100 percent of the ampacity of phase buses unless otherwise indicated, equipped with mechanical connectors for outgoing circuit neutral cables. Brace bus extensions for busway feeder neutral bus.
5. Isolation Barrier Access Provisions: Permit checking of bus-bolt tightness.

N. Future Devices: Equip compartments with mounting brackets, supports, bus connections, and appurtenances at full rating of circuit-breaker compartment.

2.02 TRANSIENT VOLTAGE SUPPRESSION DEVICES

A. Surge Protection Device Description: IEEE C62.41-compliant, integrally mounted, bolt-on, solid-state, parallel-connected, modular (with field-replaceable modules), with sine-wave tracking suppression and filtering modules, UL 1449, second edition, short-circuit current rating matching or exceeding the switchboard short-circuit rating, and with the following features and accessories:

1. Fuses, rated at 200-kA interrupting capacity.
2. Integral disconnect switch.
3. Redundant suppression circuits.
4. Redundant replaceable modules.
5. LED indicator lights for power and protection status.
6. Audible alarm, with silencing switch, to indicate when protection has failed.
7. Form-C contacts rated at 5 A and 250-V ac, one normally open and one normally closed, for remote monitoring of system operation. Contacts shall reverse position on failure of any surge diversion module or on opening of any current-limiting device. Coordinate with building power monitoring and control system.
8. Six-digit, transient-event counter set to totalize transient surges.

B. Peak Single-Impulse Surge Current Rating: 160 kA per mode/320 kA per phase.

C. Withstand Capabilities: 12,000 IEEE C62.41, Category C3 (10 kA), 8-by-20-mic.sec. surges with less than 5 percent change in clamping voltage.

D. Protection modes and UL 1449 SVR for grounded wye circuits with 480Y/277-V, three-phase, four-wire circuits shall be as follows:

1. Line to Neutral: 800 V for 480Y/277.
2. Line to Ground: 800 V for 480Y/277.
3. Neutral to Ground: 800 V for 480Y/277.

2.03 DISCONNECTING AND OVERCURRENT PROTECTIVE DEVICES

A. Molded-Case Circuit Breaker (MCCB): Comply with UL 489, with interrupting capacity to meet available fault currents.

1. Electronic trip circuit breakers with rms sensing; field-replaceable rating plug or field-replicable 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.

2. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
3. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
4. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

    a. Standard frame sizes, trip ratings, and number of poles.
    b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor material.
    c. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge (HID) lighting circuits.
    d. Ground-Fault Protection: Integrally mounted relay and trip unit with adjustable pickup and time-delay settings, push-to-test feature, and ground-fault indicator.
    e. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

f. Shunt Trip: 120-V trip coil energized from separate circuit, set to trip at 75 percent of rated voltage.
g. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
h. Auxiliary Contacts: Two SPDT switches with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
i. Key Interlock Kit: Externally mounted to prohibit circuit-breaker operation; key shall be removable only when circuit breaker is in off position.

2.04 INSTRUMENTATION

A. Instrument Transformers: IEEE C57.13, NEMA EI 21.1, and the following:
1. Current Transformers: IEEE C57.13; 5 A, 60 Hz, secondary; bar or window type; single secondary winding and secondary shorting device. Burden and accuracy shall be consistent with connected metering and relay devices.

B. Multifunction Digital-Metering Monitor: Microprocessor-based unit suitable for three- or four-wire systems and with the following features:

1. Switch-selectable digital display of the following values with maximum accuracy tolerances as indicated:

a. Phase Currents, Each Phase: Plus or minus 1 percent.
b. Phase-to-Phase Voltages, Three Phase: Plus or minus 1 percent.
c. Phase-to-Neutral Voltages, Three Phase: Plus or minus 1 percent.
d. Kilowatts: Plus or minus 2 percent.
e. Kilovars: Plus or minus 2 percent.
f. Power Factor: Plus or minus 2 percent.
g. Frequency: Plus or minus 0.5 percent.
h. Accumulated Energy, Kilowatt Hours: Plus or minus 2 percent; accumulated values unaffected by power outages up to 72 hours.
i. Kilowatt Demand: Plus or minus 2 percent; demand interval programmable from five to 60 minutes.
j. Contact devices to operate remote impulse-totalizing demand meter.

2. Mounting: Display and control unit flush or semiflush mounted in instrument compartment door.

3. Metering must comply with the Maine Advanced buildings metering requirements. Provide (1) category 6 data cable wired and connected from the switchboard meter to the building DDC system. Also, provide (1) category 6 data cable wired and connected from the switchboard meter to the building data network rack in the MDF room.

2.05 CONTROL POWER

A. Control Circuits: 120-V ac, supplied through secondary disconnecting devices from control-power transformer.

B. Control-Power Fuses: Primary and secondary fuses for current-limiting and overload protection of transformer and fuses for protection of control circuits.

C. Control Wiring: Factory installed, with bundling, lacing, and protection included. Provide flexible conductors for No. 8 AWG and smaller, for conductors across hinges, and for conductors for interconnections between shipping units.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

B. Portable Test Set: For testing functions of solid-state trip devices without removing from switchboard. Include relay and meter test plugs suitable for testing switchboard meters and switchboard class relays.

2.07 IDENTIFICATION

A. Service Equipment Label: NRTL labeled for use as service equipment for switchboards with one or more service disconnecting and overcurrent protective devices.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Receive, inspect, handle, and store switchboards according to NECA 400.

B. Examine switchboards before installation. Reject switchboards that are moisture damaged or physically damaged.

C. Examine elements and surfaces to receive switchboards for compliance with installation tolerances and other conditions affecting performance of the Work.

D. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install switchboards and accessories according to NECA 400.

B. Equipment Mounting: Install switchboards on concrete base, 4-inch (100-mm) nominal thickness. Comply with requirements for concrete base specified in Division 03.

1. Install dowel rods to connect concrete base to concrete floor. Unless otherwise indicated, install dowel rods on 18-inch (450-mm) centers around the full perimeter of concrete base.
2. For supported equipment, install epoxy-coated anchor bolts that extend through concrete base and anchor into structural concrete floor.
3. Place and secure anchorage devices. Use setting drawings, templates, diagrams, instructions, and directions furnished with items to be embedded.
4. Install anchor bolts to elevations required for proper attachment to switchboards.

C. Temporary Lifting Provisions: Remove temporary lifting eyes, channels, and brackets and temporary blocking of moving parts from switchboard units and components.

D. Comply with mounting and anchoring requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

E. Operating Instructions: Frame and mount the printed basic operating instructions for switchboards, including control and key interlocking sequences and emergency procedures. Fabricate frame of finished wood or metal and cover instructions with clear acrylic plastic. Mount on front of switchboards.

F. Install filler plates in unused spaces of panel-mounted sections.

G. Install overcurrent protective devices, transient voltage suppression devices, and instrumentation.

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

H. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Switchboard Nameplates: Label each switchboard compartment with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

C. Device Nameplates: Label each disconnecting and overcurrent protective device and each meter and control device mounted in compartment doors with a nameplate complying with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

1. Manufacturer's Field Service: Engage a factory-authorized service representative to inspect components, assemblies, and equipment installations, including connections, 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.
3. Perform the following infrared scan tests and inspections and prepare reports:

a. Initial Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switchboard. Remove front panels so joints and connections are accessible to portable scanner.
b. Follow-up Infrared Scanning: Perform an additional follow-up infrared scan of each switchboard 11 months after date of Substantial Completion.

c. Instruments and Equipment:

1) Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.

4. Test and adjust controls, remote monitoring, and safeties. Replace damaged and malfunctioning controls and equipment.

C. Switchboard will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports, including a certified report that identifies switchboards included and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges as specified in Section 26 05 73.16 "Overcurrent Protective Device Coordination Study."

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat, to maintain temperature according to manufacturer's written instructions, until switchboard is ready to be energized and placed into service.

3.07 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain switchboards, overcurrent protective devices, instrumentation, and accessories, and to use and reprogram microprocessor-based trip, monitoring, and communication units.

END OF SECTION

SECTION 26 24 16

PANELBOARDS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Distribution panelboards.
2. Lighting and appliance branch-circuit panelboards.

1.03 RELATED SECTIONS

A. Section 26 29 13 “Enclosed Controllers” for power shutoff switches associated with panelboard contactors.

1.04 DEFINITIONS

A. SVR: Suppressed voltage rating.

B. TVSS: Transient voltage surge suppressor.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of panelboard, switching and overcurrent protective device, transient voltage suppression device, accessory, and component indicated. Include dimensions and manufacturers' technical data on features, performance, electrical characteristics, ratings, and finishes.

B. Shop Drawings: For each panelboard and related equipment.

1. Include dimensioned plans, elevations, sections, and details. Show tabulations of installed devices, equipment features, and ratings.
2. Detail enclosure types and details for types other than NEMA 250, Type 1.
3. Detail bus configuration, current, and voltage ratings.
4. Short-circuit current rating of panelboards and overcurrent protective devices.
5. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices and auxiliary components.
6. Include wiring diagrams for power, signal, and control wiring.

7. Include time-current coordination curves for each type and rating of overcurrent protective device included in panelboards. Submit on translucent log-log graft paper; include selectable ranges for each type of overcurrent protective device.

1.06 INFORMATIONAL SUBMITTALS

A. 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.

B. Panelboard Schedules: For installation in panelboards. Submit final versions after load balancing.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For panelboards and components to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, 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.

1.08 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. Keys: Two spares for each type of panelboard cabinet lock.

1.09 QUALITY ASSURANCE

A. Source Limitations: Obtain panelboards, overcurrent protective devices, components, and accessories from single source from single manufacturer.

B. Product Selection for Restricted Space: Drawings indicate maximum dimensions for panelboards including clearances between panelboards and adjacent surfaces and other items. Comply with indicated maximum dimensions.

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

D. Comply with NEMA PB 1.

E. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Remove loose packing and flammable materials from inside panelboards.

B. Handle and prepare panelboards for installation according to NECA 407.

1.11 PROJECT CONDITIONS

A. Environmental Limitations:

1. Rate equipment for continuous operation under the following conditions unless otherwise indicated:

   a. Ambient Temperature: Not exceeding minus 22 deg F (minus 30 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).

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

1. Notify Owner no fewer than five days in advance of proposed interruption of electric service.
2. Do not proceed with interruption of electric service without Owner's written permission.
3. Comply with NFPA 70E.

1.12 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.

B. Coordinate sizes and locations of concrete bases with actual equipment provided. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.

1.13 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.

PART 2 - PRODUCTS

2.01 GENERAL REQUIREMENTS FOR PANELBOARDS

A. Fabricate and test panelboards according to IEEE 344 to withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

B. Enclosures: Flush- and surface-mounted cabinets as indicated on the drawings.

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.

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 feeder locations.

D. Phase, Neutral, and Ground Buses:

1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
2. Equipment Ground Bus: Adequate for feeder and branch-circuit equipment grounding conductors; bonded to box.

E. Conductor Connectors: Suitable for use with conductor material and sizes.

1. Material: Tin-plated aluminum or Hard-drawn copper, 98 percent conductivity.
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.

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.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Panelboards 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."

B. Surge Suppression: Factory installed as an integral part of indicated panelboards, complying with UL 1449 SPD Type 2.

2.03 DISTRIBUTION 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.
5. Panelboards: NEMA PB 1, power and feeder distribution type.

B. Doors: Secured with vault-type latch with tumbler lock; keyed alike.

1. For doors more than 36 inches (914 mm) high, provide two latches, keyed alike.

C. Mains: Circuit breaker or Lugs only as scheduled.

D. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes 125 A and Smaller: Bolt-on circuit breakers.

E. Branch Overcurrent Protective Devices for Circuit-Breaker Frame Sizes Larger Than 125 A: Bolt-on circuit breakers; plug-in circuit breakers where individual positive-locking device requires mechanical release for removal.

F. 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.

2.04 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: Circuit breaker or lugs only as scheduled.

D. Branch Overcurrent Protective Devices: Bolt-on circuit breakers, replaceable without disturbing adjacent units.

E. Doors: Concealed hinges; secured with flush latch with tumbler lock; keyed alike.

F. Column-Type Panelboards: Narrow gutter extension, with cover, to overhead junction box equipped with ground and neutral terminal buses.

A. 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.

2.05 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. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller; let-through ratings less than NEMA FU 1, RK-5.
4. GFCI Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).
5. Ground-Fault Equipment Protection (GFEP) Circuit Breakers: Class B ground-fault protection (30-mA trip).
6. Molded-Case Circuit-Breaker (MCCB) Features and Accessories:

a. Standard frame sizes, trip ratings, and number of poles.
b. Lugs: Mechanical style, suitable for number, size, trip ratings, and conductor 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: 120-V trip coil energized from separate circuit, set to trip at 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 or off position.
j. Handle Clamp: Loose attachment, for holding circuit-breaker handle in on position.

2.06 ACCESSORY COMPONENTS AND FEATURES

A. Accessory Set: Include tools and miscellaneous items required for overcurrent protective device test, inspection, maintenance, and operation.

PART 3 - EXECUTION

3.01 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.

3.02 INSTALLATION

A. Install panelboards and accessories according to NECA 407.

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 after completing load balancing.

H. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs complying with Section 26 05 53 "Identification for Electrical Systems."

B. Create a directory to indicate installed circuit loads after balancing panelboard loads; incorporate Owner's final room designations. Obtain approval before installing. Use a computer or typewriter to create directory; handwritten directories are not acceptable.

C. Panelboard Nameplates: Label each panelboard with a nameplate complying with requirements for identification specified in Section 26 05 53 "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 Section 26 05 53 "Identification for Electrical Systems."

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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.

3.05 ADJUSTING

A. Adjust moving parts and operable component to function smoothly, and lubricate as recommended by manufacturer.

B. Load Balancing: After Substantial Completion, but not more than 60 days after Final Acceptance, measure load balancing and make circuit changes.

1. Measure as directed during period of normal system loading.
2. Perform load-balancing circuit changes outside normal occupancy/working schedule of the facility and at time directed. Avoid disrupting critical 24-hour services such as fax machines and on-line data processing, computing, transmitting, and receiving equipment.
3. After circuit changes, recheck loads during normal load period. Record all load readings before and after changes and submit test records.

4. Tolerance: Difference exceeding 20 percent between phase loads, within a panelboard, is not acceptable. Rebalance and recheck as necessary to meet this minimum requirement.

END OF SECTION

SECTION 26 25 00

ENCLOSED BUS ASSEMBLIES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Plug-in bus assemblies.
2. Bus plug-in devices.

1.03 DEFINITIONS

A. kAIC: kiloampere interrupting capacity.

B. SPD: Surge protective device.

1.04 ACTION SUBMITTALS

A. Shop Drawings: For each type of product.

1. Show fabrication and installation details for enclosed bus assemblies. Include plans, elevations, and sections of components. Designate components and accessories, including clamps, brackets, hanger rods, connectors, straight lengths, and fittings.
2. Indicate required clearances, method of field assembly, and location and size of each field connection.
3. Cable and conductor terminal sizes for bus and plug-in device terminations.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Floor plans and sections, drawn to scale. Include scaled bus-assembly layouts and relationships between components and adjacent structural, mechanical, and electrical elements. Show the following:
1. Clearances for access above and to the side of enclosed bus assemblies.
2. Vertical elevation of enclosed bus assemblies above the floor or bottom of structure.
3. Support locations, type of support, and weight on each support.
4. Location of adjacent construction elements including luminaires, HVAC and plumbing equipment, fire sprinklers and piping, signal and control devices, and other equipment.

B. Qualification Data: For testing agency.

C. Seismic Qualification Certificates: For enclosed bus assemblies, plug-in devices, accessories, and components.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

D. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed bus assemblies to include in emergency, operation, and maintenance manuals.

1.07 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. Plug-in Units: 1 for each size indicated.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Deliver, store, and handle enclosed bus assemblies according to NEMA BU 1.1, "General Instructions for Handling, Installation, Operation, and Maintenance of Busway Rated 600 Volts or Less."

PART 2 - PRODUCTS

2.01 ASSEMBLY DESCRIPTIONS

A. Source Limitations: Obtain enclosed bus assemblies and plug-in devices 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 UL 857.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed bus assemblies, plug-in devices, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to the seismic forces specified."

2. Component Importance Factor: 1**.5**

B. Derate enclosed bus assemblies for continuous operation at indicated ampere ratings for ambient temperature not exceeding **22 deg F (50 deg C)**.

2.03 ENCLOSED BUS ASSEMBLIES

A. Plug-in Bus Assemblies: Low-impedance bus assemblies in totally enclosed, nonventilated housing; single-bolt joints; ratings as indicated.

1. Electrical Characteristics:

   a. Voltage: 120/208 V.
   b. Phase: Three phase; 4 wire.
   c. Percent of Neutral Capacity:100

2. Short-Circuit Interrupting Rating: shall match KAIC rating of the panel that feeds the bus.
3. Temperature Rise: 55 deg C above 40 deg C ambient maximum for continuous rated current.
4. Bus Materials: Current-carrying copper conductors, fully insulated with Class 130C insulation except at stabs and joints; plated surface at stabs and joints.
5. Ground: 50 percent capacity, integral with housing.
6. Enclosure: Steel with manufacturer's standard finish.
7. Plug-in Openings: 24 inches (600 mm) o.c. on each side of bus, and hinged covers over unused openings. Plug-in openings shall be finger-safe with covers open or closed.
8. Fittings and Accessories: Manufacturer's standard.
9. Mounting: Arranged flat, edgewise, or vertically without derating. Rated for hanger spacing of up to 10 feet (3 m) for horizontally mounted runs.
10. Expansion Section: Manufacturer's standard expansion fitting for the provided busway with expansion capability to accommodate thermal expansion of bus and enclosure, and to accommodate movement across building expansion joints.

B. Joints:

1. Busway joints shall use one high-strength steel bolt with Belleville washers.
2. Bolts shall be torque indicating type and at ground potential.
3. Bolts shall be two-headed design to indicate when proper torque has been applied and require only a standard long handle wrench to be properly activated.
4. Access shall be required to only one side of the busway for tightening joint bolts.
5. Joint connection assemblies shall be removable without disturbing adjacent busway lengths.
6. Joint connection assemblies that rely on the joint cover to provide ground continuity are unacceptable.

2.04 PLUG-IN DEVICES

A. Fusible Switches: NEMA KS 1, heavy duty; with **R-type rejection** fuse clips to accommodate specified fuses; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position. See Section 26 28 13 "Fuses" for fuses and fuse installation requirements.

B. Molded-Case Circuit Breakers: UL 489; hookstick-operated handle, lockable with two padlocks, and interlocked with cover in closed position. Interlocked to prevent plug-in device insertion into or removal from bus with switch in closed position.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Coordinate layout and installation of enclosed bus assemblies and suspension system with other construction that penetrates ceilings or floors or is supported by them, including luminaires, HVAC equipment, fire-suppression system, and partition assemblies.

B. Support bus assemblies independent of supports for other elements such as equipment enclosures at connections to panelboards and switchboards, pipes, conduits, ceilings, and ducts.

1. Design each fastener and support to carry load indicated by seismic requirements and to comply with seismic-restraint details according to Section 26 05 48 "Seismic Controls for Electrical Systems."
2. Design each fastener and support to carry 200 lb (90 kg) or 4 times the weight of bus assembly, whichever is greater.
3. Support bus assembly to prevent twisting from eccentric loading.
4. Support bus assembly with not less than **3/8-inch (10-mm)** steel rods. Install side bracing to prevent swaying or movement of bus assembly. Modify supports after completion to eliminate strains and stresses on bus bars and housings.
5. Fasten supports securely to building structure according to Section 26 05 29 "Hangers and Supports for Electrical Systems."
6. Bolts and nuts that are loosened for any reason after tightening to manufacturer's recommended torque setting shall be discarded and replaced with new bolts and nuts.

C. Install expansion fittings at locations where bus assemblies cross building expansion joints. Install at other locations so distance between expansion fittings does not exceed manufacturer's recommended distance between fittings.

D. Coordinate bus-assembly terminations to equipment enclosures to ensure proper phasing, connection, and closure.

E. Tighten bus-assembly joints with torque wrench or similar tool recommended by bus-assembly manufacturer. Tighten joints again after bus assemblies have been energized for 30 days.

F. Install bus-assembly, plug-in units. Support connecting conduit independent of plug-in unit.

G. Comply with NECA 1.

3.02 CONNECTIONS

A. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

B. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections:

1. After installing equipment test, for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

    a. Compare equipment nameplate data with Drawings and Specifications.
    b. Inspect physical and mechanical condition.
    c. Inspect anchorage, alignment, and grounding.
    d. Verify correct connection according to single-line diagram.
    e. Inspect bolted electrical connections for high resistance using one or more of the following methods:

        1) Use of low-resistance ohmmeter.
        2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.
        3) Perform thermographic survey.

3. Electrical Tests:

    a. Perform insulation resistance measurements through bolted connections and bus joints with low-resistance ohmmeter.
    b. Perform insulation resistance tests of each busway, phase to phase, and phase to ground.
    c. Perform a dielectric withstand voltage test on each busway, phase to ground with phases not under test grounded for one minute.
    d. Perform phasing test on each busway tie section energized by separate sources.

C. Test Labeling: On completion of satisfactory testing of each unit, attach a dated and signed "Satisfactory Test" label to tested component.

D. Enclosed bus assemblies will be considered defective if they do not pass tests and inspections.

E. Prepare test and inspection reports.

3.04 ADJUSTING

A. Set field-adjustable, circuit-breaker trip ranges.

3.05 CLEANING

A. Vacuum dirt and debris; do not use compressed air to assist in cleaning.

3.06 PROTECTION

A. Provide final protection to ensure that moisture does not enter bus assembly.

END OF SECTION

SECTION 26 27 13

ELECTRICITY METERING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes equipment for electricity metering by utility company.

1.03 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.

1.04 QUALITY ASSURANCE

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

1.05 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.

1.06 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

2.01 EQUIPMENT FOR ELECTRICITY METERING BY UTILITY COMPANY

A. Meters will be furnished by utility company.

B. Meter Sockets: Comply with requirements of electrical-power utility company.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with equipment installation requirements in NECA 1.

3.02 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Equipment Identification Labels: Adhesive film labels with clear protective overlay.

END OF SECTION

SECTION 26 27 26

WIRING DEVICES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Receptacles, receptacles with integral GFCI, and associated device plates.
2. Twist-locking receptacles.
3. Weather-resistant receptacles.
4. Snap switches and wall-box dimmers.
5. Pendant cord-connector devices.
6. Cord and plug sets.

1.03 DEFINITIONS

A. EMI: Electromagnetic interference.

B. GFCI: Ground-fault circuit interrupter.

C. Pigtail: Short lead used to connect a device to a branch-circuit conductor.

D. RFI: Radio-frequency interference.

1.04 ADMINISTRATIVE REQUIREMENTS

A. Coordination:

1. Receptacles for Owner-Furnished Equipment: Match plug configurations.
2. Retain "Cord and Plug Sets" Subparagraph below if retaining "Cord and Plug Sets" Cord and Plug Sets: Match equipment requirements.

1.05 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: List of legends and description of materials and process used for premarking wall plates.

1.06 INFORMATIONAL SUBMITTALS

A. Field quality-control reports.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For wiring devices to include in all manufacturers' packing-label warnings and instruction manuals that include labeling conditions.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Cooper Wiring Devices, Inc.; Division of Cooper Industries, Inc.
2. Hubbell Incorporated; Wiring Device-Kellems.
3. Leviton Manufacturing Co., Inc.

B. Source Limitations: Obtain each type of wiring device and associated wall plate from single source from single manufacturer.

2.02 GENERAL WIRING-DEVICE REQUIREMENTS

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

B. Comply with NFPA 70.

C. Devices that are manufactured for use with modular plug-in connectors may be substituted under the following conditions:

1. Connectors shall comply with UL 2459 and shall be made with stranding building wire.
2. Devices shall comply with the requirements in this Section.

2.03 STRAIGHT-BLADE RECEPTACLES

A. Convenience Receptacles, 125 V, 20 A: Comply with NEMA WD 1, NEMA WD 6 Configuration 5-20R, UL 498, and FS W-C-596.

B. Provide other NEMA configurations and ratings as indicated on drawings and schedules.

2.04 GFCI RECEPTACLES

A. General Description:

1. Straight blade, non-feed-through type.
2. Comply with NEMA WD 1, NEMA WD 6, UL 498, UL 943 Class A, and FS W-C-596.

3. Include indicator light that shows when the GFCI has malfunctioned and no longer provides proper GFCI protection.

B. Duplex GFCI Convenience Receptacles, 125 V, 20 A, NEMA 5-20R.

C. Provide other NEMA configurations and ratings as indicated on drawings and schedules.

2.05 TWIST-LOCKING RECEPTACLES

A. Comply with NEMA WD 1, NEMA WD 6 configurations as indicated on the drawings, and UL 498.

2.06 PENDANT CORD-CONNECTOR DEVICES

A. Description:

1. Matching, locking-type plug and receptacle body connector.
2. NEMA WD 6 Configurations as indicated on the drawings, heavy-duty grade, and FS W-C-596.
3. Body: Nylon, with screw-open, cable-gripping jaws and provision for attaching external cable grip.
4. External Cable Grip: Woven wire-mesh type made of high-strength, galvanized-steel wire strand, matched to cable diameter, and with attachment provision designed for corresponding connector.

2.07 CORD AND PLUG SETS

A. Description:

1. Match voltage and current ratings and number of conductors to requirements of equipment being connected.
2. Cord: Rubber-insulated, stranded-copper conductors, with Type SOW-A jacket; with green-insulated grounding conductor and ampacity of at least 130 percent of the equipment rating.
3. Plug: Nylon body and integral cable-clamping jaws. Match cord and receptacle type for connection.

2.08 TOGGLE SWITCHES

A. Comply with NEMA WD 1, UL 20, and FS W-S-896.

B. Switches, 120/277 V, 20 A:

1. Single Pole:
2. Two Pole:
3. Three Way:
4. Four Way:

C. Pilot-Light Switches, 20 A:

1. Description: Single pole, with neon-lighted handle, illuminated when switch is "off."

D. Toggle switches that are located in the same location as low voltage switches shall match color and type/style.

2.09 LOW-VOLTAGE SWITCHES

A. Push-button momentary-contact type.

B. Where control of multiple switch groups is indicated, provide a separately wired button for each control group mounted to a common device yoke.

2.10 WALL-BOX DIMMERS (Tag SosD)

A. Dimmer Switches: Modular, full-wave, solid-state units with integral, quiet on-off switches, with audible frequency and EMI/RFI suppression filters.

B. Control: Continuously adjustable slider; with single-pole or three-way switching. Comply with UL 1472.

C. LED Dimmer Switches: Modular; compatible with LED drivers; 0-10V dimming; trim potentiometer to adjust low-end dimming; dimmer-ballast or dimmer-driver combination capable of consistent dimming with low end not greater than 5 percent of full brightness.

2.11 WALL PLATES

A. Single and combination types shall match corresponding wiring devices.

1. Plate-Securing Screws: Metal with head color to match plate finish.
2. Third option in "Material for Finished Spaces" Subparagraph below is also available in Type 430 but is susceptible to rust and corrosion even in finished spaces.
3. Material for Finished Spaces: 0.035-inch- (1-mm-) thick, satin-finished, Type 302 stainless steel.
4. Material for Unfinished Spaces: Galvanized steel.
5. Material for Damp Locations: Cast aluminum with spring-loaded lift cover, and listed and labeled for use in wet and damp locations.

B. Wet-Location, Weatherproof Cover Plates: NEMA 250, complying with Type 3R, weather-resistant, die-cast aluminum with lockable cover.

C. Plates shall be Factory engraved “GENERATOR” for receptacles connected to generator-connected panels.

2.12 FINISHES

A. Device Color:

1. Wiring Devices: As selected by Architect unless otherwise indicated or required by NFPA 70 or device listing.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Comply with NECA 1, including mounting heights listed in that standard, unless otherwise indicated.

B. Coordination with Other Trades:

1. Protect installed devices and their boxes. Do not place wall finish materials over device boxes and do not cut holes for boxes with routers that are guided by riding against outside of boxes.
2. Keep outlet boxes free of plaster, drywall joint compound, mortar, cement, concrete, dust, paint, and other material that may contaminate the raceway system, conductors, and cables.
3. Install device boxes in brick or block walls so that the cover plate does not cross a joint unless the joint is troweled flush with the face of the wall.
4. Install device boxes so that the cover plate does not cross a joint in wall finish materials unless the joint is troweled flush with the face of the wall.
5. Install wiring devices after all wall preparation, including painting, is complete.

C. Conductors:

1. Do not strip insulation from conductors until right before they are spliced or terminated on devices.
2. Strip insulation evenly around the conductor using tools designed for the purpose. Avoid scoring or nicking of solid wire or cutting strands from stranded wire.
3. The length of free conductors at outlets for devices shall meet provisions of NFPA 70, Article 300, without pigtails.

D. Device Installation:

1. Replace devices that have been in temporary use during construction and that 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, two-thirds to three-fourths of the way around terminal screw.
6. Use a torque screwdriver when a torque is recommended or required by 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. Retain first subparagraph below if the position of the ground pin is important for consistency. Trade and professional literature is inconsistent in recommending benefits of either orientation.

2. Install ground pin of vertically mounted receptacles up, and on horizontally mounted receptacles to the left.

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. Dimmers:

1. Install dimmers within terms of their listing.
2. Install unshared neutral conductors on line and load side of dimmers according to manufacturers' device listing conditions in the written instructions.

H. Arrangement of Devices: Unless otherwise indicated, mount flush, with long dimension vertical. Group adjacent switches under single, multigang wall plates.

3.02 GFCI RECEPTACLES

A. Install non-feed-through-type GFCI receptacles where protection of downstream receptacles is not required.

3.03 IDENTIFICATION

A. Comply with Section 26 05 53 "Identification for Electrical Systems."

B. Identify each receptacle with panelboard identification and circuit number. Use hot, stamped, or engraved machine printing with-filled lettering on face of plate, and durable wire markers or tags inside outlet boxes.

3.04 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Test Instruments: Use instruments that comply with UL 1436.
2. Test Instrument for Convenience Receptacles: Digital wiring analyzer with digital readout or illuminated digital-display 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 unacceptable.
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. Tests shall be diagnostic, indicating damaged conductors, high resistance at the circuit breaker, poor connections, inadequate fault current path, defective devices, or similar problems. Correct circuit conditions, remove malfunctioning units and replace with new ones, and retest as specified above.

C. Wiring device will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

END OF SECTION

SECTION 26 28 13

FUSES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Cartridge fuses rated 600-V ac and less for use in control circuits, enclosed switches, and enclosed controllers.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material, dimensions, descriptions of individual components, and finishes for spare-fuse cabinets. Include the following for each fuse type indicated:

1. Ambient Temperature Adjustment Information: If ratings of fuses have been adjusted to accommodate ambient temperatures, provide list of fuses with adjusted ratings.

    a. For each fuse having adjusted ratings, include location of fuse, original fuse rating, local ambient temperature, and adjusted fuse rating.
    b. Provide manufacturer's technical data on which ambient temperature adjustment calculations are based.

2. Dimensions and manufacturer's technical data on features, performance, electrical characteristics, and ratings.
3. Current-limitation curves for fuses with current-limiting characteristics.
4. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
5. Coordination charts and tables and related data.
6. Fuse sizes for elevator feeders and elevator disconnect switches.

1.04 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fuses to include in emergency, operation, and maintenance manuals. In addition to items specified Division 01, include the following:

1. Ambient temperature adjustment information.
2. Current-limitation curves for fuses with current-limiting characteristics.
3. Time-current coordination curves (average melt) and current-limitation curves (instantaneous peak let-through current) for each type and rating of fuse.
4. Coordination charts and tables and related data.

1.05 MAINTENANCE MATERIAL SUBMITTALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Fuses: Equal to 10 percent of quantity installed for each size and type, but no fewer than three of each size and type.

1.06 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.

1.07 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.

1.08 COORDINATION

A. Coordinate fuse ratings with utilization equipment nameplate limitations of maximum fuse size and with system short-circuit current levels.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

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

1. Cooper Bussmann, Inc.
2. Edison Fuse, Inc.
3. Ferraz Shawmut, Inc.
4. Littelfuse, Inc.

2.02 CARTRIDGE FUSES

A. Characteristics: NEMA FU 1, nonrenewable cartridge fuses with voltage ratings consistent with circuit voltages.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine fuses before installation. Reject fuses that are moisture damaged or physically damaged.

B. Examine holders to receive fuses for compliance with installation tolerances and other conditions affecting performance, such as rejection features.

C. Examine utilization equipment nameplates and installation instructions. Install fuses of sizes and with characteristics appropriate for each piece of equipment.

D. Evaluate ambient temperatures to determine if fuse rating adjustment factors must be applied to fuse ratings.

E. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 FUSE APPLICATIONS

A. Cartridge Fuses:

1. Feeders: Class RK1, time delay or Class RK5, time delay.
2. Motor Branch Circuits: Class RK5, time delay.
3. Other Branch Circuits: Class RK1, time delay or Class RK5, time delay.
4. Control Circuits: Class CC, time delay.

B. Install fuses in fusible devices. Arrange fuses so rating information is readable without removing fuse.

3.03 IDENTIFICATION

A. Install labels complying with requirements for identification specified in Section 26 05 53 "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

SECTION 26 28 16

ENCLOSED SWITCHES AND CIRCUIT BREAKERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Fusible switches.
2. Nonfusible switches.
3. Shunt trip switches.
4. Molded-case circuit breakers (MCCBs).
5. Molded-case switches.
6. Enclosures.

1.03 DEFINITIONS

A. NC: Normally closed.

B. NO: Normally open.

C. SPDT: Single pole, double throw.

1.04 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."

1.05 ACTION 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. Detail features, characteristics, ratings, and factory settings of individual overcurrent protective devices, accessories, and auxiliary components.
5. Include time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

B. Shop Drawings: For enclosed switches and circuit breakers. Include plans, elevations, sections, details, and attachments to other work.

1. Wiring Diagrams: For power, signal, and control wiring.

1.06 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed switches and circuit breakers, accessories, and components, from manufacturer.

1. Basis for Certification: Indicate whether withstand certification is based on actual test of assembled components or on calculation.
2. Dimensioned Outline Drawings of Equipment Unit: Identify center of gravity and locate and describe mounting and anchorage provisions.
3. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

B. 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.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed switches and circuit breakers to include in emergency, operation, and maintenance manuals. In addition to items specified in Section 01 78 23 "Operation and Maintenance Data," include the following:

1. Manufacturer's written instructions for testing and adjusting enclosed switches and circuit breakers.
2. Time-current coordination curves (average melt) for each type and rating of overcurrent protective device; include selectable ranges for each type of overcurrent protective device.

1.08 QUALITY ASSURANCE

A. Source Limitations: Obtain enclosed switches and circuit breakers, overcurrent protective devices, components, and accessories, within same product category, from single source from single manufacturer.

B. 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.

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

D. Comply with NFPA 70.

1.09 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).

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

1. Notify Owner no fewer than five days in advance of proposed interruption of electric service.
2. Indicate method of providing temporary electric service.
3. Do not proceed with interruption of electric service without Owner's written permission.
4. Comply with NFPA 70E.

1.10 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.

PART 2 - PRODUCTS

2.01 FUSIBLE SWITCHES

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. Type HD, Heavy Duty, Single Throw, 240 or 600-V ac as appropriate for circuit voltage, 1200 A and Smaller: UL 98 and NEMA KS 1, horsepower rated, with clips or bolt pads to accommodate indicated fuses, lockable handle with capability to accept three padlocks, and interlocked with cover in closed position.

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. Auxiliary Contact Kit: Two 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.
5. Service-Rated Switches: Labeled for use as service equipment.

2.02 NONFUSIBLE SWITCHES

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. Type HD, Heavy Duty, Single Throw,-240 or 600-V ac as appropriate for circuit voltage, 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.

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. Auxiliary Contact Kit: Two 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.

2.03 MOLDED-CASE CIRCUIT BREAKERS

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. General Requirements: Comply with UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents.

C. Electronic Trip Circuit Breakers: Field-replaceable rating plug, rms sensing, with the following field-adjustable settings:

1. Instantaneous trip.
2. Long- and short-time pickup levels.
3. Long- and short-time time adjustments.
4. Ground-fault pickup level, time delay, and I^2t response.

D. Current-Limiting Circuit Breakers: Frame sizes 400 A and smaller, and let-through ratings less than NEMA FU 1, RK-5.

E. Ground-Fault, Circuit-Interrupter (GFCI) Circuit Breakers: Single- and two-pole configurations with Class A ground-fault protection (6-mA trip).

F. Ground-Fault, Equipment-Protection (GFEP) Circuit Breakers: With Class B ground-fault protection (30-mA trip).

G. Features and Accessories:

1. Standard frame sizes, trip ratings, and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Application Listing: Appropriate for application; Type SWD for switching fluorescent lighting loads; Type HID for feeding fluorescent and high-intensity discharge lighting circuits.
4. Ground-Fault Protection: Comply with UL 1053; integrally mounted, self-powered type with mechanical ground-fault indicator; relay with adjustable pickup and time-delay settings, push-to-test feature, internal memory, and shunt trip unit; and three-phase, zero-sequence current transformer/sensor.
5. Shunt Trip: Trip coil energized from separate circuit, with coil-clearing contact.
6. Undervoltage Trip: Set to operate at 35 to 75 percent of rated voltage without intentional time delay.
7. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic circuit-breaker contacts, "b" contacts operate in reverse of circuit-breaker contacts.
8. Zone-Selective Interlocking: Integral with electronic trip unit; for interlocking ground-fault protection function.

2.04 MOLDED-CASE SWITCHES

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. General Requirements: MCCB with fixed, high-set instantaneous trip only, and short-circuit withstand rating equal to equivalent breaker frame size interrupting rating.

C. Features and Accessories:

1. Standard frame sizes and number of poles.
2. Lugs: Mechanical type, suitable for number, size, trip ratings, and conductor material.
3. Auxiliary Contacts: One SPDT switch with "a" and "b" contacts; "a" contacts mimic switch contacts, "b" contacts operate in reverse of switch contacts.

2.05 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.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine elements and surfaces to receive enclosed switches and circuit breakers for compliance with installation tolerances and other conditions affecting performance of the Work.

B. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Install individual wall-mounted switches and circuit breakers with tops at uniform height unless otherwise indicated.

B. Comply with mounting and anchoring requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Install fuses in fusible devices.

D. Comply with NECA 1.

3.03 IDENTIFICATION

A. Comply with requirements in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved metal or laminated-plastic nameplate.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

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.
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.

3.05 ADJUSTING

A. Adjust moving parts and operable components to function smoothly, and lubricate as recommended by manufacturer.

B. Set field-adjustable circuit-breaker trip ranges.

END OF SECTION

SECTION 26 29 13

ENCLOSED CONTROLLERS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes the following enclosed controllers rated 600 V and less:

1. Full-voltage manual.
2. Full-voltage magnetic.

B. Section includes Enclosed combination Contactors.

1.03 DEFINITIONS

A. CPT: Control power transformer.

B. MCCB: Molded-case circuit breaker.

C. MCP: Motor circuit protector.

D. N.C.: Normally closed.

E. N.O.: Normally open.

F. OCPD: Overcurrent protective device.

G. SCR: Silicon-controlled rectifier.

1.04 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Enclosed controllers 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."

1.05 ACTION 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.
e. Features, characteristics, ratings, and factory settings of individual OCPDs in combination controllers.

2. Wiring Diagrams: For power, signal, and control wiring.

1.06 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Certificates: For enclosed controllers, 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.

B. Field quality-control reports.

C. 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.

D. Load-Current and List of Settings of Adjustable Overload Relays: Compile after motors have been installed, and arrange to demonstrate that switch settings for motor running overload protection suit actual motors to be protected.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For enclosed controllers to include in emergency, operation, and maintenance manuals. In addition to items specified in Division 01, include the following:

1. Routine maintenance requirements for enclosed controllers and installed components.
2. Manufacturer's written instructions for testing and adjusting circuit breaker and MCP trip settings.
3. Manufacturer's written instructions for setting field-adjustable overload relays.

1.08 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.

C. IEEE Compliance: Fabricate and test enclosed controllers according to IEEE 344 to withstand seismic forces defined in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

1.09 DELIVERY, STORAGE, AND HANDLING

A. Store enclosed controllers indoors in clean, dry space with uniform temperature to prevent condensation. Protect enclosed controllers from exposure to dirt, fumes, water, corrosive substances, and physical damage.

1.10 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).

B. Interruption of Existing Electrical Systems: Do not interrupt electrical systems in 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 systems.
2. Indicate method of providing temporary utilities.
3. Do not proceed with interruption of electrical systems without Owner's written permission.
4. Comply with NFPA 70E.

1.11 COORDINATION

A. Coordinate layout and installation of enclosed controllers with other construction including conduit, piping, equipment, and adjacent surfaces. Maintain required workspace clearances and required clearances for equipment access doors and panels.

PART 2 - PRODUCTS

2.01 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. 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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing.
3. Surface mounting.
4. Red pilot light.

C. Magnetic Controllers: Full voltage, across the line, electrically held.

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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Configuration: Nonreversing
3. Contactor Coils: Pressure-encapsulated type.

a. Operating Voltage: Depending on contactor NEMA size and line-voltage rating, manufacturer's standard matching control power or line voltage.

4. Power Contacts: Totally enclosed, double-break, silver-cadmium oxide; assembled to allow inspection and replacement without disturbing line or load wiring.
5. Control Circuits: 120-V ac maximum; obtained from integral CPT, with primary and secondary fuses, of sufficient capacity to operate integral devices and remotely located pilot, indicating, and control devices.

a. CPT Spare Capacity: 100 VA.

6. Melting Alloy Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 tripping characteristic.
c. Heaters in each phase matched to nameplate full-load current of actual protected motor and with appropriate adjustment for duty cycle.

7. Bimetallic Overload Relays:

a. Inverse-time-current characteristic.
b. Class 20 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.

8. Solid-State Overload Relay:

a. Switch or dial selectable for motor running overload protection.
b. Sensors in each phase.
c. Class 20 tripping characteristic selected to protect motor against voltage and current unbalance and single phasing.

9. N.O., isolated overload alarm contact.
10. External overload reset push button.

D. Combination Magnetic Controller: Factory-assembled combination of magnetic controller, OCPD, and disconnecting means.

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. Eaton Electrical Inc.; Cutler-Hammer Business Unit.
b. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
c. Rockwell Automation, Inc.; Allen-Bradley brand.
d. Siemens Energy & Automation, Inc.
e. Square D; a brand of Schneider Electric.

2. Fusible Disconnecting Means:

a. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

3. Auxiliary Contacts: N.O./N.C., arranged to activate before switch blades open.
4. MCP Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents, instantaneous-only circuit breaker with front-mounted, field-adjustable, short-circuit trip coordinated with motor locked-rotor amperes.
b. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
c. Auxiliary contacts "a" and "b" arranged to activate with MCP handle.
d. N.O. alarm contact that operates only when MCP has tripped.
e. Current-limiting module to increase controller short-circuit current (withstand) rating to 100 kA.

5. MCCB Disconnecting Means:

a. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.

b. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
c. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
d. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
e. N.O. alarm contact that operates only when MCCB has tripped.

2.02 ENCLOSED COMBINATION CONTACTORS

A. Enclosed combination Contactor: Factory-assembled combination of magnetic contactor, OCPD, and disconnecting means.

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 Electrical Inc.; Cutler-Hammer Business Unit.
2. General Electric Company; GE Consumer & Industrial - Electrical Distribution.
3. Siemens Energy & Automation, Inc.
4. Square D; a brand of Schneider Electric.

C. Fusible Disconnecting Means:

1. NEMA KS 1, heavy-duty, horsepower-rated, fusible switch with clips or bolt pads to accommodate Class R fuses.
2. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.

D. MCCB Disconnecting Means:

1. UL 489, NEMA AB 1, and NEMA AB 3, with interrupting capacity to comply with available fault currents; thermal-magnetic MCCB, with inverse time-current element for low-level overloads and instantaneous magnetic trip element for short circuits.
2. Front-mounted, adjustable magnetic trip setting for circuit-breaker frame sizes 250 A and larger.
3. Lockable Handle: Accepts three padlocks and interlocks with cover in closed position.
4. Auxiliary contacts "a" and "b" arranged to activate with MCCB handle.
5. N.O. alarm contact that operates only when MCCB has tripped.

E. Ratings:

1. Adequately rated for circuit voltage.
2. Continuously rated for ampacity indicated on the drawings.
3. Number of poles to match feeder configuration.
4. Coil voltage shall voltage of controlled circuit for each unit.

2.03 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.

2.04 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, type.

a. Push Buttons: Recessed types; momentary.
b. Pilot Lights: LED types; colors as indicated; push to test.
c. Selector Switches: Rotary type Hand-off-automatic for units with remote automatic control; on-off for units with only local control
d. Power shutoff Switch: Red mushroom head, latching pushbutton with manual twist-to-release feature. Voltage rating shall match coil voltage of controlled contactor or shunt trip device. Provide enclosure as specified for environment in which switch is located.

B. Reversible N.C./N.O. auxiliary contact(s).

C. 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.

D. Breather and drain assemblies, to maintain interior pressure and release condensation in Type 4X enclosures installed outdoors or in unconditioned interior spaces subject to humidity and temperature swings.

PART 3 - EXECUTION

3.01 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.

3.02 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 Section 26 05 29 "Hangers and Supports for Electrical Systems."

B. Seismic Bracing: Comply with requirements specified in Section 26 05 48 "Vibration and Seismic Controls for Electrical Systems."

C. Install fuses in each fusible-switch enclosed controller.

D. Install fuses in control circuits if not factory installed. Comply with requirements in Section 26 28 13 "Fuses."

E. Install heaters in thermal overload relays. Select heaters based on actual nameplate full-load amperes after motors have been installed.

F. Install, connect, and fuse thermal-protector monitoring relays furnished with motor-driven equipment.

G. Comply with NECA 1.

3.03 IDENTIFICATION

A. Identify enclosed controllers, components, and control wiring. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

1. Identify field-installed conductors, interconnecting wiring, and components; provide warning signs.
2. Label each enclosure with engraved nameplate.
3. Label each enclosure-mounted control and pilot device.

3.04 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Inspect controllers, wiring, components, connections, and equipment installation. Test and adjust controllers, components, and equipment.
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. If outside this range for any motor, notify Architect before starting the motor(s).
5. Test each motor for proper phase rotation.
6. Perform each electrical test and visual and mechanical inspection stated in NETA Acceptance Testing Specification. Certify compliance with test parameters.
7. Correct malfunctioning units on-site, where possible, and retest to demonstrate compliance; otherwise, replace with new units and retest.

C. Enclosed controllers 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 controllers and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.05 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, notifyArchitect before increasing settings.

D. Set field-adjustable circuit-breaker trip ranges.

3.06 PROTECTION

A. Temporary Heating: Apply temporary heat to maintain temperature according to manufacturer's written instructions until enclosed controllers are ready to be energized and placed into service.

B. Replace controllers whose interiors have been exposed to water or other liquids prior to Substantial Completion.

3.07 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain enclosed controllers

END OF SECTION

SECTION 26 32 13.17

GASEOUS ENGINE GENERATORS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes packaged engine generators for non-emergency use with the following features:.

1. LP gas engine.
2. Gaseous fuel system.
3. Control and monitoring.
4. Generator overcurrent and fault protection.
5. Generator, exciter, and voltage regulator.
6. Outdoor generator-set enclosure.
7. Vibration isolation devices.
8. Finishes.

B. Related Requirements:

1. Section 26 36 00 "Transfer Switches" for transfer switches including sensors and relays to initiate automatic-starting and -stopping signals for engine generators.

1.03 DEFINITIONS

A. EPS: Emergency power supply.

B. EPSS: Emergency power supply system.

C. Operational Bandwidth: The total variation from the lowest to highest value of a parameter over the range of conditions indicated, expressed as a percentage of the nominal value of the parameter.

D. LP: Liquefied petroleum.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.
2. Include thermal damage curve for generator.

3. Include time-current characteristic curves for generator protective device.
4. Include fuel consumption in cubic feet per hour (cubic meters per hour) at 0.8 power factor at 0.5, 0.75 and 1.0 times generator capacity.
5. Include generator efficiency at 0.8 power factor at 0.5, 0.75, and 1.0 times generator capacity.
6. Include air flow requirements for cooling and combustion air in cfm at 0.8 power factor, with air supply temperature of 95 deg F (35 deg C), 80 deg F (27 deg C), 70 deg F (21 deg C), and 50 deg F (10 deg C). Provide drawings showing requirements and limitations for location of air intake and exhausts.
7. Include generator characteristics, including, but not limited to, kilowatt rating, efficiency, reactances, and short-circuit current capability.

B. Shop Drawings:

1. Include plans and elevations for engine generator and other components specified.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Identify fluid drain ports and clearance requirements for proper fluid drain.
4. Vibration Isolation Base Details: Detail fabrication including anchorages and attachments to structure and to supported equipment. Include base weights.
5. Include diagrams for power, signal, and control wiring. Complete schematic, wiring, and interconnection diagrams showing terminal markings for EPS equipment and functional relationship between all electrical components.

1.05 INFORMATIONAL SUBMITTALS

A. Seismic Qualification Data: Certificates, for engine generator, 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: With engine and generator mounted on rails, identify center of gravity and total weight, supplied enclosure, external silencer, and each piece of equipment not integral to the engine generator, 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.

B. Source Quality-Control Reports: Including, but not limited to, the following:

1. Certified summary of prototype-unit test report.
2. Certified Test Reports: For components and accessories that are equivalent, but not identical, to those tested on prototype unit.
3. Certified Summary of Performance Tests: Certify compliance with specified requirement to meet performance criteria for sensitive loads.
4. Report of factory test on units to be shipped for this Project, showing evidence of compliance with specified requirements.
5. Report of sound generation.
6. Report of exhaust emissions showing compliance with applicable regulations.

C. Field quality-control reports.

D. Warranty: For special warranty.

1.06 CLOSEOUT SUBMITTALS

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

1. In addition to items specified in Division 01, include the following:

a. List of tools and replacement items recommended to be stored at Project for ready access. Include part and drawing numbers, current unit prices, and source of supply.
b. Operating instructions laminated and mounted adjacent to generator location.
c. Training plan.

1.07 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. Fuses: One for every 10 of each type and rating, but no fewer than one of each.
2. Filters: One set each of lubricating oil, fuel, and combustion-air filters.
3. Tools: Each tool listed by part number in operations and maintenance manual.

1.08 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.09 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of packaged engine generators and associated auxiliary components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Source Limitations: Obtain packaged engine generators and auxiliary components through one source from a single manufacturer.

2.02 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Engine generator housing, engine generator, batteries, battery racks, silencers, and sound attenuating equipment, accessories, and components shall withstand the effects of earthquake motions determined according to ASCE/SEI **7**.

1. The term "withstand" means "the unit will remain in place without separation of any parts when subjected to seismic forces.
2. Shake-table testing shall comply with ICC-ES AC156. Testing shall be performed with all fluids at worst-case normal levels.
3. Component Importance Factor: 1.0

B. B11 Compliance: Comply with B11.19.

C. NFPA Compliance:

1. Comply with NFPA 37
2. Comply with NFPA 70
3. Comply with NFPA 110 requirements for Level 1 EPSS.

D. UL Compliance: Comply with UL 2200.

E. Engine Exhaust Emissions: Comply with EPA Tier 4 requirements and applicable state and local government requirements.

F. Noise Emission: Comply with applicable state and local government requirements]for maximum noise level allowed at adjacent property boundaries due to sound emitted by engine generator including engine, engine exhaust, engine cooling-air intake and discharge, and other components of installation.

G. Environmental Conditions: Engine generator system shall withstand the following environmental conditions without mechanical or electrical damage or degradation of performance capability:

1. Ambient Temperature: **5 to 104 deg F (Minus 15 to plus 40 deg C)**.
2. Relative Humidity: Zero to 95 percent.
3. Altitude: Sea level to **1000 feet (300 m)**.

H. Unusual Service Conditions: Engine generator equipment and installation are required to operate under the following conditions:

1. High salt-dust content in the air due to proximity to ocean.

2.03 ENGINE GENERATOR ASSEMBLY DESCRIPTION

A. Factory-assembled and -tested, water-cooled engine, with brushless generator and accessories.

B. Electrical Components, Devices, and Accessories: Listed and labeled as defined in NFPA 70, by a testing agency acceptable to authorities having jurisdiction, and marked for intended location and use.

C. EPSS Class: Engine generator shall be classified as Class 48 according to NFPA 110.

D. Service Load: 98 KW

E. Overload Capacity: 110 percent of service load for 1 hour in 12 consecutive hours.

F. Power Factor: 0.8, lagging.

G. Frequency: 60 Hz

H. Voltage: 277/480 V ac.

I. Phase: Three-phase, 4 wire, wye

J. Induction Method: Naturally aspirated.

K. Governor: Adjustable isochronous, with speed sensing.

L. Mounting Frame: Structural steel framework to maintain alignment of mounted components without depending on concrete foundation. Provide lifting attachments sized and spaced to prevent deflection of base during lifting and moving.

1. Rigging Diagram: Inscribed on metal plate permanently attached to mounting frame to indicate location and lifting capacity of each lifting attachment and generator-set center of gravity.

M. Capacities and Characteristics:

1. Power Output Ratings: Nominal ratings as indicated at 0.8 power factor excluding power required for the continued and repeated operation of the unit and auxiliaries.
2. Nameplates: For each major system component to identify manufacturer's name and address, and model and serial number of component.

N. Engine Generator Performance:

1. Steady-State Voltage Operational Bandwidth: 3 percent of rated output voltage from no load to full load.
2. Transient Voltage Performance: Not more than 20 percent variation for 50 percent step-load increase or decrease. Voltage shall recover and remain within the steady-state operating band within three seconds.
3. Steady-State Frequency Operational Bandwidth: 0.5 percent of rated frequency from no load to full load.
4. Steady-State Frequency Stability: When system is operating at any constant load within the rated load, there shall be no random speed variations outside the steady-state operational band and no hunting or surging of speed.
5. Transient Frequency Performance: Less than 5 percent variation for 50 percent step-load increase or decrease. Frequency shall recover and remain within the steady-state operating band within five seconds.
6. Output Waveform: At no load, harmonic content measured line to line or line to neutral shall not exceed 5 percent total and 3 percent for single harmonics. Telephone influence factor, determined according to NEMA MG 1, shall not exceed 50 percent.
7. Sustained Short-Circuit Current: For a three-phase, bolted short circuit at system output terminals, system shall supply a minimum of 250 percent of rated full-load current for not less than 10 seconds and then clear the fault automatically, without damage to generator system components.
8. Start Time: Comply with NFPA 110, Type 10, system requirements..

2.04 GASEOUS ENGINE

A. Fuel: LP gas

B. Rated Engine Speed: 1800 rpm.

C. Lubrication System: Engine or skid-mounted.

1. Filter and Strainer: Rated to remove 90 percent of particles 5 micrometers and smaller while passing full flow.
2. Thermostatic Control Valve: Control flow in system to maintain optimum oil temperature. Unit shall be capable of full flow and is designed to be fail-safe.
3. Crankcase Drain: Arranged for complete gravity drainage to an easily removable container with no disassembly and without use of pumps, siphons, special tools, or appliances.

D. Jacket Coolant Heater: Electric-immersion type, factory installed in coolant jacket system. Comply with UL 499.

E. Cooling System: Closed loop, liquid cooled, with radiator factory mounted on engine generator mounting frame and integral engine-driven coolant pump.

1. Coolant: Solution of 50 percent ethylene-glycol-based antifreeze and 50 percent water, with anticorrosion additives as recommended by engine manufacturer.
2. Size of Radiator: Adequate to contain expansion of total system coolant from cold start to 110 percent load condition.
3. Expansion Tank: Constructed of welded steel plate and rated to withstand maximum closed-loop coolant system pressure for engine used. Equip with gage glass and petcock.
4. Temperature Control: Self-contained, thermostatic-control valve modulates coolant flow automatically to maintain optimum constant coolant temperature as recommended by engine manufacturer.
5. Coolant Hose: Flexible assembly with inside surface of nonporous rubber and outer covering of aging-, ultraviolet-, and abrasion-resistant fabric.

    a. Rating: 50-psig (345-kPa) maximum working pressure with coolant at 180 deg F (82 deg C), and noncollapsible under vacuum.
    b. End Fittings: Flanges or steel pipe nipples with clamps to suit piping and equipment connections.

F. Muffler/Silencer and Sound attenuation enclosure: Critical type, sized as recommended by engine manufacturer and selected with exhaust piping system to not exceed engine manufacturer's engine backpressure requirements.

1. Minimum sound attenuation of 25 dB at 500 Hz.
2. Sound level measured at the property line shall comply with the local ordinance for sound levels at the property line.

G. Air-Intake Filter: standard-duty, engine-mounted air cleaner with replaceable dry-filter element and "blocked filter" indicator.

H. Starting System: 12 V electric, with negative ground.

1. Components: Sized so they are not damaged during a full engine-cranking cycle with ambient temperature at maximum specified in "Performance Requirements" Article.
2. Cranking Motor: Heavy-duty unit that automatically engages and releases from engine flywheel without binding.
3. Cranking Cycle: 60 seconds.
4. Battery: Lead acid with capacity within ambient temperature range specified in "Performance Requirements" Article to provide specified cranking cycle at least twice] without recharging.

5. Battery Cable: Size as recommended by engine manufacturer for cable length indicated. Include required interconnecting conductors and connection accessories.
6. Battery Compartment: Factory fabricated of metal with acid-resistant finish and thermal insulation. Thermostatically controlled heater shall be arranged to maintain battery above 50 deg F (10 deg C)regardless of external ambient temperature within range specified in "Performance Requirements" Article. Include accessories required to support and fasten batteries in place. Provide ventilation to exhaust battery gases.
7. Battery Stand: Factory-fabricated, two-tier metal with acid-resistant finish designed to hold the quantity of battery cells required and to maintain the arrangement to minimize lengths of battery interconnections.
8. Battery-Charging Alternator: Factory mounted on engine with solid-state voltage regulation and 35 A minimum continuous rating.
9. Battery Charger: Current-limiting, automatic-equalizing and float-charging type designed for lead acid batteries. Unit shall comply with UL 1236 and include the following features:

    a. Operation: Equalizing-charging rate of 10 A shall be initiated automatically after battery has lost charge until an adjustable equalizing voltage is achieved at battery terminals. Unit shall then be automatically switched to a lower float-charging mode and shall continue to operate in that mode until battery is discharged again.
    b. Automatic Temperature Compensation: Adjust float and equalize voltages for variations in ambient temperature from minus 40 deg F (minus 40 deg C) to 140 deg F (plus 60 deg C) to prevent overcharging at high temperatures and undercharging at low temperatures.
    c. Automatic Voltage Regulation: Maintain constant output voltage regardless of input voltage variations up to plus or minus 10 percent.
    d. Ammeter and Voltmeter: Flush mounted in door. Meters shall indicate charging rates.
    e. Safety Functions: Sense abnormally low battery voltage and close contacts providing low battery voltage indication on control and monitoring panel. Sense high battery voltage and loss of ac input or dc output of battery charger. Either condition shall close contacts that provide a battery-charger malfunction indication at system control and monitoring panel.
    f. Enclosure: NEMA 250, Type 1 mounted within generator enclosure.

2.05 GASEOUS FUEL SYSTEM

A. LP Gas Piping: Comply with requirements in Division 22.

B. Gas Train: Comply with NFPA 37.

C. LP gas Vapor-Withdrawal System:

1. Carburetor.
2. Secondary Gas Regulator: with atmospheric vents piped to building exterior.
3. Fuel-Shutoff Solenoid Valves: NRTL-listed, normally closed, safety shutoff valves; one for each fuel source.
4. Fuel Filter
5. Manual Fuel Shutoff Valve
6. Flexible Fuel Connector.

2.06 CONTROL AND MONITORING

A. Automatic Starting System Sequence of Operation: When mode-selector switch on the control and monitoring panel is in the automatic position, remote-control contacts in one or more separate automatic transfer switches initiate starting and stopping of engine generator. When mode-selector switch is switched to the on position, engine generator starts. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

B. Manual Starting System Sequence of Operation: Switching on-off switch on the generator control panel to the on position starts engine generator. The off position of same switch initiates generator-set shutdown. When engine generator is running, specified system or equipment failures or derangements automatically shut down engine generator and initiate alarms.

C. Provide minimum run time control set for 15 minutes with override only by operation of a remote emergency-stop switch.

D. Comply with UL 508A.

E. Configuration: Operating and safety indications, protective devices, basic system controls, and engine gages shall be grouped in a common control and monitoring panel mounted on the engine generator. Mounting method shall isolate the control panel from generator-set vibration. Panel shall be powered from the engine generator battery.

F. Control and Monitoring Panel:

1. Digital controller with integrated LCD, controls, and microprocessor, capable of local and remote control, monitoring, and programming, with battery backup.
2. Analog control panel with dedicated gages and indicator lights for the instruments and alarms indicated below.
3. Instruments: Located on the control and monitoring panel and viewable during operation.

    a. Engine lubricating-oil pressure gage.
    b. Engine-coolant temperature gage.
    c. DC voltmeter (alternator battery charging).
    d. Running-time meter.
    e. AC voltmeter, for each phase
    f. AC ammeter, for each phase
    g. AC frequency meter.
    h. Generator-voltage adjusting rheostat.

4. Controls and Protective Devices: Controls, shutdown devices, and common visual alarm indication, including the following:

    a. Cranking control equipment.
    b. Run-Off-Auto switch.
    c. Control switch not in automatic position alarm.
    d. Overcrank alarm.
    e. Overcrank shutdown device.
    f. Low water temperature alarm.
    g. High engine temperature prealarm.
    h. High engine temperature.
    i. High engine temperature shutdown device.
    j. Overspeed alarm.

k. Overspeed shutdown device.
l. Low fuel main tank.
m. Coolant low-level alarm.
n. Coolant low-level shutdown device.
o. Coolant high-temperature prealarm.
p. Coolant high-temperature alarm.
q. Coolant low-temperature alarm.
r. Coolant high-temperature shutdown device.
s. EPS supplying load indicator.
t. Battery high-voltage alarm.
u. Low cranking voltage alarm.
v. Battery-charger malfunction alarm.
w. Battery low-voltage alarm.
x. Lamp test.
y. Contacts for local and remote common alarm.
z. Low-starting air pressure alarm.
aa. Low-starting hydraulic pressure alarm.
bb. Remote manual stop shutdown device.
cc. Air shutdown damper alarm when used.
dd. Air shutdown damper shutdown device when used.
ee. Hours of operation.
ff. Engine generator metering, including voltage, current, Hz, kW, kVA, and power factor.
gg. Generator overcurrent protective device not closed alarm.

G. Engine Generator Metering: Comply with Section 26 27 13 "Electricity Metering."

H. Connection to Datalink:

1. A separate terminal block, factory wired to Form C dry contacts, for each alarm and status indication.

I. Common Remote Panel with Common Audible Alarm: Comply with NFPA 110 requirements for Level 1 systems. Include necessary contacts and terminals in control and monitoring panel. Remote panel shall be powered from the engine generator battery.

J. Remote Emergency-Stop Switch: Flush; wall mounted, unless otherwise indicated; and labeled. Push button shall be protected from accidental operation. Locate in Facilities, coordinate exact location with Owner.

K. Supporting Items: Include sensors, transducers, terminals, relays, and other devices and include wiring required to support specified items. Locate sensors and other supporting items on engine or generator, unless otherwise indicated.

2.07 GENERATOR OVERCURRENT AND FAULT PROTECTION

A. Overcurrent protective devices for the entire EPSS shall be coordinated to optimize selective tripping when a short circuit occurs. Coordination of protective devices shall consider both utility and EPSS as the voltage source.

1. Overcurrent protective devices for the EPSS shall be accessible only to authorized personnel.

B. Generator Circuit Breaker: Molded-case, electronic-trip type; 100 percent rated; complying with UL 489.

1. Tripping Characteristics: Adjustable long-time and short-time delay and instantaneous.
2. Trip Settings: Selected to coordinate with generator thermal damage curve.
3. Shunt Trip: Connected to trip breaker when engine generator is shut down by other protective devices.
4. Mounting: Adjacent to or integrated with control and monitoring panel.

C. Generator Protector: Microprocessor-based unit shall continuously monitor current level in each phase of generator output, integrate generator heating effect over time, and predict when thermal damage of alternator will occur. When signaled by generator protector or other generator-set protective devices, a shunt-trip device in the generator disconnect switch shall open the switch to disconnect the generator from load circuits. Protector performs the following functions:

1. Initiates a generator overload alarm when generator has operated at an overload equivalent to 110 percent of full-rated load for 60 seconds. Indication for this alarm is integrated with other generator-set malfunction alarms. Contacts shall be available for load shed functions.
2. Under single or three-phase fault conditions, regulates generator to 300 percent of rated full-load current for up to 10 seconds.
3. As overcurrent heating effect on the generator approaches the thermal damage point of the unit, protector switches the excitation system off, opens the generator disconnect device, and shuts down the engine generator.
4. Senses clearing of a fault by other overcurrent devices and controls recovery of rated voltage to avoid overshoot.

2.08 GENERATOR, EXCITER, AND VOLTAGE REGULATOR

A. Comply with NEMA MG 1.

B. Drive: Generator shaft shall be directly connected to engine shaft. Exciter shall be rotated integrally with generator rotor.

C. Electrical Insulation: Class H

D. Stator-Winding Leads: Brought out to terminal box to permit future reconnection for other voltages if required. Provide six lead alternator.

E. Range: Provide limited range of output voltage by adjusting the excitation level.

F. Construction shall prevent mechanical, electrical, and thermal damage due to vibration, overspeed up to 125 percent of rating, and heat during operation at 110 percent of rated capacity.

G. Enclosure: Drip proof.

H. Instrument Transformers: Mounted within generator enclosure.

I. Voltage Regulator: Solid-state type, separate from exciter.

1. Adjusting Rheostat on Control and Monitoring Panel: Provide plus or minus 5 percent adjustment of output-voltage operating band.

2. Maintain voltage within 30 percent on one step, full load.
3. Provide anti-hunt provision to stabilize voltage.
4. Maintain frequency within 10 percent and stabilize at rated frequency within 5 seconds.

J. Strip Heater: Thermostatically controlled unit arranged to maintain stator windings above dew point.

K. Windings: Two-thirds pitch stator winding and fully linked amortisseur winding.

L. Subtransient Reactance: 12 percent, maximum.

2.09 OUTDOOR GENERATOR-SET ENCLOSURE

A. Description: Vandal-resistant, sound-attenuating, weatherproof steel housing, wind resistant up to 100 mph (160 km/h). Multiple panels shall be lockable and provide adequate access to components requiring maintenance. Panels shall be removable by one person without tools. Instruments and control shall be mounted within enclosure.

1. Sound Attenuation Level: as required to be below the local property line dBA requirement limits.

B. Description: Prefabricated or pre-engineered galvanized-steel-clad, integral structural-steel-framed, walk-in enclosure, erected on concrete foundation.

C. Structural Design and Anchorage: Comply with ASCE/SEI 7 for wind loads up to 100 mph (160 km/h).

D. Seismic Design: Comply with seismic requirements in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

E. Hinged Doors: With padlocking provisions.

F. Space Heater: Thermostatically controlled and sized to prevent condensation.

G. Thermal Insulation: Manufacturer's standard materials and thickness selected in coordination with space heater to maintain winter interior temperature within operating limits required by engine generator components.

H. Muffler Location: within enclosure.

I. Engine Cooling Airflow through Enclosure: Maintain temperature rise of system components within required limits when unit operates at 110 percent of rated load for 2 hours with ambient temperature at top of range specified in system service conditions.

1. Louvers: Fixed-engine, cooling-air inlet and discharge. Storm-proof and drainable louvers prevent entry of rain and snow.
2. Automatic Dampers: At engine cooling-air inlet and discharge. Dampers shall be closed to reduce enclosure heat loss in cold weather when unit is not operating.
3. Ventilation: Provide temperature-controlled exhaust fan interlocked to prevent operation when engine is running.

J. Convenience Outlets: Factory wired, GFCI. Arrange for external electrical connection.

2.10 VIBRATION ISOLATION DEVICES

A. Elastomeric Isolator Pads: Oil- and water-resistant elastomer or natural rubber, arranged in single or multiple layers, molded with a nonslip pattern and galvanized-steel baseplates of sufficient stiffness for uniform loading over pad area, and factory cut to sizes that match requirements of supported equipment.

1. Material: standard neoprene separated by steel shims.
2. Shore "A" Scale Durometer Rating: 30
3. Number of Layers: one.
4. Minimum Deflection: 1 inch

B. Restrained Spring Isolators: Freestanding, steel, open-spring isolators with seismic restraint.

1. Housing: Steel with resilient vertical-limit stops to prevent spring extension due to wind loads or if weight is removed; factory-drilled baseplate bonded to 1/4-inch- (6-mm-) thick, elastomeric isolator pad attached to baseplate underside; and adjustable equipment mounting and leveling bolt that acts as blocking during installation.
2. Outside Spring Diameter: Not less than 80 percent of compressed height of the spring at rated load.
3. Minimum Additional Travel: 50 percent of required deflection at rated load.
4. Lateral Stiffness: More than 80 percent of rated vertical stiffness.
5. Overload Capacity: Support 200 percent of rated load, fully compressed, without deformation or failure.
6. Minimum Deflection: 1 inch

C. Comply with requirements in Division 23 for vibration isolation and flexible connector materials for steel piping.

D. Vibration isolation devices shall not be used to accommodate misalignments or to make bends.

2.11 FINISHES

A. Indoor and Outdoor Enclosures and Components: Manufacturer's standard finish over corrosion-resistant pretreatment and compatible primer.

2.12 SOURCE QUALITY CONTROL

A. Prototype Testing: Factory test engine generator using same engine model, constructed of identical or equivalent components and equipped with identical or equivalent accessories.

1. Tests: Comply with IEEE 115.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas, equipment bases, and conditions, with Installer present, for compliance with requirements for installation and other conditions affecting packaged engine generator performance.

B. Examine roughing-in for piping systems and electrical connections. Verify actual locations of connections before packaged engine generator installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 INSTALLATION

A. Comply with NECA 1 and NECA 404.

B. Comply with packaged engine generator manufacturers' written installation and alignment instructions and with NFPA 110.

C. Equipment Mounting:

1. Install packaged engine generators on cast-in-place concrete equipment bases. Comply with requirements for equipment bases and foundations specified in Section 03 30 00 "Cast-in-Place Concrete."
2. Coordinate size and location of concrete bases for packaged engine generators. Cast anchor-bolt inserts into bases. Concrete, reinforcement, and formwork requirements are specified with concrete.
3. Install packaged engine generator with elastomeric isolator pads having a minimum deflection of 1 inch (25 mm) on 4-inch- (100-mm-) high concrete base. Secure engine generator enclosure to anchor bolts installed in concrete bases. Concrete base construction is specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

D. Install packaged engine generator to provide access, without removing connections or accessories, for periodic maintenance.

E. Gaseous Fuel Piping:
1. LP gas piping, valves, and specialties for gas piping are specified in Section 23 11 26 "Facility Liquefied-Petroleum Gas Piping."

F. Electrical Wiring: Install electrical devices furnished by equipment manufacturers but not specified to be factory mounted.

3.03 CONNECTIONS

A. Piping installation requirements are specified in other Sections. Drawings indicate general arrangement of piping and specialties.

B. Connect fuel piping adjacent to packaged engine generator to allow service and maintenance.

C. Gaseous Fuel Connections:

1. Connect fuel piping to engines with a gate valve and union and flexible connector.
2. Install manual shutoff valve in a remote location to isolate gaseous fuel supply to the generator.
3. Vent gas pressure regulators outside building a minimum of 60 inches (1500 mm) from building openings.

D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables." Provide a minimum of one 90-degree bend in flexible conduit routed to the engine generator from a stationary element.

F. Balance single-phase loads to obtain a maximum of 10 percent unbalance between any two phases.

3.04 IDENTIFICATION

A. Identify system components according to Section 23 05 53 "Identification for HVAC Piping and Equipment" and Section 26 05 53 "Identification for Electrical Systems."

B. Install a sign indicating the generator neutral is bonded to the main service neutral at the main service location.

3.05 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Tests and Inspections:

1. Perform tests recommended by manufacturer and each visual and mechanical inspection and electrical and mechanical test listed in the first two subparagraphs below as specified in the NETA ATS. Certify compliance with test parameters.

    a. Visual and Mechanical Inspection

        1) Compare equipment nameplate data with drawings and specifications.
        2) Inspect physical and mechanical condition.
        3) Inspect anchorage, alignment, and grounding.
        4) Verify the unit is clean.

    b. Electrical and Mechanical Tests

        1) Perform insulation-resistance tests in accordance with IEEE 43.

            a) Machines larger than 200 hp (150 kW). Test duration shall be 10 minutes. Calculate polarization index.
            b) Machines 200 hp (150 kW) or less. Test duration shall be one minute. Calculate the dielectric-absorption ratio.

        2) Test protective relay devices.
        3) Verify phase rotation, phasing, and synchronized operation as required by the application.
        4) Functionally test engine shutdown for low oil pressure, overtemperature, overspeed, and other protection features as applicable.
        5) Perform vibration test for each main bearing cap.
        6) Verify correct functioning of the governor and regulator.

2. NFPA 110 Acceptance Tests: Perform tests required by NFPA 110 that are additional to those specified here including, but not limited to, single-step full-load pickup test.

3. Battery Tests: Equalize charging of battery cells according to manufacturer's written instructions. Record individual cell voltages.

    a. Measure charging voltage and voltages between available battery terminals for full-charging and float-charging conditions. Check electrolyte level and specific gravity under both conditions.
    b. Test for contact integrity of all connectors. Perform an integrity load test and a capacity load test for the battery.
    c. Verify acceptance of charge for each element of the battery after discharge.
    d. Verify that measurements are within manufacturer's specifications.

4. Battery-Charger Tests: Verify specified rates of charge for both equalizing and float-charging conditions.
5. System Integrity Tests: Methodically verify proper installation, connection, and integrity of each element of engine generator system before and during system operation. Check for air, exhaust, and fluid leaks.
6. Exhaust Emissions Test: Comply with applicable government test criteria.
7. Voltage and Frequency Transient Stability Tests: Use recording oscilloscope to measure voltage and frequency transients for 50 and 100 percent step-load increases and decreases, and verify that performance is as specified.
8. Noise Level Tests: Measure A-weighted level of noise emanating from generator-set installation, including engine exhaust and cooling-air intake and discharge, at four locations 25 feet (8 m) from edge of the generator enclosure, on the property line, and compare measured levels with required values.

C. Coordinate tests with tests for transfer switches and run them concurrently.

D. Test instruments shall have been calibrated within the last 12 months, traceable to NIST Calibration Services, and adequate for making positive observation of test results. Make calibration records available for examination on request.

E. Leak Test: After installation, charge exhaust, coolant, and fuel systems and test for leaks. Repair leaks and retest until no leaks exist.

F. Operational Test: After electrical circuitry has been energized, start units to confirm proper motor rotation and unit operation for generator and associated equipment.

G. Test and adjust controls and safeties. Replace damaged and malfunctioning controls and equipment.

H. Remove and replace malfunctioning units and retest and reinspect as specified above.

I. Retest: Correct deficiencies identified by tests and observations and retest until specified requirements are met.

J. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation resistances, time delays, and other values and observations. Attach a label or tag to each tested component indicating satisfactory completion of tests.

3.06 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, provide 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include quarterly exercising to check for proper starting, load transfer, and running under load. Include

routine preventive maintenance as recommended by manufacturer and adjusting as required for proper operation. Provide parts and supplies same as those used in the manufacture and installation of original equipment.

3.07 DEMONSTRATION

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

END OF SECTION

SECTION 26 36 00

TRANSFER SWITCHES

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes automatic transfer switches rated 600 V and less.

1.03 ACTION SUBMITTALS

A. Product Data: For each type of product.

1. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for transfer switches.
2. Include rated capacities, operating characteristics, electrical characteristics, and accessories.

B. Shop Drawings:

1. Include plans, elevations, sections, details showing minimum clearances, conductor entry provisions, gutter space, and installed features and devices.
2. Include material lists for each switch specified.
3. Single-Line Diagram: Show connections between transfer switch, power sources, and load; and show interlocking provisions for each combined transfer switch and bypass/isolation switch.

1.04 INFORMATIONAL SUBMITTALS

A. Qualification Data: For manufacturer-authorized service representative.

B. Seismic Qualification Data: Certificates, for transfer switches, 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.

C. Field quality-control reports.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For each type of product to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01, include the following:

a. Features and operating sequences, both automatic and manual.
b. List of all factory settings of relays; provide relay-setting and calibration instructions, including software, where applicable.

1.06 WARRANTY

A. Manufacturer's Warranty: Manufacturer agrees to repair or replace components of transfer switch or transfer switch components that fail in materials or workmanship within specified warranty period.

1. Warranty Period: Two years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

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

B. Comply with NEMA ICS 1.

C. Comply with NFPA 110.

D. Comply with UL 1008 unless requirements of these Specifications are stricter.

E. Indicated Current Ratings: Apply as defined in UL 1008 for continuous loading and total system transfer, including tungsten filament lamp loads not exceeding 30 percent of switch ampere rating, unless otherwise indicated.

F. Tested Fault-Current Closing and Short-Circuit Ratings: Adequate for duty imposed by protective devices at installation locations in Project under the fault conditions indicated, based on testing according to UL 1008.
1. Short-time withstand capability for three cycles.

G. Repetitive Accuracy of Solid-State Controls: All settings shall be plus or minus 2 percent or better over an operating temperature range of minus 20 to plus 70 deg C.

H. Resistance to Damage by Voltage Transients: Components shall meet or exceed voltage-surge withstand capability requirements when tested according to IEEE C62.62. Components shall meet or exceed voltage-impulse withstand test of NEMA ICS 1.

I. Electrical Operation: Accomplish by a nonfused, momentarily energized solenoid or electric-motor-operated mechanism. Switches for emergency or standby purposes shall be mechanically and electrically interlocked in both directions to prevent simultaneous connection to both power sources unless closed transition.

J. Service-Rated Transfer Switch:

1. Comply with UL 869A and UL 489.
2. Provide terminals for bonding the grounding electrode conductor to the grounded service conductor.
3. In systems with a neutral, the bonding connection shall be on the neutral bus.
4. Provide removable link for temporary separation of the service and load grounded conductors.
5. Service Disconnecting Means: Externally operated, manual mechanically actuated. Provide disconnecting means for the alternate source incoming feeder.

K. Neutral Terminal: Solid and fully rated unless otherwise indicated.

L. Factory Wiring: Train and bundle factory wiring and label, consistent with Shop Drawings, by color-code or by numbered or lettered wire and cable with printed tape or shrinkable sleeve markers at terminations. Color-coding and wire and cable markers are specified in Section 26 05 53 "Identification for Electrical Systems."

1. Designated Terminals: Pressure type, suitable for types and sizes of field wiring indicated.
2. Power-Terminal Arrangement and Field-Wiring Space: Suitable for top, side, or bottom entrance of feeder conductors as indicated.
3. Control Wiring: Equipped with lugs suitable for connection to terminal strips.
4. Accessible via front access.

M. Enclosures: General-purpose NEMA 250, Type 1, complying with NEMA ICS 6 and UL 508, unless otherwise indicated.

2.02 CONTACTOR-TYPE AUTOMATIC TRANSFER SWITCHES

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. Caterpillar, Inc.; Electric Power Division.
2. Cummins Power Generation.
3. Emerson.
4. Kohler Power Systems.

B. Comply with Level 1 equipment according to NFPA 110.

C. Switch Characteristics: Designed for continuous-duty repetitive transfer of full-rated current between active power sources.
1. Switch Action: Double throw; mechanically held in both directions.
2. Contacts: Silver composition or silver alloy for load-current switching. Contactor-style automatic transfer-switch units, rated 600 A and higher, shall have separate arcing contacts.
3. Conductor Connectors: Suitable for use with conductor material and sizes.
4. Material: Tin-plated aluminum.
5. Main and Neutral Lugs: Mechanical type.
6. Ground Lugs and Bus-Configured Terminators: Mechanical type.
7. Connectors shall be marked for conductor size and type according to UL 1008.

D. Automatic Open-Transition Transfer Switches: Interlocked to prevent the load from being closed on both sources at the same time.

1. Sources shall be mechanically and electrically interlocked to prevent closing both sources on the load at the same time.

E. Manual Switch Operation: Unloaded. Control circuit automatically disconnects from electrical operator during manual operation.

F. Signal-Before-Transfer Contacts: A set of normally open/normally closed dry contacts operates in advance of retransfer to normal source. Interval shall be adjustable from 1 to 30 seconds.

G. Digital Communication Interface: Matched to capability of remote annunciator or annunciator and control panel.

H. Automatic Transfer-Switch Controller Features:

1. Controller operates through a period of loss of control power.
2. Undervoltage Sensing for Each Phase of Normal and Alternate Source: Sense low phase-to-ground voltage on each phase. Pickup voltage shall be adjustable from 85 to 100 percent of nominal, and dropout voltage shall be adjustable from 75 to 98 percent of pickup value. Factory set for pickup at 90 percent and dropout at 85 percent.
3. Voltage/Frequency Lockout Relay: Prevent premature transfer to generator. Pickup voltage shall be adjustable from 85 to 100 percent of nominal. Factory set for pickup at 90 percent. Pickup frequency shall be adjustable from 90 to 100 percent of nominal. Factory set for pickup at 95 percent.
4. Time Delay for Retransfer to Normal Source: Adjustable from zero to 30 minutes, and factory set for 10 minutes. Override shall automatically defeat delay on loss of voltage or sustained undervoltage of emergency source, provided normal supply has been restored.
5. Test Switch: Simulate normal-source failure.
6. Switch-Position Pilot Lights: Indicate source to which load is connected.
7. Source-Available Indicating Lights: Supervise sources via transfer-switch normal- and emergency-source sensing circuits.

    a. Normal Power Supervision: Green light with nameplate engraved "Normal Source Available."
    b. Emergency Power Supervision: Red light with nameplate engraved "Emergency Source Available."

8. Unassigned Auxiliary Contacts: Two normally open, single-pole, double-throw contacts for each switch position, rated 10 A at 240-V ac.
9. Transfer Override Switch: Overrides automatic retransfer control so transfer switch will remain connected to emergency power source regardless of condition of normal source. Pilot light indicates override status.
10. Engine Starting Contacts: One isolated and normally closed, and one isolated and normally open; rated 10 A at 32-V dc minimum.
11. Engine Shutdown Contacts: Time delay adjustable from zero to five minutes, and factory set for five minutes. Contacts shall initiate shutdown at remote engine-generator controls after retransfer of load to normal source.
12. Engine-Generator Exerciser: Solid-state, programmable-time switch starts engine generator and transfers load to it from normal source for a preset time, then retransfers and shuts down engine after a preset cool-down period. Initiates exercise cycle at preset intervals adjustable from 7 to 30 days. Running periods shall be adjustable from 10 to 30 minutes. Factory settings shall be for 7-day exercise cycle, 20-minute running period, and 5-minute cool-down period. Exerciser features include the following:

    a. Exerciser Transfer Selector Switch: Permits selection of exercise with and without load transfer.
    b. Push-button programming control with digital display of settings.

c. Integral battery operation of time switch when normal control power is unavailable.

I. Large-Motor-Load Power Transfer:

1. In-Phase Monitor: Factory-wired, internal relay controls transfer so contacts close only when the two sources are synchronized in phase and frequency. Relay shall compare phase relationship and frequency difference between normal and emergency sources and initiate transfer when both sources are within 15 electrical degrees, and only if transfer can be completed within 60 electrical degrees. Transfer shall be initiated only if both sources are within 2 Hz of nominal frequency and 70 percent or more of nominal voltage.
2. Programmed Neutral Switch Position: Switch operator with programmed neutral position arranged to provide a midpoint between the two working switch positions, with an intentional, time-controlled pause at midpoint during transfer. Adjustable pause from 0.5 to 30 seconds minimum, and factory set for 0.5 second unless otherwise indicated. Time delay occurs for both transfer directions. Disable pause unless both sources are live.

2.03 SOURCE QUALITY CONTROL

A. Factory Tests: Test and inspect components, assembled switches, and associated equipment according to UL 1008. Ensure proper operation. Check transfer time and voltage, frequency, and time-delay settings for compliance with specified requirements. Perform dielectric strength test complying with NEMA ICS 1.

B. Prepare test and inspection reports.

1. For each of the tests required by UL 1008, performed on representative devices, for emergency systems. Include results of test for the following conditions:

a. Overvoltage.
b. Undervoltage.
c. Loss of supply voltage.
d. Reduction of supply voltage.
e. Alternative supply voltage or frequency is at minimum acceptable values.
f. Temperature rise.
g. Dielectric voltage-withstand; before and after short-circuit test.
h. Overload.
i. Contact opening.
j. Endurance.
k. Short circuit.
l. Short-time current capability.
m. Receptacle withstand capability.
n. Insulating base and supports damage.

PART 3 - EXECUTION

3.01 INSTALLATION

A. Annunciator and Control Panel Mounting: Flush in wall unless otherwise indicated.

B. Identify components according to Section 26 05 53 "Identification for Electrical Systems."

C. Set field-adjustable intervals and delays, relays, and engine exerciser clock.

D. Comply with NECA 1.

3.02 CONNECTIONS

A. Wiring to Remote Components: Match type and number of cables and conductors to generator sets, control, and communication requirements of transfer switches as recommended by manufacturer. Increase raceway sizes at no additional cost to Owner if necessary to accommodate required wiring.

B. Wiring Method: Install cables in raceways and cable trays except within electrical enclosures. Conceal raceway and cables except in unfinished spaces.

1. Comply with requirements for raceways and boxes specified in Section 26 05 33 "Raceways and Boxes for Electrical Systems."

C. Wiring within Enclosures: Bundle, lace, and train conductors to terminal points with no excess and without exceeding manufacturer's limitations on bending radii.

D. Ground equipment according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

E. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

F. Connect twisted pair cable according to Section 26 05 23 "Control-Voltage Electrical Power Cables."

G. Route and brace conductors according to manufacturer's written instructions[.] and Section 26 05 29 "Hangers and Supports for Electrical Systems." Do not obscure manufacturer's markings and labels.

H. Brace and support equipment according to Section 26 05 48.16 "Seismic Controls for Electrical Systems."

3.03 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. After installing equipment, test for compliance with requirements according to NETA ATS.
2. Visual and Mechanical Inspection:

a. Compare equipment nameplate data with Drawings and Specifications.
b. Inspect physical and mechanical condition.
c. Inspect anchorage, alignment, grounding, and required clearances.
d. Verify that the unit is clean.
e. Verify appropriate lubrication on moving current-carrying parts and on moving and sliding surfaces.

f. Verify that manual transfer warnings are attached and visible.
g. Verify tightness of all control connections.
h. Inspect bolted electrical connections for high resistance using one of the following methods, or both:

1) Use of low-resistance ohmmeter.
2) Verify tightness of accessible bolted electrical connections by calibrated torque-wrench method according to manufacturer's published data.

i. Perform manual transfer operation.
j. Verify positive mechanical interlocking between normal and alternate sources.
k. Inspect control power transformers.

1) Inspect for physical damage, cracked insulation, broken leads, tightness of connections, defective wiring, and overall general condition.
2) Verify that primary and secondary fuse or circuit-breaker ratings match Drawings.
3) Verify correct functioning of drawout disconnecting contacts, grounding contacts, and interlocks.

3. Electrical Tests:

a. Perform insulation-resistance tests on all control wiring with respect to ground.
b. Verify settings and operation of control devices.
c. Calibrate and set all relays and timers.
d. Verify phase rotation, phasing, and synchronized operation.
e. Perform automatic transfer tests.
f. Verify correct operation and timing of the following functions:

1) Normal source voltage-sensing and frequency-sensing relays.
2) Engine start sequence.
3) Time delay on transfer.
4) Alternative source voltage-sensing and frequency-sensing relays.
5) Automatic transfer operation.
6) Interlocks and limit switch function.
7) Time delay and retransfer on normal power restoration.
8) Engine cool-down and shutdown feature.

4. After energizing circuits, perform each electrical test for transfer switches stated in NETA ATS and demonstrate interlocking sequence and operational function for each switch at least three times.

a. Simulate power failures of normal source to automatic transfer switches and retransfer from emergency source with normal source available.
b. Verify time-delay settings.
c. Verify pickup and dropout voltages by data readout or inspection of control settings.
d. Verify proper sequence and correct timing of automatic engine starting, transfer time delay, retransfer time delay on restoration of normal power, and engine cool-down and shutdown.

C. Coordinate tests with tests of generator and run them concurrently.

D. Report results of tests and inspections in writing. Record adjustable relay settings and measured insulation and contact resistances and time delays. Attach a label or tag to each tested component indicating satisfactory completion of tests.

E. Transfer switches will be considered defective if they do not pass tests and inspections.

F. Remove and replace malfunctioning units and retest as specified above.

G. Prepare test and inspection reports.

H. Infrared Scanning: After Substantial Completion, but not more than 60 days after Final Acceptance, perform an infrared scan of each switch. Remove all access panels so joints and connections are accessible to portable scanner.

1. Instrument: Use an infrared scanning device designed to measure temperature or to detect significant deviations from normal values. Provide calibration record for device.
2. Record of Infrared Scanning: Prepare a certified report that identifies switches checked and that describes scanning results. Include notation of deficiencies detected, remedial action taken, and observations after remedial action.

3.04 DEMONSTRATION

A. Engage a factory-authorized service representative to train Owner's maintenance personnel to adjust, operate, and maintain transfer switches and related equipment.

B. Coordinate this training with that for generator equipment.

END OF SECTION

SECTION 26 51 19

LED INTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Interior solid-state luminaires that use LED technology.
2. Lighting fixture supports.

B. Related Requirements:

1. Section 26 09 23"Lighting Control Devices" for automatic control of lighting, including photoelectric relays, occupancy sensors, and multipole lighting relays and contactors.
2. Section 26 09 43"Network Lighting Controls for lighting control panels.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color Rendering Index.

C. Fixture: See "Luminaire."

D. IP: International Protection or Ingress Protection Rating.

E. LED: Light-emitting diode.

F. Lumen: Measured output of lamp and luminaire, or both.

G. Luminaire: Complete lighting unit, including lamp, reflector, and housing.

1.04 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. 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. Shop Drawings: For nonstandard or custom luminaires.

1. Include plans, elevations, sections, and mounting and attachment details.
2. Include details of luminaire assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include diagrams for power, signal, and control wiring.

C. Samples for Verification: As requested by Architect.

1. Include Samples of luminaires and accessories to verify finish selection.

D. Product Schedule: For luminaires and lamps. Use same designations indicated on Drawings.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings: Reflected ceiling plan(s) and other details, drawn to scale, on which the following items are shown and coordinated with each other, using input from installers of the items involved:

1. Lighting luminaires.
2. Suspended ceiling components.
3. Partitions and millwork that penetrate the ceiling or extend to within 12 inches (300 mm) of the plane of the luminaires.
4. Structural members to which equipment and/or luminaires will be attached.
5. Initial access modules for acoustical tile, including size and locations.
6. Items penetrating finished ceiling, including the following:

    a. Other luminaires.
    b. Air outlets and inlets.
    c. Speakers.
    d. Sprinklers.
    e. Access panels.
    f. Ceiling-mounted projectors.

B. Qualification Data: For testing laboratory providing photometric data for luminaires.

C. Seismic Qualification Certificates: For luminaires, 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.

D. Detailed description of equipment anchorage devices on which the certification is based and their installation requirements.

E. Product Certificates: For each type of luminaire.

F. Product Test Reports: For each luminaire, for tests performed by manufacturer and witnessed by a qualified testing agency.

G. Sample warranty.

1.06 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.

1.07 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. Lamp modules: Ten for every 100 of each type and rating installed. Furnish at least one of each type.
2. Diffusers and Lenses: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.08 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Luminaire manufacturer's laboratory that is accredited under the NVLAP for Energy Efficient Lighting Products.

B. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by an independent agency, with the experience and capability to conduct the testing indicated, that is an NRTL as defined by OSHA in 29 CFR 1910.7, accredited under the NVLAP for Energy Efficient Lighting Products, and complying with the applicable IES testing standards.

C. Provide luminaires from a single manufacturer for each luminaire type.

D. Each luminaire type shall be binned within a three-step MacAdam Ellipse to ensure color consistency among luminaires.

E. Mockups: For interior lighting luminaires in room or module mockups, complete with power and control connections.

1. Obtain Architect's approval of luminaires in mockups before starting installations.
2. Maintain mockups during construction in an undisturbed condition as a standard for judging the completed Work.
3. Approval of mockups does not constitute approval of deviations from the Contract Documents contained in mockups unless Architect specifically approves such deviations in writing.

4. Subject to compliance with requirements, approved mockups may become part of the completed Work if undisturbed at time of Substantial Completion.

1.09 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

1.10 WARRANTY

A. Warranty: Manufacturer and Installer agree to repair or replace components of luminaires that fail in materials or workmanship within specified warranty period.

B. Warranty Period: Five year(s) from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Luminaires shall withstand the effects of earthquake motions determined according to ASCE/SEI 7

1. The term "withstand" means "the luminaire will remain in place without separation of any parts when subjected to the seismic forces specified."

2.02 LUMINAIRE REQUIREMENTS

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

B. NRTL Compliance: Luminaires for hazardous locations shall be listed and labeled for indicated class and division of hazard by an NRTL.

C. Recessed Fixtures: Comply with NEMA LE 4.

D. CRI of minimum 70. CCT as scheduled on the drawings.

E. Rated lamp life of 50,000 hours.

F. Lamps dimmable from 100 percent to 0 percent of maximum light output where dimming control is indicated on the drawings.

G. Internal driver or remote driver as applicable for each scheduled luminaire.

H. Nominal Operating Voltage: As scheduled on the drawings. .

1. Lens Thickness: At least 0.125 inch (3.175 mm) minimum unless otherwise indicated.

2.03 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.

2.04 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.

2.05 LUMINAIRE FIXTURE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "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

3.01 EXAMINATION

A. Examine substrates, areas, and conditions, with Installer present, for compliance with requirements for installation tolerances and other conditions affecting performance of the Work.

B. Examine 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.

3.02 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.

3.03 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 3/4-inch (20-mm) 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 26 05 19 "Low-Voltage Electrical Power Conductors and Cables" for wiring connections.

3.04 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.05 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.

C. Prepare test and inspection reports.

3.06 STARTUP SERVICE

A. Comply with requirements for startup specified in Section 26 09 43 "Network Lighting Controls."

3.07 ADJUSTING

A. Occupancy Adjustments: When requested within 12 months of date of Substantial Completion, provide on-site assistance in adjusting the direction of aim of luminaires to suit occupied conditions. Make up to two visits to Project during other-than-normal hours for this purpose. Some of this work may be required during hours of darkness.

1. During adjustment visits, inspect all luminaires. Replace lamps or luminaires that are defective.
2. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.
3. Adjust the aim of luminaires in the presence of the Architect.

END OF SECTION

SECTION 26 52 19

EMERGENCY AND EXIT LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Exit signs.
2. Emergency lighting units.
3. Luminaire supports.

1.03 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.

1.04 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.

1.05 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For luminaires and lighting systems to include in emergency, operation, and maintenance manuals.

1.06 DELIVERY, STORAGE, AND HANDLING

A. Protect finishes of exposed surfaces by applying a strippable, temporary protective covering before shipping.

PART 2 - PRODUCTS

2.01 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.

2.02 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 277 V ac.
2. Lamps for AC Operation: LEDs; 50,000 hours minimum rated lamp life.

2.03 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.

2.04 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.

2.05 LUMINAIRE SUPPORT COMPONENTS

A. Comply with requirements in Section 26 05 29 "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

3.01 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.

3.02 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.

3.03 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.04 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.

3.05 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

SECTION 26 56 00

EXTERIOR LIGHTING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Exterior luminaires with LED arrays and drivers.
2. Luminaire-mounted photoelectric relays.
3. Poles and accessories.

B. Related Sections:

1. Section 26 51 00 "Interior Lighting" for exterior luminaires normally mounted on exterior surfaces of buildings.

1.03 DEFINITIONS

A. CCT: Correlated color temperature.

B. CRI: Color-rendering index.

C. HID: High-intensity discharge.

D. LED: Light emitting diode

E. LER: Luminaire efficacy rating.

F. Luminaire: Complete lighting fixture, including ballast housing if provided.

G. Pole: Luminaire support structure, including tower used for large area illumination.

H. Standard: Same definition as "Pole" above.

1.04 STRUCTURAL ANALYSIS CRITERIA FOR POLE SELECTION

A. Dead Load: Weight of luminaire and its horizontal and vertical supports, lowering devices, and supporting structure, applied as stated in AASHTO LTS-4-M.

B. Live Load: Single load of 500 lbf (2224 N), distributed as stated in AASHTO LTS-4-M.

C. Ice Load: Load of 3 lbf/sq. ft. (145 Pa), applied as stated in AASHTO LTS-4-M Ice Load Map.

D. Wind Load: Pressure of wind on pole and luminaire and banners and banner arms, calculated and applied as stated in AASHTO LTS-4-M.

1. Basic wind speed for calculating wind load for poles 50 feet (15 m) high or less is 90 mph (40 m/s).

a. Wind Importance Factor: 1.0.
b. Minimum Design Life: 25 years.
c. Velocity Conversion Factors: 1.0.

1.05 ACTION SUBMITTALS

A. Product Data: For each luminaire, pole, and support component, arranged in order of lighting unit designation. Include data on features, accessories, finishes, and the following:

1. Physical description of luminaire, including materials, dimensions, effective projected area, and verification of indicated parameters.
2. Details of attaching luminaires and accessories.
3. Details of installation and construction.
4. Luminaire materials.
5. Photometric data based on laboratory tests of each luminaire type, complete with indicated lamps, ballasts, and accessories.

a. Manufacturer Certified Data: Photometric data shall be certified by manufacturer's laboratory with a current accreditation under the National Voluntary Laboratory Accreditation Program for Energy Efficient Lighting Products.

6. Photoelectric relays.
7. Ballasts, including energy-efficiency data.
8. Lamps, including life, output, CCT, CRI, lumens, and energy-efficiency data.
9. Materials, dimensions, and finishes of poles.
10. Means of attaching luminaires to supports, and indication that attachment is suitable for components involved.
11. Anchor bolts for poles.
12. Manufactured pole foundations.

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. Anchor-bolt templates keyed to specific poles and certified by manufacturer.
3. Wiring Diagrams: For power, signal, and control wiring.

1.06 INFORMATIONAL SUBMITTALS

A. Pole and Support Component Certificates: Signed by manufacturers of poles, certifying that products are designed for indicated load requirements in AASHTO LTS-4-M and that load imposed by luminaire and attachments has been included in design. The certification shall be based on design calculations by a professional engineer.

B. Field quality-control reports.

C. Warranty: Sample of special warranty.

1.07 CLOSEOUT SUBMITTALS

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

1.08 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: One for every 100 of each type and rating installed. Furnish at least one of each type.
2. Glass and Plastic Lenses, Covers, and Other Optical Parts: One for every 100 of each type and rating installed. Furnish at least one of each type.
3. Ballasts: One for every 100 of each type and rating installed. Furnish at least one of each type.
4. Globes and Guards: One for every 20 of each type and rating installed. Furnish at least one of each type.

1.09 QUALITY ASSURANCE

A. Luminaire Photometric Data Testing Laboratory Qualifications: Provided by manufacturers' laboratories that are accredited under the National Volunteer Laboratory Accreditation Program for Energy Efficient Lighting Products.

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 IEEE C2, "National Electrical Safety Code."

D. Comply with NFPA 70.

1.10 DELIVERY, STORAGE, AND HANDLING

A. Store poles on decay-resistant-treated skids at least 12 inches (300 mm) above grade and vegetation. Support poles to prevent distortion and arrange to provide free air circulation.

B. Retain factory-applied pole wrappings on metal poles until right before pole installation. For poles with nonmetallic finishes, handle with web fabric straps.

1.11 WARRANTY

A. Special Warranty: Manufacturer's standard form in which manufacturer agrees to repair or replace products that fail in materials or workmanship; that corrode; or that fade, stain, perforate, erode, or chalk due to effects of weather or solar radiation within specified warranty

period. Manufacturer may exclude lightning damage, hail damage, vandalism, abuse, or unauthorized repairs or alterations from special warranty coverage.

1. Warranty Period for Luminaires: Five years from date of Substantial Completion.
2. Warranty Period for Metal Corrosion: Five years from date of Substantial Completion.
3. Warranty Period for Color Retention: Five years from date of Substantial Completion.
4. Warranty Period for Poles: Repair or replace lighting poles and standards that fail in finish, materials, and workmanship within manufacturer's standard warranty period, but not less than three years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 MANUFACTURERS

A. Products: Subject to compliance with requirements, available products that may be incorporated into the Work include, but are not limited to, product(s) indicated on Drawings.

2.02 GENERAL REQUIREMENTS FOR LUMINAIRES

A. Luminaires shall comply with UL 1598 and be listed and labeled for installation in wet locations by an NRTL acceptable to authorities having jurisdiction.

1. LER Tests Incandescent Fixtures: Where LER is specified, test according to NEMA LE 5A.
2. LER Tests HID Fixtures: Where LER is specified, test according to NEMA LE 5B.

B. Lateral Light Distribution Patterns: Comply with IESNA RP-8 for parameters of lateral light distribution patterns indicated for luminaires.

C. Metal Parts: Free of burrs and sharp corners and edges.

D. Sheet Metal Components: Corrosion-resistant aluminum unless otherwise indicated. Form and support to prevent warping and sagging.

E. Housings: Rigidly formed, weather- and light-tight enclosures that will not warp, sag, or deform in use. Provide filter/breather for enclosed luminaires.

F. Doors, Frames, and Other Internal Access: Smooth operating, free of light leakage under operating conditions, and designed to permit relamping without use of tools. Designed to prevent doors, frames, lenses, diffusers, and other components from falling accidentally during relamping and when secured in operating position. Doors shall be removable for cleaning or replacing lenses. Designed to disconnect ballast when door opens.

G. Exposed Hardware Material: Stainless steel.

H. Plastic Parts: High resistance to yellowing and other changes due to aging, exposure to heat, and UV radiation.

I. Light Shields: Metal baffles, factory installed and field adjustable, arranged to block light distribution to indicated portion of normally illuminated area or field.

J. Reflecting surfaces shall have minimum reflectance as follows unless otherwise indicated:

1. White Surfaces: 85 percent.
2. Specular Surfaces: 83 percent.
3. Diffusing Specular Surfaces: 75 percent.

K. Lenses and Refractors Gaskets: Use heat- and aging-resistant resilient gaskets to seal and cushion lenses and refractors in luminaire doors.

L. Luminaire Finish: Manufacturer's standard paint applied to factory-assembled and -tested luminaire before shipping. Where indicated, match finish process and color of pole or support materials.

M. Factory-Applied Finish for Steel Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or SSPC-SP 8, "Pickling."
2. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected from manufacturer's standard catalog of colors.

N. Factory-Applied Finish for Aluminum Luminaires: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Finish designations prefixed by AA comply with the system established by the Aluminum Association for designating aluminum finishes.
2. Class I, Color Anodic Finish: AA-M32C22A42/A44 (Mechanical Finish: medium satin; Chemical Finish: etched, medium matte; Anodic Coating: Architectural Class I, integrally colored or electrolytically deposited color coating 0.018 mm or thicker) complying with AAMA 611.

a. Color: As selected by Architect from manufacturer's standard catalog of colors.

O. Factory-Applied Labels: Comply with UL 1598. Include recommended lamps/LED engines and ballasts/drivers. Labels shall be located where they will be readily visible to service personnel, but not seen from normal viewing angles when lamps are in place.

2.03 LUMINAIRE-MOUNTED PHOTOELECTRIC RELAYS

A. Comply with UL 773 or UL 773A.

B. Contact Relays: Factory mounted, single throw, designed to fail in the on position, and factory set to turn light unit on at 1.5 to 3 fc (16 to 32 lx) and off at 4.5 to 10 fc (48 to 108 lx) with 15-second minimum time delay. Relay shall have directional lens in front of photocell to prevent artificial light sources from causing false turnoff.

1. Relay with locking-type receptacle shall comply with ANSI C136.10.
2. Adjustable window slide for adjusting on-off set points.

2.04 DRIVERS FOR LED ENGINES

A. UL 1598, suitable for Wet Locations.

B. RoHS compliant.

C. Design Lights Consortium (DLC) Certified.

D. Housing: IP 66 rating.

E. Voltage: Unit accepts 120V through 277V, 50hz to 60hz input.

F. Output based on wattage of LED array.

G. Include plug type disconnect.

H. Power factor shall not be less than 90 percent.

2.05 LED LIGHT ENGINES

A. Array wattage shall be as scheduled on the drawings plus or minus 8 percent for ambient temperature and forward voltage.

B. Minimum Lumen Output: As scheduled on the drawings based on IESNA LM-79 or LM-80 testing.

C. Color Temperature: As scheduled on the drawings with minimum 70 CRI.

D. Lumen depreciation: 70 percent of initial output after 215,000 hours at a temperature of 40°C using IESNA LM-80 methodology.

2.06 GENERAL REQUIREMENTS FOR POLES AND SUPPORT COMPONENTS

A. Structural Characteristics: Comply with AASHTO LTS-4-M.

1. Wind-Load Strength of Poles: Adequate at indicated heights above grade without failure, permanent deflection, or whipping in steady winds of speed indicated in "Structural Analysis Criteria for Pole Selection" Article.
2. Strength Analysis: For each pole, multiply the actual equivalent projected area of luminaires and brackets by a factor of 1.1 to obtain the equivalent projected area to be used in pole selection strength analysis.

B. Luminaire Attachment Provisions: Comply with luminaire manufacturers' mounting requirements. Use stainless-steel fasteners and mounting bolts unless otherwise indicated.

C. Mountings, Fasteners, and Appurtenances: Corrosion-resistant items compatible with support components.

1. Materials: Shall not cause galvanic action at contact points.
2. Anchor Bolts, Leveling Nuts, Bolt Caps, and Washers: Hot-dip galvanized after fabrication unless otherwise indicated.
3. Anchor-Bolt Template: Plywood or steel.

D. Handhole: Oval-shaped, with minimum clear opening of 2-1/2 by 5 inches (65 by 130 mm), with cover secured by stainless-steel captive screws.

E. Concrete Pole Foundations: Pre-cast, with anchor bolts to match pole-base flange. Concrete, reinforcement, and formwork are specified in Division 03.

2.07 STEEL POLES

A. Poles: Comply with ASTM A 500, Grade B, carbon steel with a minimum yield of 46,000 psig (317 MPa); one-piece construction up to 40 feet (12 m) in height with access handhole in pole wall.

1. Shape: Square, straight.
2. Mounting Provisions: Butt flange for bolted mounting on foundation or breakaway support.

B. Brackets for Luminaires: Detachable, cantilever, without underbrace.

1. Adapter fitting welded to pole, allowing the bracket to be bolted to the pole mounted adapter, then bolted together with stainless-steel bolts.
2. Cross Section: Tapered oval, with straight tubular end section to accommodate luminaire.
3. Match pole material and finish.

C. Pole-Top Tenons: Fabricated to support luminaire or luminaires and brackets indicated, and securely fastened to pole top.

D. Grounding and Bonding Lugs: Welded 1/2-inch (13-mm) threaded lug, complying with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems," listed for attaching grounding and bonding conductors of type and size listed in that Section, and accessible through handhole.

E. Cable Support Grip: Wire-mesh type with rotating attachment eye, sized for diameter of cable and rated for a minimum load equal to weight of supported cable times a 5.0 safety factor.

F. Factory-Painted Finish: Comply with NAAMM's "Metal Finishes Manual for Architectural and Metal Products" for recommendations for applying and designating finishes.

1. Surface Preparation: Clean surfaces to comply with SSPC-SP 1, "Solvent Cleaning," to remove dirt, oil, grease, and other contaminants that could impair paint bond. Grind welds and polish surfaces to a smooth, even finish. Remove mill scale and rust, if present, from uncoated steel, complying with SSPC-SP 5/NACE No. 1, "White Metal Blast Cleaning," or with SSPC-SP 8, "Pickling."
2. Interior Surfaces of Pole: One coat of bituminous paint, or otherwise treat for equal corrosion protection.
3. Exterior Surfaces: Manufacturer's standard finish consisting of one or more coats of primer and two finish coats of high-gloss, high-build polyurethane enamel.

a. Color: As selected by Architect from manufacturer's standard colors.

2.08 POLE ACCESSORIES

A. Base Covers: Manufacturers' standard metal units, arranged to cover pole's mounting bolts and nuts. Finish same as pole.

PART 3 - EXECUTION

3.01 LUMINAIRE INSTALLATION

A. Install lamps in each luminaire.

B. Fasten luminaire to indicated structural supports.

1. Use fastening methods and materials selected to resist seismic forces defined for the application and approved by manufacturer.

C. Adjust luminaires that require field adjustment or aiming. Include adjustment of photoelectric device to prevent false operation of relay by artificial light sources, favoring a north orientation.

3.02 POLE INSTALLATION

A. Alignment: Align pole foundations and poles for optimum directional alignment of luminaires and their mounting provisions on the pole.

B. Clearances: Maintain the following minimum horizontal distances of poles from surface and underground features unless otherwise indicated on Drawings:

1. Fire Hydrants and Storm Drainage Piping: 60 inches (1520 mm).
2. Water, Gas, Electric, Communication, and Sewer Lines: five feet.
3. Trees: 15 feet (5 m) from tree trunk.

C. Concrete Pole Foundations: Set anchor bolts according to anchor-bolt templates furnished by pole manufacturer. Concrete materials, installation, and finishing requirements are specified in Division 03.

D. Foundation-Mounted Poles: Mount pole with leveling nuts, and tighten top nuts to torque level recommended by pole manufacturer.

1. Use anchor bolts and nuts selected to resist seismic forces defined for the application and approved by manufacturer.
2. Grout void between pole base and foundation. Use nonshrink or expanding concrete grout firmly packed to fill space.
3. Install base covers unless otherwise indicated.
4. Use a short piece of 1/2-inch- (13-mm-) diameter pipe to make a drain hole through grout. Arrange to drain condensation from interior of pole.

E. Poles and Pole Foundations Set in Concrete Paved Areas: Install poles with minimum of 6-inch- (150-mm-) wide, unpaved gap between the pole or pole foundation and the edge of adjacent concrete slab. Fill unpaved ring with pea gravel to a level 1 inch (25 mm) below top of concrete slab.

F. Raise and set poles using web fabric slings (not chain or cable).

3.03 BOLLARD LUMINAIRE INSTALLATION

A. Align units for optimum directional alignment of light distribution.

B. Install on concrete base with top 4 inches (100 mm) above finished grade or surface at bollard location. Cast conduit into base, and shape base to match shape of bollard base. Finish by troweling and rubbing smooth. Concrete materials, installation, and finishing are specified in Division 03.

3.04 CORROSION PREVENTION

A. Aluminum: Do not use in contact with earth or concrete. When in direct contact with a dissimilar metal, protect aluminum by insulating fittings or treatment.

B. Steel Conduits: Comply with Section 26 05 33 "Raceways and Boxes for Electrical Systems." In concrete foundations, wrap conduit with 0.010-inch- (0.254-mm-) thick, pipe-wrapping plastic tape applied with a 50 percent overlap.

3.05 GROUNDING

A. Ground metal poles and support structures according to Section 26 05 26 "Grounding and Bonding for Electrical Systems."

1. Install grounding electrode for each pole unless otherwise indicated.
2. Install grounding conductor pigtail in the base for connecting luminaire to grounding system.

3.06 FIELD QUALITY CONTROL

A. Inspect each installed fixture for damage. Replace damaged fixtures and components.

B. Illumination Observations: Verify normal operation of lighting units after installing luminaires and energizing circuits with normal power source.

1. Verify operation of photoelectric controls.

C. Prepare a written report of tests, inspections, observations, and verifications indicating and interpreting results. If adjustments are made to lighting system, retest to demonstrate compliance with standards.

END OF SECTION

SECTION 27 11 00

COMMUNICATIONS EQUIPMENT ROOM FITTINGS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Telecommunications mounting elements.
2. Backboards.
3. Telecommunications equipment racks and cabinets.
4. Telecommunications service entrance pathways.
5. Grounding.

B. Related Sections:

1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Division 27 Section "Communications Horizontal Cabling" for voice and data cabling associated with system panels and devices.
3. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.03 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. BICSI: Building Industry Consulting Service International.

C. Channel Cable Tray: A fabricated structure consisting of a one-piece, ventilated-bottom or solid-bottom channel not exceeding 6 inches (152 mm) in width.

D. Ladder Cable Tray: A fabricated structure consisting of two longitudinal side rails connected by individual transverse members (rungs).

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. Solid-Bottom or Nonventilated Cable Tray: A fabricated structure consisting of a bottom without ventilation openings within integral or separate longitudinal side rails.

H. Trough or Ventilated Cable Tray: A fabricated structure consisting of integral or separate longitudinal rails and a bottom having openings sufficient for the passage of air and using 75 percent or less of the plan area of the surface to support cables.

1.04 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Floor-mounted cabinets and cable pathways shall withstand the effects of earthquake motions determined according to SEI/ASCE 7.

1.05 SUBMITTALS

A. Product Data: For each type of product indicated. Include construction details, material descriptions, dimensions of individual components and profiles, and finishes for equipment racks and cabinets. Include rated capacities, operating characteristics, electrical characteristics, and furnished specialties and accessories.

B. Shop Drawings: For communications equipment room fittings. Include plans, elevations, sections, details, and attachments to other work.

1. Detail equipment assemblies and indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
2. Equipment Racks and Cabinets: Include workspace requirements and access for cable connections.
3. Grounding: Indicate location of grounding bus bar and its mounting detail showing standoff insulators and wall mounting brackets.

1.06 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

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

C. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

D. Grounding: Comply with ANSI-J-STD-607-A.

1.07 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install equipment frames and cable trays until spaces are enclosed and weathertight, wet work in spaces is complete and dry, and work above ceilings is complete.

1.08 COORDINATION

A. Coordinate layout and installation of communications equipment with Owner's telecommunications and LAN equipment and service suppliers. Coordinate service entrance arrangement with local exchange carrier.

1. Meet jointly with telecommunications and LAN equipment suppliers, local exchange carrier representatives, and Owner to exchange information and agree on details of equipment arrangements and installation interfaces.
2. Record agreements reached in meetings and distribute them to other participants.
3. Adjust arrangements and locations of distribution frames, cross-connects, and patch panels in equipment rooms to accommodate and optimize arrangement and space requirements of telephone switch and LAN equipment.
4. Adjust arrangements and locations of equipment with distribution frames, cross-connects, and patch panels of cabling systems of other communications, electronic safety and security, and related systems that share space in the equipment room.

B. Coordinate location of power raceways and receptacles with locations of communications equipment requiring electrical power to operate.

PART 2 - PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled. Cable support brackets shall be designed to prevent degradation of cable performance and pinch points that could damage cable. Cable tie slots fasten cable ties to brackets.

1. Comply with NFPA 70 and UL 2043 for fire-resistant and low-smoke-producing characteristics.
2. Support brackets with cable tie slots for fastening cable ties to brackets.
3. Lacing bars, spools, J-hooks, and D-rings.
4. Straps and other devices.

C. Cable Trays:

1. Manufacturers: provide products by one of the following or approved equal:

   a. Cable Management Solutions, Inc.
   b. Cooper B-Line, Inc.
   c. Cope - Tyco/Allied Tube & Conduit.
   d. GS Metals Corp.

2. Cable Tray Materials: Metal, suitable for indoors and protected against corrosion by electroplated zinc galvanizing, complying with ASTM B 633, Type 1, not less than 0.000472 inch (0.012 mm) thick.
   a. Ladder Cable Trays: Nominally 18 inches (455 mm) wide, and a rung spacing of 12 inches (305 mm).

D. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems.

1. 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.

2.02 BACKBOARDS

A. Backboards: Plywood, fire-retardant treated, 3/4 by 48 by 96 inches (19 by 1220 by 2440 mm). Comply with requirements for plywood backing panels specified in Division 06 Section "Rough Carpentry."

2.03 EQUIPMENT FRAMES

A. General Frame Requirements:

1. Distribution Frames: Freestanding and wall-mounting, modular-steel units designed for telecommunications terminal support and coordinated with dimensions of units to be supported.
2. Module Dimension: Width compatible with EIA 310 standard, 19-inch (480-mm) panel mounting.
3. Finish: Manufacturer's standard, baked-polyester powder coat.

B. Floor-Mounted Racks shall be provided in the MDF and in the IDF’s unless noted otherwise: Modular-type, steel construction.

1. Vertical and horizontal cable management channels, top and bottom cable troughs, grounding lug and a power strip.
2. Baked-polyester powder coat finish.

C. Modular Wall Cabinets shall be provided where indicated:

1. Wall mounting.
2. Steel construction.
3. Treated to resist corrosion.
4. Lockable front and rear doors.
5. Louvered side panels.
6. Cable access provisions top and bottom.
7. Grounding lug.
8. Roof mounted, 250-cfm (118-L/s) fan.
9. Power strip.
10. All cabinets keyed alike.

D. Cable Management for Equipment Frames:

1. Metal, with integral wire retaining fingers.
2. Baked-polyester powder coat finish.
3. Vertical cable management panels shall have front and rear channels, with covers.
4. Provide horizontal crossover cable manager at the top of each relay rack, with a minimum height of two rack units each.

2.04 POWER STRIPS

A. Power Strips: Comply with UL 1363.

1. Rack mounting.
2. Six 20-A, 120-V ac, NEMA WD 6, Configuration 5-20R receptacles.
3. LED indicator lights for power and protection status.

4. LED indicator lights for reverse polarity and open outlet ground.
5. Circuit Breaker and Thermal Fusing: When protection is lost, circuit opens and cannot be reset.
6. Circuit Breaker and Thermal Fusing: Unit continues to supply power if protection is lost.
7. Rocker-type on-off switch, illuminated when in on position.
8. Peak Single-Impulse Surge Current Rating: 33 kA per phase.
9. Protection modes shall be line to neutral, line to ground, and neutral to ground. UL 1449 clamping voltage for all 3 modes shall be not more than 330 V.

2.05 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Telecommunications Main Bus Bar:

1. Provide Bus Bars at each MDF and IDF room.

2. Connectors: Mechanical type, cast silicon bronze, solderless compression-type wire terminals, and long-barrel, two-bolt connection to ground bus bar.
3. Ground Bus Bar: Copper, minimum 1/4 inch thick by 4 inches wide (6 mm thick by 100 mm wide) with 9/32-inch (7.14-mm) holes spaced 1-1/8 inches (28 mm) apart.
4. Stand-Off Insulators: Comply with UL 891 for use in switchboards, 600 V. Lexan or PVC, impulse tested at 5000 V.

C. Comply with ANSI-J-STD-607-A.

2.06 LABELING

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

A. Contact telecommunications service provider and arrange for installation of demarcation point, protected entrance terminals, and a housing when so directed by service provider.

B. Install underground pathways complying with recommendations in TIA/EIA-569-A, "Entrance Facilities" Article.

C. Provide protected entrance terminals in the Communications building for tel/data/catv services fed underground from the main building to any site telecommunications locations.

3.02 Install underground entrance pathway complying with Division 26 Section "Raceway and Boxes for Electrical Systems."INSTALLATION

A. Comply with NECA 1.

B. Comply with BICSI TDMM for layout and installation of communications equipment rooms.

C. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

D. Bundle, lace, and train conductors and cables to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.03 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."Comply with TIA/EIA-569-A, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.04 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

1. Bond the shield of shielded cable to the grounding bus bar in communications rooms and spaces.

3.05 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements in Division 26 Section "Identification for Electrical Systems."Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

B. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion of TIA/EIA standard as it applies to this Section.Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration.

C. Labels shall be preprinted or computer-printed type.

END OF SECTION

SECTION 27 13 00

COMMUNICATIONS BACKBONE CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Pathways.
2. UTP cable.
3. Coaxial cable.
4. Fiber optic cabling
5. Cable connecting hardware, patch panels, and cross-connects.
6. Cabling identification products.

B. Related Sections:

1. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.03 DEFINITIONS

A. BICSI: Building Industry Consulting Service International.

B. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

C. EMI: Electromagnetic interference.

D. IDC: Insulation displacement connector.

E. LAN: Local area network.

F. RCDD: Registered Communications Distribution Designer.

G. UTP: Unshielded twisted pair.

1.04 BACKBONE CABLING DESCRIPTION

A. Backbone cabling system shall provide interconnections between communications equipment rooms, main terminal space, and entrance facilities in the telecommunications cabling system structure. Cabling system consists of backbone cables, intermediate and main cross-connects,

mechanical terminations, and patch cords or jumpers used for backbone-to-backbone cross-connection.

B. Backbone cabling cross-connects may be located in communications equipment rooms. Bridged taps and splitters shall not be used as part of backbone cabling.

1.05 PERFORMANCE REQUIREMENTS

A. General Performance: Backbone cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.06 SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

    a. Nominal OD.
    b. Minimum bending radius.
    c. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics including the following:

    a. Cross-connects.
    b. Patch panels.
    c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
6. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to side of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. 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.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

E. Grounding: Comply with ANSI-J-STD-607-A.

1.08 DELIVERY, STORAGE, AND HANDLING

A. Test cables upon receipt at Project site.

1. Test optical fiber cable to determine the continuity of the strand end to end.
2. Test optical fiber cable while on reels. Use an optical time domain reflectometer to verify the cable length and locate cable defects, splices, and connector, including the loss value of each. Retain test data and include the record in maintenance data.
3. Test each pair of UTP cable for open and short circuits.

1.09 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.10 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

1.11 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for 2 years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.12 EXTRA MATERIALS

A. Furnish extra materials that match products installed and that are packaged with protective covering for storage and identified with labels describing contents.

1. Patch-Panel Units: One of each type.
2. Connecting Blocks: One of each type.

PART 2 - PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

2.02 UTP CABLE

A. Description: 100-ohm, 25-pair UTP covered with a gray thermoplastic jacket and overall metallic shield.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6.
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

    a. Communications, Plenum Rated: Type CMP complying with NFPA 262.
    b. Communications, Riser Rated: Type CMR complying with UL 1666.

2.03 UTP CABLE HARDWARE

A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

B. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

C. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP plus spares and blank positions adequate to suit specified expansion criteria.

E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

F. Patch Cords: Factory-made, 4-pair cables in 36-inch (900-mm) lengths; terminated with 8-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.04 850 NANOMETER LASER-OPTIMIZED, 50/125 MICROMETER, MULTIMODE OPTICAL FIBER CABLE (OM3)

A. Description: Multimode, 50/125-micrometer, 12-fiber, nonconductive, tight buffer, optical fiber cable.

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. Belden CDT Networking Division/NORDX.
2. CommScope, Inc.
3. Corning Cable Systems.

C. Standards:

1. Comply with ICEA S-83-596 for mechanical properties.
2. Comply with TIA-568-C.3 for performance specifications.
3. Comply with TIA-492AAAC for detailed specifications.

D. Maximum Attenuation: 3.50 dB/km at 850 nm; 1.5 dB/km at 1300 nm.

E. Minimum Overfilled Modal Bandwidth-length Product: 1500 MHz-km at 850 nm; 500 MHz-km at 1300 nm.

F. Minimum Effective Modal Bandwidth-length Product: 2000 MHz-km at 850 nm.

G. Jacket:

1. Jacket Color: Aqua.
2. Cable cordage jacket, fiber, unit, and group color shall be according to TIA-598-D.

3. Imprinted with fiber count, fiber type, and aggregate length at regular intervals not to exceed 40 inches (1000 mm).

H. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444, UL 1651, and NFPA 70 for the following types:

1. Plenum Rated, Nonconductive: Type OFNP, complying with NFPA 262; Type OFNP in listed plenum communications raceway; or Type OFNP, or Type OFNR in metallic conduit.
2. Riser Rated, Nonconductive: Type OFNP, or Type OFNR in metallic conduit installed per NFPA 70, Article 300.22, "Wiring in Ducts, Plenums, and Other Air-Handling Spaces."

2.05 OPTICAL FIBER CABLE HARDWARE

A. Cross-Connects and Patch Panels: Modular panels housing multiple-numbered, duplex cable connectors.

1. Number of Connectors per Field: One for each fiber of cable or cables assigned to field, plus spares and blank positions adequate to suit specified expansion criteria.

B. Patch Cords: Factory-made, dual-fiber cables in 36-inch (900-mm) lengths.

C. Cable Connecting Hardware:

1. Comply with Optical Fiber Connector Intermateability Standards (FOCIS) specifications of TIA/EIA-604-2, TIA/EIA-604-3-A, and TIA/EIA-604-12. Comply with TIA/EIA-568-B.3.
2. Quick-connect, simplex and duplex, Type SC connectors. Insertion loss not more than 0.75 dB.
3. Type SFF connectors may be used in termination racks, panels, and equipment packages.

2.06 COAXIAL CABLE

A. General Coaxial Cable Requirements: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

B. RG-11/U: NFPA 70, Type CATV.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
4. Jacketed with sunlight-resistant, black PVC or PE.

C. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C

D. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70, "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
2. CATV Riser Rated: Type CATVR, complying with UL 1666.

2.07 COAXIAL CABLE HARDWARE

A. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.08 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems." for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.09 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for a system of labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

2.10 SOURCE QUALITY CONTROL

A. Testing Agency: Engage a qualified testing agency to evaluate cables.

B. Factory test cables on reels according to TIA/EIA-568-B.1.

C. Factory test UTP cables according to TIA/EIA-568-B.2.

D. Factory test multimode optical fiber cables according to TIA/EIA-526-14-A and TIA/EIA-568-B.3.

E. Cable will be considered defective if it does not pass tests and inspections.

F. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

A. Coordinate backbone cabling with the protectors and demarcation point provided by communications service provider.

3.02 WIRING METHODS

A. Wiring Method: Install backbone cables in raceways and cable trays.

B. Wiring within Enclosures: Bundle, lace, and train cables within enclosures. Connect to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.03 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.04 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. All terminations for voice and data shall be by owner. Provide terminations for all CATV outlets. Terminate all conductors; no cable shall contain unterminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Use lacing bars and distribution spools.
8. 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.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.

11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

C. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.
2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

D. Optical Fiber Cable Installation:

1. Comply with TIA/EIA-568-B.3.
2. Cable may be terminated on connecting hardware that is rack or cabinet mounted.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway, a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A recommendations for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.05 FIRESTOPPING

A. Comply with requirements in Division 07 and TIA/EIA-569-A, Annex A, "Firestopping."

B. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.06 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.07 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."
   1. Color-code cross-connect fields and apply colors to voice and data service backboards, connections, covers, and labels.

B. Comply with requirements in Division 09 for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

C. See Division 27 Section "Communications Horizontal Cabling" for additional identification requirements. See Evaluations for discussion about TIA/EIA standard as it applies to this Section.Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration including optional identification requirements of this standard.

D. Comply with requirements in Division 27 Section "Communications Horizontal Cabling" for cable and asset management software.

E. Cable Schedule: Install in a prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cabling Administration Drawings: Show building floor plans with cabling administration-point labeling. Identify labeling convention and show labels for telecommunications closets,

backbone pathways and cables, entrance pathways and cables, terminal hardware and positions, horizontal cables, work areas and workstation terminal positions, grounding buses and pathways, and equipment grounding conductors.

G. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

H. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA 606-A, for the following:

1. Cables use flexible vinyl or polyester that flexes as cables are bent.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

A. Tests and Inspections:

1. Visually inspect UTP and optical fiber jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.
3. Test UTP copper cabling for DC loop resistance, shorts, opens, intermittent faults, and polarity between conductors. Test operation of shorting bars in connection blocks. Test cables after termination but not cross-connection.

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.2. Perform tests with a tester that complies with performance requirements in "Test Instruments (Normative)" Annex, complying with measurement accuracy specified in "Measurement Accuracy (Informative)" Annex. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.

4. Optical Fiber Cable Tests:

    a. Test instruments shall meet or exceed applicable requirements in TIA/EIA-568-B.1. Use only test cords and adapters that are qualified by test equipment manufacturer for channel or link test configuration.
    b. Link End-to-End Attenuation Tests:

        1) Horizontal and multimode backbone link measurements: Test at 850 or 1300 nm in 1 direction according to TIA/EIA-526-14-A, Method B, One Reference Jumper.
        2) Attenuation test results for backbone links shall be less than 2.0 dB. Attenuation test results shall be less than that calculated according to equation in TIA/EIA-568-B.1.

B. Data for each measurement shall be documented. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

C. Remove and replace cabling where test results indicate that they do not comply with specified requirements.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 27 15 00

COMMUNICATIONS HORIZONTAL CABLING

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Pathways.
2. UTP cabling.
3. Coaxial cable.
4. Multiuser telecommunications outlet assemblies.
5. Cable connecting hardware, patch panels, and cross-connects.
6. Telecommunications outlet/connectors.
7. Cabling system identification products.
8. Cable management system.

B. Related Sections:

1. Division 27 Section "Communications Backbone Cabling" for voice and data cabling associated with system panels and devices.
2. Division 28 Section "Conductors and Cables for Electronic Safety and Security" for voice and data cabling associated with system panels and devices.

1.03 DEFINITIONS

A. Basket Cable Tray: A fabricated structure consisting of wire mesh bottom and side rails.

B. BICSI: Building Industry Consulting Service International.

C. Consolidation Point: A location for interconnection between horizontal cables extending from building pathways and horizontal cables extending into furniture pathways.

D. Cross-Connect: A facility enabling the termination of cable elements and their interconnection or cross-connection.

E. EMI: Electromagnetic interference.

F. IDC: Insulation displacement connector.

G. LAN: Local area network.

H. MUTOA: Multiuser telecommunications outlet assembly, a grouping in one location of several telecommunications outlet/connectors.

I. Outlet/Connectors: A connecting device in the work area on which horizontal cable or outlet cable terminates.

J. RCDD: Registered Communications Distribution Designer.

K. UTP: Unshielded twisted pair.

1.04 HORIZONTAL CABLING DESCRIPTION

A. Horizontal cable and its connecting hardware provide the means of transporting signals between the telecommunications outlet/connector and the horizontal cross-connect located in the communications equipment room. This cabling and its connecting hardware are called "permanent link," a term that is used in the testing protocols.

1. TIA/EIA-568-B.1 requires that a minimum of two telecommunications outlet/connectors be installed for each work area.
2. Horizontal cabling shall contain no more that one transition point or consolidation point between the horizontal cross-connect and the telecommunications outlet/connector.
3. Bridged taps and splices shall not be installed in the horizontal cabling.

B. A work area is approximately 100 sq. ft. (9.3 sq. m), and includes the components that extend from the telecommunications outlet/connectors to the station equipment.

C. The maximum allowable horizontal cable length is 295 feet (90 m). This maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) to the workstation equipment. The maximum allowable length does not include an allowance for the length of 16 feet (4.9 m) in the horizontal cross-connect.

1.05 PERFORMANCE REQUIREMENTS

A. General Performance: Horizontal cabling system shall comply with transmission standards in TIA/EIA-568-B.1, when tested according to test procedures of this standard.

1.06 SUBMITTALS

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

1. For coaxial cable, include the following installation data for each type used:

a. Nominal OD.
b. Minimum bending radius.
c. Maximum pulling tension.

B. Shop Drawings:

1. System Labeling Schedules: Electronic copy of labeling schedules, in software and format selected by Owner.
2. System Labeling Schedules: Electronic copy of labeling schedules that are part of the cabling and asset identification system of the software.
3. Cabling administration drawings and printouts.
4. Wiring diagrams to show typical wiring schematics, including the following:

    a. Cross-connects.
    b. Patch panels.
    c. Patch cords.

5. Cross-connects and patch panels. Detail mounting assemblies, and show elevations and physical relationship between the installed components.
6. Cable tray layout, showing cable tray route to scale, with relationship between the tray and adjacent structural, electrical, and mechanical elements. Include the following:

    a. Vertical and horizontal offsets and transitions.
    b. Clearances for access above and to side of cable trays.
    c. Vertical elevation of cable trays above the floor or bottom of ceiling structure.
    d. Load calculations to show dead and live loads as not exceeding manufacturer's rating for tray and its support elements.

C. Maintenance Data: For splices and connectors to include in maintenance manuals.

D. 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.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: Cabling Installer must have personnel certified by BICSI on staff.

B. Surface-Burning Characteristics: As determined by testing identical products according to ASTM E 84 by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

D. Telecommunications Pathways and Spaces: Comply with TIA/EIA-569-A.

E. Grounding: Comply with ANSI-J-STD-607-A.

1.08 PROJECT CONDITIONS

A. Environmental Limitations: Do not deliver or install cables and connecting materials until wet work in spaces is complete and dry, and temporary HVAC system is operating and maintaining ambient temperature and humidity conditions at occupancy levels during the remainder of the construction period.

1.09 COORDINATION

A. Coordinate layout and installation of telecommunications pathways and cabling with Owner's telecommunications and LAN equipment and service suppliers.

B. Coordinate telecommunications outlet/connector locations with location of power receptacles at each work area.

1.10 SOFTWARE SERVICE AGREEMENT

A. Technical Support: Beginning with Substantial Completion, provide software support for 2 years.

B. Upgrade Service: Update software to latest version at Project completion. Install and program software upgrades that become available within two years from date of Substantial Completion. Upgrading software shall include operating system. Upgrade shall include new or revised licenses for use of software.

1. Provide 30 days' notice to Owner to allow scheduling and access to system and to allow Owner to upgrade computer equipment if necessary.

1.11 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. Patch-Panel Units: One of each type.
2. Connecting Blocks: One of each type.
3. Device Plates: One of each type.
4. Multiuser Telecommunications Outlet Assemblies: One of each type.

PART 2 - PRODUCTS

2.01 PATHWAYS

A. General Requirements: Comply with TIA/EIA-569-A.

B. Cable Support: NRTL labeled for support of Category 6 cabling, designed to prevent degradation of cable performance and pinch points that could damage cable.

1. Support brackets with cable tie slots for fastening cable ties to brackets.
2. Lacing bars, spools, J-hooks, and D-rings.
3. Straps and other devices.

C. Conduit and Boxes: Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems".

1. Outlet boxes shall be no smaller than 2 inches (50 mm) wide, 3 inches (75 mm) high, and 2-1/2 inches (64 mm) deep.

2.02 UTP CABLE

A. Description: 100-ohm, 4-pair UTP, formed into 25-pair, binder groups covered with a blue thermoplastic jacket.

1. Comply with ICEA S-90-661 for mechanical properties.
2. Comply with TIA/EIA-568-B.1 for performance specifications.
3. Comply with TIA/EIA-568-B.2, Category 6
4. Listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 444 and NFPA 70 for the following types:

a. Communications, Plenum Rated: Type CMP complying with NFPA 262.
b. Communications, Riser Rated: Type CMR, complying with UL 1666.
c. Multipurpose, Plenum Rated: Type MPP, complying with NFPA 262.
d. Multipurpose, Riser Rated: Type MPR, complying with UL 1666.

2.03 UTP CABLE HARDWARE

A. General Requirements for Cable Connecting Hardware: Comply with TIA/EIA-568-B.2, IDC type, with modules designed for punch-down caps or tools. Cables shall be terminated with connecting hardware of same category or higher.

B. Connecting Blocks: 110-style IDC for Category 6. Provide blocks for the number of cables terminated on the block, plus 25 percent spare. Integral with connector bodies, including plugs and jacks where indicated.

C. Cross-Connect: Modular array of connecting blocks arranged to terminate building cables and permit interconnection between cables.

1. Number of Terminals per Field: One for each conductor in assigned cables.

D. Patch Panel: Modular panels housing multiple-numbered jack units with IDC-type connectors at each jack for permanent termination of pair groups of installed cables.

1. Number of Jacks per Field: One for each four-pair UTP cable in project.

E. Jacks and Jack Assemblies: Modular, color-coded, eight-position modular receptacle units with integral IDC-type terminals.

F. Patch Cords: Factory-made, four-pair cables in 36 inch lengths; terminated with eight-position modular plug at each end.

1. Patch cords shall have bend-relief-compliant boots and color-coded icons to ensure Category 6 performance. Patch cords shall have latch guards to protect against snagging.
2. Patch cords shall have color-coded boots for circuit identification.

2.04 COAXIAL CABLE

A. Cable Characteristics: Broadband type, recommended by cable manufacturer specifically for broadband data transmission applications. Coaxial cable and accessories shall have 75-ohm nominal impedance with a return loss of 20 dB maximum from 7 to 806 MHz.

B. RG-6/U: NFPA 70, Type CATV or CM.

1. No. 16 AWG, solid, copper-covered steel conductor; gas-injected, foam-PE insulation.
2. Double shielded with 100 percent aluminum-foil shield and 60 percent aluminum braid.
3. Jacketed with black PVC or PE.
4. Suitable for indoor installations.

C. RG-11/U: NFPA 70, Type CATV.

1. No. 14 AWG, solid, copper-covered steel conductor.
2. Gas-injected, foam-PE insulation.
3. Double shielded with 100 percent aluminum polyester tape and 60 percent aluminum braid.
4. Jacketed with sunlight-resistant, black PVC or PE.

D. Suitable for outdoor installations in ambient temperatures ranging from minus 40 to plus 85 deg C

E. RG59/U (Plenum Rated): NFPA 70, Type CMP.

1. No. 20 AWG, solid, copper-covered steel conductor; foam fluorinated ethylene propylene insulation.
2. Double shielded with 100 percent aluminum-foil shield and 65 percent aluminum braid.
3. Copolymer jacket.

F. NFPA and UL compliance, listed and labeled by an NRTL acceptable to authorities having jurisdiction as complying with UL 1655 and with NFPA 70 "Radio and Television Equipment" and "Community Antenna Television and Radio Distribution" Articles. Types are as follows:

1. CATV Plenum Rated: Type CATVP, complying with NFPA 262.
2. CATV Riser Rated: Type CATVR, complying with UL 1666.

2.05 COAXIAL CABLE HARDWARE

A. Coaxial-Cable Connectors: Type BNC, 75 ohms.

2.06 GROUNDING

A. Comply with requirements in Division 26 Section "Grounding and Bonding for Electrical Systems" for grounding conductors and connectors.

B. Comply with ANSI-J-STD-607-A.

2.07 IDENTIFICATION PRODUCTS

A. Comply with TIA/EIA-606-A and UL 969 for labeling materials, including label stocks, laminating adhesives, and inks used by label printers.

B. Comply with requirements in Division 26 Section "Identification for Electrical Systems."

2.08 SOURCE QUALITY CONTROL

A. Factory test UTP cables according to TIA/EIA-568-B.2.

B. Factory-sweep test coaxial cables at frequencies from 5 MHz to 1 GHz. Sweep test shall test the frequency response, or attenuation over frequency, of a cable by generating a voltage whose frequency is varied through the specified frequency range and graphing the results.

C. Cable will be considered defective if it does not pass tests and inspections.

D. Prepare test and inspection reports.

PART 3 - EXECUTION

3.01 ENTRANCE FACILITIES

A. Coordinate cabling with the protectors and demarcation point.

3.02 WIRING METHODS

A. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible. Provide a minmum ¾" conduit(unless otherwise noted) from outlet location in wall to 6' above nearest accessible ceiling. In areas where cable tray is shown, wiring shall be routed in the cable tray. J hooks shall be used to support wiring runs above suspended ceilings in areas where there is no cable tray. Wiring shall be run in conduit when run in rooms without ceilings, above inaccessible ceilings or spaces and when cabling passes through walls.

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Provide and use lacing bars and distribution spools.

3.03 INSTALLATION OF PATHWAYS

A. Cable Trays: Comply with NEMA VE 2 and TIA/EIA-569-A-7.

B. Comply with requirements for demarcation point, pathways, cabinets, and racks specified in Division 27 Section "Communications Equipment Room Fittings." Drawings indicate general arrangement of pathways and fittings.

C. Comply with TIA/EIA-569-A for pull-box sizing and length of conduit and number of bends between pull points.

D. Comply with requirements in Division 26 Section "Raceway and Boxes for Electrical Systems" for installation of conduits and wireways.

E. Install manufactured conduit sweeps and long-radius elbows whenever possible.

F. Pathway Installation in Communications Equipment Rooms:

1. Position conduit ends adjacent to a corner on backboard where a single piece of plywood is installed, or in the corner of room where multiple sheets of plywood are installed around perimeter walls of room.
2. Install cable trays to route cables if conduits cannot be located in these positions.
3. Secure conduits to backboard when entering room from overhead.
4. Install metal conduits with grounding bushings and connect with grounding conductor to grounding system.

3.04 INSTALLATION OF CABLES

A. All horizontal cabling shall be run from outlet or device location to IT Room 208 unless noted otherwise.

B. Comply with NECA 1.

C. General Requirements for Cabling:

1. Comply with TIA/EIA-568-B.1.
2. Comply with BICSI ITSIM, Ch. 6, "Cable Termination Practices."
3. Install 110-style IDC termination hardware unless otherwise indicated.
4. Terminate all conductors for cabling where Division 27 or 28 are responsible for the terminations; no cable shall contain un-terminated elements. Make terminations only at indicated outlets, terminals, cross-connects, and patch panels.
5. Cables may not be spliced. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
6. Install lacing bars to restrain cables, to prevent straining connections, and to prevent bending cables to smaller radii than minimums recommended by manufacturer.
7. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii, but not less than radii specified in BICSI ITSIM, "Cabling Termination Practices" Chapter. Install lacing bars and distribution spools.
8. 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.
9. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used for heating.
10. In the communications equipment room, install a 10-foot- (3-m-) long service loop on each end of cable.
11. Pulling Cable: Comply with BICSI ITSIM, Ch. 4, "Pulling Cable." Monitor cable pull tensions.

D. UTP Cable Installation:

1. Comply with TIA/EIA-568-B.2.

2. Do not untwist UTP cables more than 1/2 inch (12 mm) from the point of termination to maintain cable geometry.

E. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunications spaces with terminating hardware and interconnection equipment.
2. Suspend UTP cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceilings by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or in contact with pipes, ducts, or other potentially damaging items.
4. (915 mm).

F. Group connecting hardware for cables into separate logical fields.

G. Separation from EMI Sources:

1. Comply with BICSI TDMM and TIA/EIA-569-A for separating unshielded copper voice and data communication cable from potential EMI sources, including electrical power lines and equipment.
2. Separation between open communications cables or cables in nonmetallic raceways and unshielded power conductors and electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 5 inches (127 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 12 inches (300 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 24 inches (610 mm).

3. Separation between communications cables in grounded metallic raceways and unshielded power lines or electrical equipment shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: A minimum of 2-1/2 inches (64 mm).
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 6 inches (150 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 12 inches (300 mm).

4. Separation between communications cables in grounded metallic raceways and power lines and electrical equipment located in grounded metallic conduits or enclosures shall be as follows:

    a. Electrical Equipment Rating Less Than 2 kVA: No requirement.
    b. Electrical Equipment Rating between 2 and 5 kVA: A minimum of 3 inches (76 mm).
    c. Electrical Equipment Rating More Than 5 kVA: A minimum of 6 inches (150 mm).

5. Separation between Communications Cables and Electrical Motors and Transformers, 5 kVA or HP and Larger: A minimum of 48 inches (1200 mm).
6. Separation between Communications Cables and Fluorescent Fixtures: A minimum of 5 inches (127 mm).

3.05 FIRESTOPPING

A. Comply with requirements in Division 07 Section "Penetration Firestopping."

B. Comply with TIA/EIA-569-A, Annex A, "Firestopping."

C. Comply with BICSI TDMM, "Firestopping Systems" Article.

3.06 GROUNDING

A. Install grounding according to BICSI TDMM, "Grounding, Bonding, and Electrical Protection" Chapter.

B. Comply with ANSI-J-STD-607-A.

C. Locate grounding bus bar to minimize the length of bonding conductors. Fasten to wall allowing at least 2-inch (50-mm) clearance behind the grounding bus bar. Connect grounding bus bar with a minimum No. 4 AWG grounding electrode conductor from grounding bus bar to suitable electrical building ground.

D. Bond metallic equipment to the grounding bus bar, using not smaller than No. 6 AWG equipment grounding conductor.

3.07 IDENTIFICATION

A. Identify system components, wiring, and cabling complying with TIA/EIA-606-A. Comply with requirements for identification specified in Division 26 Section "Identification for Electrical Systems."

1. Color-code cross-connect fields. Apply colors to voice and data service backboards, connections, covers, and labels.
2. Data cabling shall be blue.
3. Voice and speaker cabling shall be white.

B. Using cable management system software specified in Part 2, develop Cabling Administration Drawings for system identification, testing, and management. Use unique, alphanumeric designation for each cable and label cable, jacks, connectors, and terminals to which it connects with same designation. At completion, cable and asset management software shall reflect as-built conditions.

C. Comply with requirements in Division 09 Section "Interior Painting" for painting backboards. For fire-resistant plywood, do not paint over manufacturer's label.

D. Paint and label colors for equipment identification shall comply with TIA/EIA-606-A for Class 2 level of administration

E. Cable Schedule: Post in prominent location in each equipment room and wiring closet. List incoming and outgoing cables and their designations, origins, and destinations. Protect with rigid frame and clear plastic cover. Furnish an electronic copy of final comprehensive schedules for Project.

F. Cable and Wire Identification:

1. Label each cable within 4 inches (100 mm) of each termination and tap, where it is accessible in a cabinet or junction or outlet box, and elsewhere as indicated.
2. Each wire connected to building-mounted devices is not required to be numbered at device if color of wire is consistent with associated wire connected and numbered within panel or cabinet.
3. Exposed Cables and Cables in Cable Trays and Wire Troughs: Label each cable at intervals not exceeding 15 feet (4.5 m).
4. Label each terminal strip and screw terminal in each cabinet, rack, or panel.

    a. Individually number wiring conductors connected to terminal strips, and identify each cable or wiring group being extended from a panel or cabinet to a building-mounted device shall be identified with name and number of particular device as shown.
    b. Label each unit and field within distribution racks and frames.

5. Identification within Connector Fields in Equipment Rooms and Wiring Closets: Label each connector and each discrete unit of cable-terminating and connecting hardware. Where similar jacks and plugs are used for both voice and data communication cabling, use a different color for jacks and plugs of each service.

G. Labels shall be preprinted or computer-printed type with printing area and font color that contrasts with cable jacket color but still complies with requirements in TIA/EIA-606-A.

1. Cables use flexible vinyl or polyester that flex as cables are bent.

3.08 FIELD QUALITY CONTROL

A. Perform tests and inspections.

B. Tests and Inspections:

1. Visually inspect UTP and optical fiber cable jacket materials for NRTL certification markings. Inspect cabling terminations in communications equipment rooms for compliance with color-coding for pin assignments, and inspect cabling connections for compliance with TIA/EIA-568-B.1.
2. Visually confirm Category 6 marking of connectors and patch panels.
3. Visually inspect cable placement, cable termination, grounding and bonding, equipment and patch cords, and labeling of all components.

C. Document data for each measurement. Data for submittals shall be printed in a summary report that is formatted similar to Table 10.1 in BICSI TDMM, or transferred from the instrument to the computer, saved as text files, and printed and submitted.

D. End-to-end cabling will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

END OF SECTION

SECTION 27 51 23.50

EDUCATIONAL INTERCOMMUNICATIONS AND PROGRAM SYSTEMS

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section includes microprocessor-switched intercommunications and program systems with the following components:

1. Administrative console.
2. Call control console.
3. Intercom Speaker-microphone stations.
4. All-call amplifier.
5. Intercommunication amplifier.
6. Paging amplifier.
7. Speaker microphones.
8. Conductors and cables.
9. Raceways.

B. Related Requirements:

1. Section 26 05 23 "Control-Voltage Electrical Power Cables" for control systems communications cables and Classes 1, 2 and 3 control cables.
2. Section 27 15 13 "Communications Horizontal Cabling" for cabling used for voice and data circuits.

C. Provide full Integration with Owner provided VOIP Panasonic KX series phone system

1.03 DEFINITIONS

A. DHCP: Dynamic Host Configuration Protocol.

B. FXO: Foreign eXchange Office.

C. H.323: Audio and Video Protocol.

D. SIP: Session Initiation Protocol.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

B. Shop Drawings: For educational intercommunications and program systems.

1. Include plans, elevations, sections, and mounting details.
2. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and location and size of each field connection.
3. Include scaled drawings for administrative console and speaker-microphone station station arrangement of built-in equipment.
4. Include diagrams for power, signal, and control wiring.

    a. Identify terminals to facilitate installation, operation, and maintenance.
    b. Single-line diagram showing interconnection of components.
    c. Cabling diagram showing cable routing.

1.05 INFORMATIONAL SUBMITTALS

A. Coordination Drawings:

1. Reflected ceiling plans, drawn to scale, on which ceiling-mounted items including luminaires, diffusers, grilles, speakers, sprinklers, access panels, and special moldings are shown and coordinated with each other, using input from installers of the items involved.
2. Elevation drawings, drawn to scale, on which wall-mounted items including luminaires, intercommunications components, windows, doors, access panels, wall finishes, trims, piping, and conduit are shown and coordinated with each other, using input from Installers of the items involved.

B. Qualification Data: For installer

C. Field quality-control reports.

1.06 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For educational intercommunications and program systems to include in operation and maintenance manuals. In addition to items specified in Division 01, include the following:

1. A record of final matching transformer-tap settings and signal ground-resistance measurement certified by Installer.
2. A record of Owner's equipment-programming option decisions.
3. Plans, drawn to scale, indicating location, designation, and connection of intercommunications system components.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On USB media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.07 QUALITY ASSURANCE

A. Installer Qualifications: An authorized representative who is trained and approved by manufacturer.

1.08 COORDINATION

A. Coordinate layout and installation of ceiling-mounted speaker microphones and suspension system with other construction that penetrates ceilings or is supported by them, including light fixtures, HVAC equipment, fire-suppression system, and partition assemblies.

PART 2 - PRODUCTS

2.01 MANUFACTURERS: Valcom ES class connection or approved equal

2.02 CONTROL UNIT

A. Suitable for mounting in a standard 19-inch rack.

B. Shall be capable of expanding to 360 points. A point is defined as a speaker & call button combination.

C. Ability to program and control the built-in master clock with unlimited events and unlimited time schedules with multiple audio groups.

D. Ability to control wireless clocks (various correction methods).

E. Ability to produce user defined tone signals for time tones or emergency tones.

F. Ability to select the tone on an all-call basis from any, or selected, administrative telephones.

G. Provide an Ethernet port, which will give ability to monitor operations and functions of the systems.

H. Provide off-site programming and diagnostics of the system. It shall also be capable of determining basic circuit faults.

I. The system shall be capable of simultaneous conversations between administrative ports.

J. The system shall have a Windows® based PC administration programming tool which allows the administrative personnel to easily manage Audio Sources, Class Change schedules, paging groups, time updates, holiday schedules and day/night mode operation from their desktop PC across a standard Ethernet LAN. It shall also have the ability to activate on board WAV files on a schedule and/or immediately in the event of an emergency at the highest priority override level. Systems that require propriety consoles, special LCD displays or solely utilize DTMF for changes to perform these functions shall not be acceptable.

K. System shall provide calendar based scheduling up to one year in advance.

L. The system shall be programmable via Ethernet or direct COM port cable connection.

M. System speakers shall be capable of utilizing standard CAT 5 (five) or 6 (six) telephone/data wiring for installation, thus allowing for only one type of wiring infrastructure within the school. The speakers, call buttons and clocks shall be capable of utilizing pairs within a single cable to the classroom, allowing for lower installation cost. Systems that waste infrastructure by requiring separate heavy gauge infrastructure wire shall not be acceptable.

N. Provide 8 (eight) unrestricted simultaneous audio paths for communication between administrative phones, program material, time tone distribution, and paging. Systems that do not allow simultaneous pages to different paging groups will not be accepted.

O. Provide 6 (six) software programmable pushbutton inputs that can be used to activate tones, emergency tones, time tones, schedules, set system time, force a holiday schedule, door entry, etc.

P. Provide 8 (eight) software programmable output contact closures which can be activated manually to turn on cameras, unlock doors, emergency lockdown, etc., or automatically via Master Time Control Center.

2.03 SYSTEM DESCRIPTION

A. Equipment: Modular type using solid-state components, fully rated for continuous duty unless otherwise indicated. Select equipment for normal operation on input power usually supplied at 110 to 130 V, 60 Hz in a satisfactory manner without the requirement of any external power conditioning equipment. Comply with UL 813.

B. Expansion Capability: Increase number of stations in the future by [25] <Insert number> percent above those indicated without adding any internal or external components or main trunk cable conductors.

C. Integration: Coordinate features and select components to form an integrated system. Match components and interconnections for optimum performance of specified functions.

D. Local Area Network: The system will utilize a LAN for the connectivity of all devices and components within the facility for the transmission of electronic data. The LAN will be an expansion to the existing or a separate standalone structure in support of the intercommunication system as dictated by the project design documents.

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

F. Weather-Resistant Equipment: Listed and labeled by an NRTL for duty outdoors or in damp locations.

G. Provide separate paging groups for all-call, first floor, and second floor.

2.04 FUNCTIONAL DESCRIPTION OF MICROPROCESSOR-SWITCHED SYSTEMS

A. Administrative Console:

1. Communicating selectively with other administrative and speaker-microphone stations by dialing station's number on a 12-digit keypad.
2. Communicating with individual stations in privacy.

3. Communicating on a minimum of three voice channels with up to two simultaneous conversations between administrative consoles and one conversation between an administrative console and a speaker-microphone station.
4. Increasing the number of conversation channels by adding a module in central-control cabinet.
5. Include up to three other station connections in a conference call.
6. Access separate paging speakers or groups of paging speakers by dialing designated numbers on a 12-digit keypad.
7. Display indicates selected station, originating station call, all-call, zone page, normal or emergency status of call(s), and time/date.
8. Communicating simultaneously with all other stations by dialing a designated number on a 12-digit keypad.
9. Automatic control of gain to ensure constant intercom speech level.
10. Controlling simultaneous distribution of program material to various combinations of speaker-microphone stations or groups over two program channels by using keypad to control sources and distribute programs.
11. Operating and controlling class-change signals to speakers and bells by using keypad.
12. User-programmable features include the following:
    a. Station calling by room number.
    b. Room station call-in priority levels.
    c. Audible signal schedule functions.
    d. Schedule characteristics of audible signals.
    e. Call-in tone characteristic.
    f. Grouping of rooms and speakers into zones for paging and program distribution purposes.

B. Intercom Speaker-Microphone Station:
1. Remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
2. Communicating hands free.
3. Calling administrative console by actuating call switch.
4. Returning a busy signal to indicate that station is already in use.

C. Speakers: Free of noise and distortion during operation and when in standby mode.

D. Remote Stations:
1. Speaker-Microphone Station:
    a. Revise first subparagraph below to indicate privacy features required. Coordinate with Drawings.
    b. Having privacy from remote monitoring without a warning tone signal at monitored station. Designated speaker-microphone stations have a privacy switch to prevent another station from listening and to permit incoming calls.
    c. Communicating hands free.
    d. Calling administrative console by actuating call switch.
    e. Returning a busy signal to indicate that station is already in use.

E. Speakers: Free of noise and distortion during operation and when in standby mode.

2.05 ADMINISTRATIVE CONSOLE FOR MICROPROCESSOR-SWITCHED SYSTEMS

A. Locate at Control Unit location.

B. 12-Digit Keypad Selector: Transmits calls to other stations and initiates commands for programming and operation.

C. Volume Control: Regulates incoming-call volume.

D. Tone Annunciation: Momentary audible tone signal announces incoming calls.

E. LED Annunciation: Identifies calling stations and stations in use. LED remains on until call is answered.

F. Speaker Microphone: Transmits intercom voice signals when used via a voice-operated switch.

1. Minimum Speaker Sensitivity: 91 dB at one meter, with 1-W input.

G. Hard Buttons: To transfer and place calls on hold.

H. Reset Control: Cancels call and resets system for next call.

I. Digital Display: 16-digit alphanumeric LCD readout to register up to four three-digit station numbers.

J. Central-Equipment Cabinet: Comply with EIA/ECA-310-E. Lockable, ventilated metal cabinet houses terminal strips, power supplies, amplifiers, system volume control, and other switching and control devices required for conversation channels and control functions.

2.06 INTERCOM SPEAKER-MICROPHONE STATIONS- Valcom V-1072A-ST

A. Mounting: Flush unless otherwise indicated, and suitable for mounting conditions indicated.

B. Faceplate: Stainless steel or anodized aluminum with tamperproof mounting screws.

C. Enclosure: Two-gang galvanized steel with 2-1/2-inch (64-mm) minimum depth.

D. Speaker: Minimum axial sensitivity shall be 91 dB at one meter, with 1-W input. Voice coil shall be not less than 3 inches (76 mm), 2.3 oz. (65 g) minimum; permanent magnet.

E. Tone Annunciation: Recurring momentary tone indicates incoming calls.

F. Call Switch: Mount on faceplate. Permits calls to administrative console.

G. Privacy Switch: Mount on faceplate. When in on position, switch prevents transmission of sound from remote station to system; when in off position, without further switch manipulation, response can be made to incoming calls.

2.07 ALL-CALL AMPLIFIER

A. Output Power: 70-V balanced line. 80 percent of the sum of wattage settings of connected for each station and speaker connected in all-call mode of operation, plus an allowance for future stations.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to quantity of stations connected in all-call mode of operation.

C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.

D. Frequency Response: Within plus or minus 2 dB from 50 to 12,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Compatible with administrative console and central equipment so amplifier delivers full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on administrative console, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.08 INTERCOMMUNICATION AMPLIFIER

A. Minimum Output Power: 15 W; adequate for all functions.

B. Total Harmonic Distortion: Less than 5 percent at rated output power with load equivalent to one station connected to output terminals.

C. Minimum Signal-to-Noise Ratio: 50 dB, at rated output.

D. Frequency Response: Within plus or minus 3 dB from 70 to 10,000 Hz.

E. Output Regulation: Maintains output level within 2 dB from full to no load.

F. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on microphones in administrative console, speaker microphones, or handset transmitters.

G. Amplifier Protection: Prevents damage from shorted or open output.

2.09 PAGING AMPLIFIER

A. Input Voltage: 120-V ac, 60 Hz.

B. Frequency Response: Within plus or minus 3 dB from 60 to 10,000 Hz.

C. Minimum Signal-to-Noise Ratio: 60 dB, at rated output.

D. Total Harmonic Distortion: Less than 3 percent at rated output power from 70 to 12,000 Hz.

E. Output Regulation: Less than 2 dB from full to no load.

F. Controls: On-off, input levels, and low-cut filter.

G. Input Sensitivity: Matched to input circuit and to provide full-rated output with sound-pressure level of less than 10 dynes/sq. cm impinging on speaker microphones or handset transmitters.

H. Amplifier Protection: Prevents damage from shorted or open output.

2.10 CONE-TYPE LOUDSPEAKERS/SPEAKER MICROPHONES

A. Minimum Axial Sensitivity: 91 dB at one meter, with 1-W input.

B. Frequency Response: Within plus or minus 3 dB from 70 to 15,000 Hz.

C. Minimum Dispersion Angle: 100 degrees.

D. Line Transformer: Maximum insertion loss of 0.5 dB, power rating equal to speaker's, and at least four level taps.

E. Enclosures: Steel housings or back boxes, acoustically dampened, with front face of at least 0.0478-inch (1.2-mm) steel and whole assembly rust proofed and factory primed; complete with mounting assembly and suitable for surface ceiling, flush ceiling, pendant or wall mounting; with relief of back pressure.

F. Baffle: For flush speakers, minimum thickness of 0.032-inch (0.8-mm) aluminum with textured white finish.

G. Vandal-Proof, High-Strength Baffle: For surface-mounted speakers, self-aging cast aluminum with tensile strength of 44,000 psi (303 MN/sq. m), 0.025-inch (0.65-mm) minimum thickness; countersunk heat-treated alloy mounting screws; and textured white epoxy finish.

H. Speaker types:

1. 2x2 Lay in Speaker-talkback
   a. Cone Diameter: 8”
   b. Voice coil impedance: 45 Ohms
   c. Power Handling: 12 Watts
   d. Frequency response: 80Hz to 10 Khz
   e. 50 mA @ 24 VDC
   f. Built in volume control
   g. Steel Housing with a white baked on acrylic enamel finish
   h. Valcom VC-9062-W

2. Surface Wall Speaker-talkback

   a. Cone Diameter: 8”
   b. Voice coil impedance: 45 Ohms
   c. Power Handling: 12 Watts
   d. Frequency response: 80Hz to 10 Khz
   e. 50 mA @ 24 VDC
   f. Built in volume control
   g. Gray Metal enamel fish with white cloth grill
   h. Valcom V-1061-W

3. Recessed flush 11 ½” square Speaker-talkback

   a. Cone Diameter: 8”
   b. Voice coil impedance: 45 Ohms
   c. Power Handling: 12 Watts
   d. Frequency response: 80Hz to 10 Khz
   e. 50 mA @ 24 VDC
   f. Built in volume control
   g. Steel Housing with a white baked on acrylic enamel finish
   h. Valcom V-1961

4. Pendant Speaker – 1 way

   a. Cone Diameter: 8”
   b. Voice coil impedance: 45 Ohms
   c. Power Handling: 10 Watts

d. Frequency response: 70Hz to 16Khz
e. 300 mA @ 24 VDC
f. Built in volume control
g. Aluminum housing with white finish
h. Valcom V-1015B-WW

2.11 NOISE AUTO SENSING VOLUME CONTROL(Valcom V-993A) AND MICROPHONE(Valcom V-9934)

A. Provide where indicated on drawings to automatically detect ambient noise levels and adjust speaker output accordingly

2.12 MASTER CLOCK

A. The Master Clock shall be directly connected to the systems CPU allowing programming and visual annunciation of all clock features from the same software package controlling the system. Systems requiring a separate assembly with a separate software package will not be accepted.

B. The Master Clock shall have the ability to control 2 or 3 wire analog and digital secondary clocks.

C. Provide for programming multiple independent event schedules into memory and running them simultaneously for different output circuits.

1. Quantity of Programmable Schedules: Eight, minimum.
2. Number of Weekly Events That Can Be Programmed for Each Schedule: 128, minimum.
3. Simultaneous operation of independent schedules shall be limited only by the number of signal-device and equipment-switching output circuits.
4. Advance Programming for Automatic Holiday Schedule Changes: Number of schedule changes that can be programmed to suit holidays and vacations shall be 100, and each change may be programmed up to a year in advance to occur on any day of the calendar year.

2.13 SYSTEM CLOCKS

A. The clocks shall be Digital and shall have either a full 2.5" high efficiency red LED numeral display (Valcom V-D2425), or a full 4.0" high efficiency red LED numeral display (Valcom V-D2440). The clock shall operate as a Valcom 2-wire secondary clock with 12/24-hour display format and two levels of adjustable brightness and shall feature immediate correction for time changes. When input is lost, the colon of the clock display shall flash. The clock bezel shall be anti-glare red with a smooth surface. No external screws or studs shall be visible on the bezel or clock housing. The clock shall have UL, cUL and FCC compliance.

2.14 CONDUCTORS AND CABLES

A. Conductors: Category 6 UTP UL listed cabling. All intercoms and speakers shall be homerun.

B. Insulation: Thermoplastic, not less than 1/32 inch (0.8 mm) thick.

C. Plenum Cable: Listed and labeled for plenum installation.

2.15 RACEWAYS

A. Educational Intercommunication and Program System Raceways and Boxes: Comply with requirements in Section 27 05 28 "Pathways for Communications Systems."

B. Flexible metal conduit is prohibited.

PART 3 - EXECUTION

3.01 WIRING METHODS

A. Wiring Method: Install cables in raceways and cable trays except within consoles, cabinets, desks, and counters, and except in accessible ceiling spaces and in gypsum board partitions where unenclosed wiring method may be used. Conceal raceway and cables except in unfinished spaces.

1. Install plenum cable in environmental air spaces, including plenum ceilings.
2. Comply with requirements for raceways and boxes specified in Section 27 05 28 "Pathways for Communications Systems."

B. Wiring Method: Conceal conductors and cables in accessible ceilings, walls, and floors where possible.

C. Wiring within Enclosures: Bundle, lace, and train cables to terminal points with no excess and without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

3.02 INSTALLATION OF RACEWAYS

A. Comply with requirements in Section 27 05 28 "Pathways for Communications Systems" for installation of conduits and wireways.

B. Install manufactured conduit sweeps and long-radius elbows whenever possible.

3.03 INSTALLATION OF CABLES

A. Comply with NECA 1.

B. General Requirements:

1. Terminate conductors; no cable shall contain unterminated elements. Make terminations only at outlets and terminals.
2. Splices, Taps, and Terminations: Arrange on numbered terminal strips in junction, pull, and outlet boxes; terminal cabinets; and equipment enclosures. Cables may not be spliced.
3. Secure and support cables at intervals not exceeding 30 inches (760 mm) and not more than 6 inches (150 mm) from cabinets, boxes, fittings, outlets, racks, frames, and terminals.
4. Bundle, lace, and train conductors to terminal points without exceeding manufacturer's limitations on bending radii. Install lacing bars and distribution spools.

5. 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.
6. Cold-Weather Installation: Bring cable to room temperature before dereeling. Heat lamps shall not be used.

C. Open-Cable Installation:

1. Install cabling with horizontal and vertical cable guides in telecommunication spaces with terminating hardware and interconnection equipment.
2. Suspend cable not in a wireway or pathway a minimum of 8 inches (200 mm) above ceiling by cable supports not more than 60 inches (1524 mm) apart.
3. Cable shall not be run through structural members or be in contact with pipes, ducts, or other potentially damaging items.

D. Separation of Wires: Separate speaker-microphone, line-level, speaker-level, and power wiring runs. Install in separate raceways or, where exposed or in same enclosure, separate conductors at least 12 inches (300 mm) apart for speaker microphones and adjacent parallel power and telephone wiring. Separate other intercommunication equipment conductors as recommended by equipment manufacturer.

3.04 INSTALLATION

A. Match input and output impedances and signal levels at signal interfaces. Provide matching networks where required.

B. Identification of Conductors and Cables: Color-code conductors and apply wire and cable marking tape to designate wires and cables so they identify media in coordination with system wiring diagrams.

C. Weatherproof Equipment: For units that are mounted outdoors, in damp locations, or where exposed to weather, install consistent with requirements of weatherproof rating.

D. Connect wiring according to Section 26 05 19 "Low-Voltage Electrical Power Conductors and Cables."

E. Mounting of Stations: Surface mount at 54 inches (137.2 cm) above finished floor to center of station unless otherwise indicated.

3.05 GROUNDING

A. Ground cable shields and equipment to eliminate shock hazard and to minimize ground loops, common-mode returns, noise pickup, cross talk, and other impairments.

B. Signal Ground Terminal: Locate at main equipment cabinet. Isolate from power system and equipment grounding.

C. Install grounding electrodes as specified in Section 27 05 26 "Grounding and Bonding for Communications Systems."

3.06 SYSTEM PROGRAMMING

A. Programming: Fully brief Owner on available programming options. Record Owner's decisions and set up initial system program. Prepare a written record of decisions, implementation methodology, and final results.

3.07 FIELD QUALITY CONTROL

A. Manufacturer's Field Service: Engage a factory-authorized service representative to test and inspect components, assemblies, and equipment installations, including connections.

B. Perform tests and inspections with the assistance of a factory-authorized service representative:

C. Tests and Inspections:

1. Schedule tests with at least seven days' advance notice of test performance.
2. After installing educational intercommunications and program systems and after electrical circuitry has been energized, test for compliance with requirements.
3. Operational Test: Test originating station-to-station, all-call, and page messages at each intercommunication station. Verify proper routing and volume levels and that system is free of noise and distortion. Test each available message path from each station on system.
4. Frequency Response Test: Determine frequency response of two transmission paths, including all-call and paging, by transmitting and recording audio tones. Minimum acceptable performance is within 3 dB from 150 to 2500 Hz.
5. Signal-to-Noise Ratio Test: Measure signal-to-noise ratio of complete system at normal gain settings as follows:

    a. Disconnect speaker microphone and replace it in the circuit with a signal generator using a 1000-Hz signal. Measure signal-to-noise ratio at speakers.
    b. Repeat test for three speaker microphones, and one administrative console microphone, and for each separately controlled zone of paging loudspeakers].
    c. Minimum acceptable ratio is 45 dB.

6. Distortion Test: Measure distortion at normal gain settings and rated power. Feed signals at frequencies of 150, 200, 400, 1000, and 2500 Hz into each intercom, paging, and all-call amplifier]. For each frequency, measure distortion in the paging and all-call amplifier outputs. Maximum acceptable distortion at any frequency is 5 percent total harmonics.
7. Acoustic Coverage Test: Feed pink noise into system using octaves centered at 500 and 4000 Hz. Use sound-level meter with octave-band filters to measure level at five locations in each paging zone. Maximum permissible variation in level is plus or minus 3 dB; in levels between adjacent zones, plus or minus 5 dB.
8. Power Output Test: Measure electrical power output of each paging amplifier at normal gain settings of 150, 1000, and 2500 Hz. Maximum variation in power output at these frequencies is plus or minus 3 dB.
9. Signal Ground Test: Measure and report ground resistance at system signal ground. Comply with testing requirements in Section 27 05 26 "Grounding and Bonding for Communications Systems."

D. Inspection: Verify that units and controls are properly labeled and interconnecting wires and terminals are identified. Prepare a list of final tap settings of paging and independent room speaker-line matching transformers.

E. Educational intercommunications and program systems will be considered defective if they do not pass tests and inspections.

F. Prepare test and inspection reports.

3.08 STARTUP SERVICE

A. Engage a factory-authorized service representative to perform startup service and initial system programming.

1. Verify that electrical wiring installation complies with manufacturer's submittal and installation requirements.
2. Complete installation and startup checks according to manufacturer's written instructions.

3.09 ADJUSTING

A. On-Site Assistance: Engage a factory-authorized service representative to provide on-site assistance in adjusting sound levels, resetting transformer taps, and adjusting controls to meet occupancy conditions.

B. Occupancy Adjustments: When requested within 12 months from date of Substantial Completion, provide on-site assistance in adjusting system to suit actual occupied conditions. Provide up to two visits to Project during other-than-normal occupancy hours for this purpose.

3.10 DEMONSTRATION

A. Train Owner's maintenance personnel to adjust, operate, and maintain the educational intercommunications and program systems.
1. Train Owner's maintenance personnel on programming equipment for starting up and shutting down, troubleshooting, servicing, and maintaining the system and equipment.

END OF SECTION

SECTION 28 05 13

CONDUCTORS AND CABLES FOR ELECTRONIC SAFETY AND SECURITY

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 SUMMARY

A. Section Includes:

1. Fire alarm wire and cable.
2. Identification products.

1.03 DEFINITIONS

A. 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.

B. Open Cabling: Passing cabling through open space (e.g., between the studs of a wall cavity).

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For qualified layout technician, installation supervisor, and field inspector.

1.06 FIELD 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.

PART 2 - PRODUCTS

2.01 PERFORMANCE REQUIREMENTS

A. Surface-Burning Characteristics: Comply with ASTM E 84; testing by a qualified testing agency. Identify products with appropriate markings of applicable testing agency.

1. Flame-Spread Index: 25 or less.
2. Smoke-Developed Index: 50 or less.

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

2.02 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.

B. General Wire and Cable Requirements: NRTL listed and labeled as complying with NFPA 70, Article 760.

C. Signaling Line Circuits: Twisted, shielded pair, size as recommended by system manufacturer, but not smaller than 18 AWG.

1. Multiconductor Armored Cable: NFPA 70, Type MC, copper conductors, Type TFN/THHN conductor insulation, copper drain wire, copper armor with red identifier stripe, NTRL listed for fire alarm and cable tray installation, plenum rated.

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, NTRL listed for fire alarm and cable tray installation, plenum rated.

2.03 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 Worldwide, Inc.
2. Kroy LLC.
3. 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 Section 26 05 53 "Identification for Electrical Systems."

PART 3 - EXECUTION

3.01 INSTALLATION OF HANGERS AND SUPPORTS

A. Comply with requirements in Section 26 05 29 "Hangers and Supports for Electrical Systems" for installation of supports for cables.

3.02 WIRING METHOD

A. Install wiring in metal raceways where exposed. Listed fire alarm MC cable shall be permitted where concealed in walls and ceilings and above accessible ceilings if allowed by the Authority Having Jurisdiction.

1. Minimum conduit size shall be 3/4 inch (21 mm). Control and data transmission wiring shall not share conduit with other building wiring systems.
2. Comply with requirements in Division 26.

B. Install cable, concealed in accessible ceilings, walls, and floors when possible.

3.03 FIRE ALARM WIRING INSTALLATION

A. Comply with NECA 1 and NFPA 72.

B. 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.

C. Cable Taps: Use numbered terminal strips in junction, pull, and outlet boxes, cabinets, or equipment enclosures where circuit connections are made.

D. 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.

E. For Class A circuits, provide separate conduits or cable for outgoing and return conductors.

F. 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.

3.04 POWER AND CONTROL-CIRCUIT CONDUCTORS

A. 120-V Power Wiring: Install according to Section 26 05 19 "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.

3.05 CONNECTIONS

A. Comply with requirements in Section 28 31 11 "Digital, Addressable Fire-Alarm System for connecting, terminating, and identifying wires and cables.

3.06 FIRESTOPPING

A. Comply with requirements in Division 07.

3.07 GROUNDING

A. For low-voltage wiring and cabling, comply with requirements in Section 26 05 26 "Grounding and Bonding for Electrical Systems."

3.08 IDENTIFICATION

A. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

3.09 FIELD QUALITY CONTROL

A. Perform the following tests and inspections:

1. Visually inspect cable placement, cable termination, grounding and bonding, equipment, and labeling of all components.

END OF SECTION

SECTION 28 31 11

DIGITAL, ADDRESSABLE FIRE-ALARM SYSTEM

PART 1 - GENERAL

1.01 RELATED DOCUMENTS

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

1.02 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. Device guards.
7. Magnetic door holders.
8. Remote annunciator.
9. Addressable interface device.
10. Digital alarm communicator transmitter.
11. Network communications.

B. Related Requirements:

1. Section 28 05 13 "Conductors and Cables for Electronic Safety and Security" for cables and conductors for fire-alarm systems.

1.03 DEFINITIONS

A. EMT: Electrical Metallic Tubing.

B. FACP: Fire Alarm Control Panel.

C. HLI: High Level Interface.

D. NICET: National Institute for Certification in Engineering Technologies.

E. PC: Personal computer.

F. VESDA: Very Early Smoke-Detection Apparatus.

1.04 ACTION SUBMITTALS

A. Product Data: For each type of product, including furnished options and accessories.

1. Include construction details, material descriptions, dimensions, profiles, and finishes.
2. Include rated capacities, operating characteristics, and electrical characteristics.

B. Shop Drawings: For fire-alarm system.

1. Comply with recommendations and requirements in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
2. Include plans, elevations, sections, details, and attachments to other work.
3. Include details of equipment assemblies. Indicate dimensions, weights, loads, required clearances, method of field assembly, components, and locations. Indicate conductor sizes, indicate termination locations and requirements, and distinguish between factory and field wiring.
4. Detail assembly and support requirements.
5. Include voltage drop calculations for notification-appliance circuits.
6. Include battery-size calculations.
7. Include input/output matrix.
8. Include statement from manufacturer that all equipment and components have been tested as a system and meet all requirements in this Specification and in NFPA 72.
9. Include performance parameters and installation details for each detector.
10. Verify that each duct detector is listed for complete range of air velocity, temperature, and humidity possible when air-handling system is operating.
11. Include plans, sections, and elevations of heating, ventilating, and air-conditioning ducts, drawn to scale; coordinate location of duct smoke detectors and access to them.

    a. Show critical dimensions that relate to placement and support of sampling tubes, detector housing, and remote status and alarm indicators.
    b. Retain one of first three subparagraphs below.
    c. Show field wiring required for HVAC unit shutdown on alarm.
    d. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' control system.
    e. Show field wiring and equipment required for HVAC unit shutdown on alarm and override by firefighters' smoke-evacuation system.
    f. Locate detectors according to manufacturer's written recommendations.
    g. Show air-sampling detector pipe routing.

12. Include voice/alarm signaling-service equipment rack or console layout, grounding schematic, amplifier power calculation, and single-line connection diagram.
13. Include floor plans to indicate final outlet locations showing address of each addressable device. Show size and route of cable and conduits and point-to-point wiring diagrams.

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; Level III minimum.
    c. Licensed or certified by authorities having jurisdiction.

1.05 INFORMATIONAL SUBMITTALS

A. Qualification Data: For Installer.

B. 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.

C. Field quality-control reports.

1.06 Sample Warranty: For special warranty.

1.07 CLOSEOUT SUBMITTALS

A. Operation and Maintenance Data: For fire-alarm systems and components to include in emergency, operation, and maintenance manuals.

1. In addition to items specified in Division 01, include the following and deliver copies to authorities having jurisdiction:

a. Comply with the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
b. Provide "Fire Alarm and Emergency Communications System Record of Completion Documents" according to the "Completion Documents" Article in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
c. Complete wiring diagrams showing connections between all devices and equipment. Each conductor shall be numbered at every junction point with indication of origination and termination points.
d. Riser diagram.
e. Device addresses.
f. Record copy of site-specific software.
g. Provide "Inspection and Testing Form" according to the "Inspection, Testing and Maintenance" chapter in NFPA 72, and include the following:

1) Equipment tested.
2) Frequency of testing of installed components.
3) Frequency of inspection of installed components.
4) Requirements and recommendations related to results of maintenance.
5) Manufacturer's user training manuals.

h. Manufacturer's required maintenance related to system warranty requirements.
i. Abbreviated operating instructions for mounting at fire-alarm control unit and each annunciator unit.

B. Software and Firmware Operational Documentation:

1. Software operating and upgrade manuals.
2. Program Software Backup: On magnetic media or compact disk, complete with data files.
3. Device address list.
4. Printout of software application and graphic screens.

1.08 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 one unit.
2. Lamps for Strobe Units: Quantity equal to 10 percent of amount installed, but no fewer than one unit.
3. Smoke Detectors, Fire Detectors: Quantity equal to 10 percent of amount of each type installed, but no fewer than one unit of each type.
4. Detector Bases: Quantity equal to 2 percent of amount of each type installed, but no fewer than one unit of each type.
5. Keys and Tools: One extra set for access to locked or tamperproofed components.
6. Audible and Visual Notification Appliances: one of each type installed.
7. Fuses: two of each type installed in the system. Provide in a box or cabinet with compartments marked with fuse types and sizes.

1.09 QUALITY ASSURANCE

A. Installer Qualifications: Personnel shall be trained and certified by manufacturer for installation of units required for this Project.

B. Installer Qualifications: Installation shall be by personnel certified by NICET as fire-alarm Level III technician.

1.10 PROJECT CONDITIONS

A. Use of Devices during Construction: Protect devices during construction unless devices are placed in service to protect the facility during construction.

1.11 WARRANTY

A. Special Warranty: Manufacturer agrees to repair or replace fire-alarm system equipment and components that fail in materials or workmanship within specified warranty period.

1. Warranty Extent: All equipment and components not covered in the Maintenance Service Agreement.
2. Warranty Period: 5 years from date of Substantial Completion.

PART 2 - PRODUCTS

2.01 SYSTEM DESCRIPTION

A. Noncoded, UL-certified addressable system, with multiplexed signal transmission and voice/strobe evacuation.

B. Automatic sensitivity control of certain smoke detectors.

C. All components provided shall be listed for use with the selected system.

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

2.02 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. Combustible gas detectors.
6. Automatic sprinkler system water flow.

B. Fire-alarm signal shall initiate the following actions:

1. Continuously operate alarm notification appliances, including voice evacuation notices.
2. Identify alarm and specific initiating device at fire-alarm control unit and remote annunciators.
3. Transmit an alarm signal to the remote alarm receiving station.
4. Unlock electric door locks in designated egress paths.
5. Release fire and smoke doors held open by magnetic door holders.
6. Activate voice/alarm communication system.
7. Switch heating, ventilating, and air-conditioning equipment controls to fire-alarm mode.
8. Disable intercommunications system.
9. Close smoke dampers in air ducts of designated air-conditioning duct systems.
10. Recall elevators to primary or alternate recall floors.
11. Activate elevator power shunt trip prior to water flow at elevator machine room and hoistway where equipped with sprinklers.
12. Activate emergency lighting control.
13. Activate emergency shutoffs for gas and fuel supplies.
14. Record events in the system memory.
15. Indicate device in alarm on the annunciator.
16. Activate emergency shutoffs for power to equipment as required by code and as indicated.

C. Supervisory signal initiation shall be by one or more of the following devices and actions:

1. Valve supervisory switch.
2. Gas detectors.
3. Elevator shunt-trip supervision.
4. Independent fire-detection and -suppression systems.
5. User disabling of zones or individual devices.
6. Loss of communication with any panel on the network.

D. System trouble signal initiation shall be by one or more of the following devices and actions:

1. Open circuits, shorts, and grounds in designated circuits.
2. Opening, tampering with, or removing alarm-initiating and supervisory signal-initiating devices.
3. Loss of communication with any addressable sensor, input module, relay, control module, remote annunciator, printer interface, or Ethernet module.
4. Loss of primary power at fire-alarm control unit.
5. Ground or a single break in internal circuits of fire-alarm control unit.

6. Abnormal ac voltage at fire-alarm control unit.
7. Break in standby battery circuitry.
8. Failure of battery charging.
9. Abnormal position of any switch at fire-alarm control unit or annunciator.
10. Voice signal amplifier failure.

E. System Supervisory Signal Actions:

1. Initiate notification appliances.
2. After a time delay of 200 seconds, transmit a trouble or supervisory signal to the remote alarm receiving station.

2.03 PERFORMANCE REQUIREMENTS

A. Seismic Performance: Fire-alarm control unit and raceways 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.

2.04 FIRE-ALARM CONTROL UNIT

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. Faraday.
2. GAMEWELL.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.

B. General Requirements for Fire-Alarm Control Unit:

1. Field-programmable, microprocessor-based, modular, power-limited design with electronic modules, complying with UL 864.

a. System software and programs shall be held in nonvolatile flash, electrically erasable, programmable, read-only memory, retaining the information through failure of primary and secondary power supplies.
b. Include a real-time clock for time annotation of events on the event recorder and printer.
c. Provide communication between the FACP and remote circuit interface panels, annunciators, and displays.
d. The FACP shall be listed for connection to a central-station signaling system service.
e. Provide nonvolatile memory for system database, logic, and operating system and event history. The system shall require no manual input to initialize in the event of a complete power down condition. The FACP shall provide a minimum 500-event history log.

2. Addressable Initiation Device Circuits: The FACP shall indicate which communication zones have been silenced and shall provide selective silencing of alarm notification appliance by building communication zone.

3. Addressable Control Circuits for Operation of Notification Appliances and Mechanical Equipment: The FACP shall be listed for releasing service.

C. Alphanumeric Display and System Controls: Arranged for interface between human operator at fire-alarm control unit and addressable system components including annunciation and supervision. Display alarm, supervisory, and component status messages and the programming and control menu.

1. Annunciator and Display: Liquid-crystal type, 2 lines 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.

D. Initiating-Device, Notification-Appliance, and Signaling-Line Circuits:

1. Pathway Class Designations: NFPA 72, Class A.
2. Pathway Survivability: Level 0
3. Install no more than 99 addressable devices on each signaling-line circuit.
4. Serial Interfaces:

a. One dedicated RS 485 port for central-station operation using point ID DACT.
b. One RS 485 port for remote annunciators, Ethernet module, or multi-interface module (printer port).
c. One USB port for PC configuration.
d. One RS 232 port for voice evacuation interface.

E. Smoke-Alarm Verification:

1. Initiate audible and visible indication of an "alarm-verification" signal at fire-alarm control unit.
2. Activate an approved "alarm-verification" sequence at fire-alarm control unit and detector.
3. Sound general alarm if the alarm is verified.
4. Cancel fire-alarm control unit indication and system reset if the alarm is not verified.

F. Notification-Appliance Circuit:

1. Audible appliances shall sound in a three-pulse temporal pattern, as defined in NFPA 72.
2. Where notification appliances provide signals to sleeping areas, the alarm signal shall be a 520-Hz square wave with an intensity 15 dB above the average ambient sound level or 5 dB above the maximum sound level, or at least 75 dBA, whichever is greater, measured at the pillow.
3. Visual alarm appliances shall flash in synchronization where multiple appliances are in the same field of view, as defined in NFPA 72.

G. Elevator Recall:

1. Elevator recall shall be initiated only by one of the following alarm-initiating devices:

a. Elevator lobby detectors except the lobby detector on the designated floor.
b. Smoke detector in elevator machine room.
c. Smoke detectors in elevator hoistway.

2. Elevator controller shall be programmed to move the cars to the alternate recall floor if lobby detectors located on the designated recall floors are activated.

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.

4. Coordinate locations of detectors associated with elevator recall with and elevator shutdown with Division 21. Do not locate detectors in hoistways where prohibited by code.

H. Door Controls: Door hold-open devices that are controlled by smoke detectors at doors in smoke-barrier walls shall be connected to fire-alarm system.

I. Remote Smoke-Detector Sensitivity Adjustment: Controls shall select specific addressable smoke detectors for adjustment, display their current status and sensitivity settings, and change those settings. Allow controls to be used to program repetitive, time-scheduled, and automated changes in sensitivity of specific detector groups. Record sensitivity adjustments and sensitivity-adjustment schedule changes in system memory.

J. Transmission to Remote Alarm Receiving Station: Automatically transmit alarm, supervisory, and trouble signals to a remote alarm station.

K. Voice/Alarm Signaling Service: Central emergency communication system with redundant microphones, preamplifiers, amplifiers, and tone generators provided in a separate cabinet located in the fire command center or as a special module that is part of fire-alarm control unit.

1. Indicate number of alarm channels for automatic, simultaneous transmission of different announcements to different zones or for manual transmission of announcements by use of the central-control microphone. Amplifiers shall comply with UL 1711.

    a. Allow the application of, and evacuation signal to, indicated number of zones and, at the same time, allow voice paging to the other zones selectively or in any combination.
    b. Programmable tone and message sequence selection.
    c. Standard digitally recorded messages for "Evacuation" and "All Clear."
    d. Generate tones to be sequenced with audio messages of type recommended by NFPA 72 and that are compatible with tone patterns of notification-appliance circuits of fire-alarm control unit.

2. Status Annunciator: Indicate the status of various voice/alarm speaker zones and the status of firefighters' two-way telephone communication zones.
3. Preamplifiers, amplifiers, and tone generators shall automatically transfer to backup units, on primary equipment failure.

L. Printout of Events: On receipt of signal, print alarm, supervisory, and trouble events. Identify zone, device, and function. Include type of signal (alarm, supervisory, or trouble) and date and time of occurrence. Differentiate alarm signals from all other printed indications. Also print system reset event, including same information for device, location, date, and time. Commands initiate the printing of a list of existing alarm, supervisory, and trouble conditions in the system and a historical log of events.

M. 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 and digital alarm radio 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.

N. Secondary Power: 24-V dc supply system with batteries, automatic battery charger, and automatic transfer switch.

1. Batteries: Sealed lead calcium.

O. 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.

2.05 MANUAL FIRE-ALARM BOXES

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 Wheelock.
2. Faraday.
3. Federal Signal Corporation.
4. GAMEWELL.
5. Siemens Industry, Inc.; Fire Safety Division.
6. System Sensor.

B. General Requirements for Manual Fire-Alarm Boxes: Comply with UL 38. Boxes shall be finished in red with molded, raised-letter operating instructions in contrasting color; shall show visible indication of operation; and shall be mounted on recessed outlet box. If indicated as surface mounted, provide manufacturer's surface back box.

1. Double-action mechanism requiring two actions to initiate an alarm, pull-lever type; with integral addressable module arranged to communicate manual-station status (normal, alarm, or trouble) to fire-alarm control unit.
2. Station Reset: Key- or wrench-operated switch.
3. Indoor Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm. Lifting the cover actuates an integral battery-powered audible horn intended to discourage false-alarm operation.
4. Weatherproof Protective Shield: Factory-fabricated, clear plastic enclosure hinged at the top to permit lifting for access to initiate an alarm.

2.06 SYSTEM SMOKE DETECTORS

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. Faraday.
2. GAMEWELL.
3. Gentex Corporation.
4. Notifier.
5. Siemens Industry, Inc.; Fire Safety Division.
6. System Sensor.

B. General Requirements for System Smoke Detectors:

1. Comply with UL 268; operating at 24-V dc, nominal.
2. Detectors shall be 2 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 digital-addressable type, individually monitored at fire-alarm control unit for calibration, sensitivity, and alarm condition and individually adjustable for sensitivity by fire-alarm control unit.

    a. Retain first two subparagraphs below only for combination smoke- and heat-detection units.
    b. Rate-of-rise temperature characteristic of combination smoke- and heat-detection units shall be selectable at fire-alarm control unit for 15 or 20 deg F (8 or 11 deg C) per minute.
    c. Fixed-temperature sensing characteristic of combination smoke- and heat-detection units 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).
    d. Number of settable levels in fire-alarm control unit varies among manufacturers and between detector types. Indicate specific number of levels on Drawings or in "Remarks" column of a detector schedule.
    e. Multiple levels of detection sensitivity for each sensor.
    f. Sensitivity levels based on time of day.

C. 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.).

D. Duct Smoke Detectors: Photoelectric type complying with UL 268A.

1. Detector address shall be accessible from fire-alarm control unit and shall be able to identify the detector's location within the system and its sensitivity setting.
2. An operator at fire-alarm control unit, having the designated access level, shall be able to manually access the following for each detector:

    a. Primary status.
    b. Device type.
    c. Present average value.
    d. Present sensitivity selected.
    e. Sensor range (normal, dirty, etc.).

3. Weatherproof Duct Housing Enclosure: NEMA 250, Type 4X; NRTL listed for use with the supplied detector for smoke detection in HVAC system ducts.
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: Fully programmable relay rated to interrupt fan motor-control circuit.

2.07 HEAT DETECTORS

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. Faraday.
2. GAMEWELL.
3. Notifier.
4. Siemens Industry, Inc.; Fire Safety Division.
5. System Sensor.

B. General Requirements for Heat Detectors: Comply with UL 521.

1. Temperature sensors shall test for and communicate the sensitivity range of the device.

C. 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.

D. 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.

2.08 NOTIFICATION APPLIANCES

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 Wheelock.
2. Gentex Corporation.
3. Siemens Industry, Inc.; Fire Safety Division.
4. System Sensor.

B. General Requirements for Notification Appliances: Individually addressed, connected to a signaling-line circuit, equipped for mounting as indicated, and with screw terminals for system connections.

C. 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.

D. Visible Notification Appliances: Xenon strobe lights complying with UL 1971, with clear or nominal white polycarbonate lens mounted on an aluminum faceplate. The word "FIRE" is engraved in minimum 1-inch- (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.

E. Voice/Tone Notification Appliances:

1. Comply with UL 1480.
2. Speakers for Voice Notification: Locate speakers for voice notification to provide the intelligibility requirements of the "Notification Appliances" and "Emergency Communications Systems" chapters in NFPA 72.
3. High-Range Units: Rated 2 to 15 W.
4. Low-Range Units: Rated 1 to 2 W.
5. Mounting: semi-recessed
6. Matching Transformers: Tap range matched to acoustical environment of speaker location.

2.09 MAGNETIC DOOR HOLDERS

A. Description: Units are equipped for wall or floor mounting as indicated and are complete with matching doorplate.

1. Electromagnets: Require no more than 3 W to develop 25-lbf (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.
5. Coordinated with Hardware specification 08 71 00

B. Material and Finish: Match door hardware.

2.10 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.

C. Match Voice evacuation microphone and control functions of the fire alarm control unit.

2.11 ADDRESSABLE INTERFACE DEVICE

A. General:

1. Include address-setting means on the module.
2. Store an internal identifying code for control panel use to identify the module type.
3. Listed for controlling HVAC fan motor controllers.

B. Monitor Module: Microelectronic module providing a system address for alarm-initiating devices for wired applications with normally open contacts.

C. Integral Relay: Capable of providing a direct signal to elevator controller to initiate elevator recall and to circuit-breaker shunt trip for power shutdown.

1. Allow the control panel to switch the relay contacts on command.
2. Have a minimum of two normally open and two normally closed contacts available for field wiring.

D. Control Module:

1. Operate notification devices.
2. Operate solenoids for use in sprinkler service.
3. < Retain one of two transmitter articles below if Project requires alarm and transmission of alarm, supervisory, and trouble signals to a remote alarm receiving station or another remote location.

2.12 DIGITAL ALARM COMMUNICATOR TRANSMITTER

A. Digital alarm communicator transmitter shall be acceptable to the remote central station and shall comply with UL 632.

B. Functional Performance: Unit shall receive an alarm, supervisory, or trouble signal from fire-alarm control unit and automatically capture [**one**] [**two**] telephone line(s) and dial a preset number for a remote central station. When contact is made with central station(s), signals shall be transmitted. If service on either line is interrupted for longer than 45 seconds, transmitter shall initiate a local trouble signal and transmit the signal indicating loss of telephone line to the

remote alarm receiving station over the remaining line. Transmitter shall automatically report telephone service restoration to the central station. If service is lost on both telephone lines, transmitter shall initiate the local trouble signal.

C. Local functions and display at the digital alarm communicator transmitter shall include the following:

1. Verification that both telephone lines are available.
2. Programming device.
3. LED display.
4. Manual test report function and manual transmission clear indication.
5. Communications failure with the central station or fire-alarm control unit.

D. Digital data transmission shall include the following:

1. Address of the alarm-initiating device.
2. Address of the supervisory signal.
3. Address of the trouble-initiating device.
4. Loss of ac supply.
5. Loss of power.
6. Low battery.
7. Abnormal test signal.
8. Communication bus failure.

E. Secondary Power: Integral rechargeable battery and automatic charger.

F. Self-Test: Conducted automatically every 24 hours with report transmitted to central station.

2.13 DEVICE GUARDS

A. Description: Welded wire mesh of size and shape for the manual station, smoke detector, gong, or other device requiring protection.

1. Factory fabricated and furnished by device manufacturer.
2. Finish: Paint of color to match the protected device.

PART 3 - EXECUTION

3.01 EXAMINATION

A. Examine areas and conditions for compliance with requirements for ventilation, temperature, humidity, and other conditions affecting performance of the Work.

1. Verify that manufacturer's written instructions for environmental conditions have been permanently established in spaces where equipment and wiring are installed, before installation begins.

B. Examine roughing-in for electrical connections to verify actual locations of connections before installation.

C. Proceed with installation only after unsatisfactory conditions have been corrected.

3.02 EQUIPMENT INSTALLATION

A. Comply with NFPA 72, NFPA 101, and requirements of authorities having jurisdiction for installation and testing of fire-alarm equipment. Install all electrical wiring to comply with requirements in NFPA 70 including, but not limited to, Article 760, "Fire Alarm Systems."

1. Devices placed in service before all other trades have completed cleanup shall be replaced.
2. Devices installed but not yet placed in service shall be protected from construction dust, debris, dirt, moisture, and damage according to manufacturer's written storage instructions.

B. Install wall-mounted equipment, with tops of cabinets not more than 78 inches (1980 mm) above the finished floor.

1. Comply with requirements for seismic-restraint devices specified in Section 26 05 48.16 "Seismic Controls for Electrical Systems."

C. Manual Fire-Alarm Boxes:

1. Install manual fire-alarm box in the normal path of egress within 60 inches (1520 mm) of the exit doorway.
2. Mount manual fire-alarm box on a background of a contrasting color.
3. The operable part of manual fire-alarm box shall be between 42 inches (1060 mm) and 48 inches (1220 mm) above floor level. All devices shall be mounted at the same height unless otherwise indicated.

D. Smoke- or Heat-Detector Spacing:

1. Comply with the "Smoke-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, for smoke-detector spacing.
2. Comply with the "Heat-Sensing Fire Detectors" section in the "Initiating Devices" chapter in NFPA 72, 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 Annex A or B in NFPA 72.
5. HVAC: Locate detectors not closer than 36 inches (910 mm) 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 and not directly above pendant mounted or indirect lighting.

E. Install a cover on each smoke detector that is not placed in service during construction. Cover shall remain in place except during system testing. Remove cover prior to system turnover.

F. Duct Smoke Detectors: Comply with NFPA 72 and NFPA 90A. Install sampling tubes so they extend the full width of duct. Tubes more than 36 inches (9100 mm) long shall be supported at both ends.

1. Do not install smoke detector in duct smoke-detector housing during construction. Install detector only during system testing and prior to system turnover.

G. Elevator Shafts: Coordinate temperature rating and location with sprinkler rating and location. Do not install smoke detectors in sprinklered elevator shafts.

H. Remote Status and Alarm Indicators: Install in a visible location near each smoke detector, sprinkler water-flow switch, and valve-tamper switch that is not readily visible from normal viewing position.

I. Audible Alarm-Indicating Devices: Install not less than 6 inches (150 mm) below the ceiling. Install bells and horns on flush-mounted back boxes with the device-operating mechanism concealed behind a grille. Install all devices at the same height unless otherwise indicated.

J. Visible Alarm-Indicating Devices: Install adjacent to each alarm bell or alarm horn and at least 6 inches (150 mm) below the ceiling. Install all devices at the same height unless otherwise indicated.

K. Device Location-Indicating Lights: Locate in public space near the device they monitor.

3.03 PATHWAYS

A. Pathways above recessed ceilings and in non accessible locations may be routed exposed.

1. Exposed pathways located less than 96 inches (2440 mm) above the floor shall be installed in EMT.

B. Pathways shall be installed in EMT.

C. Exposed EMT shall be painted red enamel.

3.04 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 Section 08 71 00 "Door Hardware." Connect hardware and devices to fire-alarm system.

1. Verify that hardware and devices are listed for use with installed fire-alarm system before making connections.

B. Make addressable connections with a supervised interface device to the following devices and systems. Install the interface device less than 36 inches (910 mm) from the device controlled. Make an addressable confirmation connection when such feedback is available at the device or system being controlled.

1. Smoke dampers in air ducts of designated HVAC duct systems.
2. Magnetically held-open doors.
3. Electronically locked doors and access gates.
4. Alarm-initiating connection to elevator recall system and components.
5. Alarm-initiating connection to activate emergency lighting control.
6. Alarm-initiating connection to activate emergency shutoffs for gas and fuel supplies.
7. Supervisory connections at valve supervisory switches.
8. Supervisory connections at low-air-pressure switch of each dry-pipe sprinkler system.
9. Supervisory connections at elevator shunt-trip breaker.
10. Data communication circuits for connection to building management system.

3.05 IDENTIFICATION

A. Identify system components, wiring, cabling, and terminals. Comply with requirements for identification specified in Section 26 05 53 "Identification for Electrical Systems."

B. Install framed instructions in a location visible from fire-alarm control unit.

3.06 GROUNDING

A. Ground fire-alarm control unit and associated circuits; comply with IEEE 1100. Install a ground wire from main service ground to fire-alarm control unit.

B. Ground shielded cables at the control panel location only. Insulate shield at device location.

3.07 FIELD QUALITY CONTROL

A. Field tests shall be witnessed by authorities having jurisdiction.

B. Perform the following tests and inspections with the assistance of a factory-authorized service representative:

1. Visual Inspection: Conduct visual inspection prior to testing.

    a. Inspection shall be based on completed record Drawings and system documentation that is required by the "Completion Documents, Preparation" table in the "Documentation" section of the "Fundamentals" chapter in NFPA 72.
    b. Comply with the "Visual Inspection Frequencies" table in the "Inspection" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72; retain the "Initial/Reacceptance" column and list only the installed components.

2. System Testing: Comply with the "Test Methods" table in the "Testing" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Test audible appliances for the public operating mode according to manufacturer's written instructions. Perform the test using a portable sound-level meter complying with Type 2 requirements in ANSI S1.4.
4. Test audible appliances for the private operating mode according to manufacturer's written instructions.
5. Test visible appliances for the public operating mode according to manufacturer's written instructions.
6. Factory-authorized service representative shall prepare the "Fire Alarm System Record of Completion" in the "Documentation" section of the "Fundamentals" chapter in NFPA 72 and the "Inspection and Testing Form" in the "Records" section of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

C. Reacceptance Testing: Perform reacceptance testing to verify the proper operation of added or replaced devices and appliances.

D. Fire-alarm system will be considered defective if it does not pass tests and inspections.

E. Prepare test and inspection reports.

F. Maintenance Test and Inspection: Perform tests and inspections listed for weekly, monthly, quarterly, and semiannual periods. Use forms developed for initial tests and inspections.

G. Annual Test and Inspection: One year after date of Substantial Completion, test fire-alarm system complying with visual and testing inspection requirements in NFPA 72. Use forms developed for initial tests and inspections.

3.08 MAINTENANCE SERVICE

A. Initial Maintenance Service: Beginning at Substantial Completion, maintenance service shall include 12 months' full maintenance by skilled employees of manufacturer's designated service organization. Include preventive maintenance, repair or replacement of worn or defective components, lubrication, cleaning, and adjusting as required for proper operation. Parts and supplies shall be manufacturer's authorized replacement parts and supplies.

1. Include visual inspections according to the "Visual Inspection Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
2. Perform tests in the "Test Methods" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.
3. Perform tests per the "Testing Frequencies" table in the "Testing" paragraph of the "Inspection, Testing and Maintenance" chapter in NFPA 72.

3.09 SOFTWARE SERVICE AGREEMENT

A. Comply with UL 864.

B. Technical Support: Beginning at Substantial Completion, service agreement shall include software support for 2 years.

C. Upgrade Service: At Substantial Completion, update software to latest version. Install and program software upgrades that become available within 2 years from date of Substantial Completion. Upgrading software shall include operating system and new or revised licenses for using software.

1. Upgrade Notice: At least 30 days to allow Owner to schedule access to system and to upgrade computer equipment if necessary.

3.10 DEMONSTRATION

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

END OF SECTION

SECTION 31 05 13
SOILS FOR EARTHWORK

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
1. Provide, place and compact borrow and bedding material in authorized excavation(s) below normal depth and in other location(s) as shown on the Drawings and/or as specified herein.

B. Related Work Specified Elsewhere:
1. Trench Excavation - Earth, Trench Excavation - Ledge, Trench Backfilling, Compaction, Control and Testing are specified in the appropriate sections in this division.

PART 2 - PRODUCTS

2.1 MATERIALS

All materials shall be applicable as specified in owner's geotechnical report. Utilize materials specified in the geotechnical report in all applicable locations. Materials otherwise not specified in owner's geotechnical report shall conform to the following minimum standards:

A. Gravel Borrow:
1. Well graded granular material having no rocks with a maximum dimension over six (6) inches, except where it is used for pipe bedding in which case the maximum size shall be two (2) inches.
2. Free from frozen material and other unsuitable material.
3. That portion passing a three inch square mesh sieve shall contain no more than 70 percent passing a l/4" mesh sieve and not more than l0 percent passing a number 200 mesh sieve when used as pipe bedding material and not more than five percent passing a number 200 mesh sieve when used as backfill around structures.

B. Screened Stone (Bedding Material):
1. Shall be either screened stone or crushed stone and shall be well graded in size from 1/4" to 3/4".
2. Clean, hard, and durable particles or fragments.
3. Free from dirt, vegetable, or other objectionable matter, and excess of soft, thin elongated, laminated or disintegrated pieces.
4. Sieve Analysis:

Sieve Designation	% Passing by Weight Square Opening
1"	100
3/4"	90-100
3/8"	20-50
No. 4	0-10
No. 8	0-5

C. Sand:
1. Clean, hard and durable particles or fragments.
2. Sieve Analysis:

Sieve Designation	% Passing by Weight Square Opening
3/8"	100
No. 4	95-100
No. 16	50-85
No. 50	10-30
No. 100	2-10

D. Underdrain Backfill Material:
   1. Free from organic matter.
   2. Gradations:

Type “B” Underdrain:

Sieve Designation	% Passing by Weight Square Mesh Sieves
1”	95-100
1/2”	75-100
No. 4	50-100
No. 20	15-80
No. 50	0-15
No. 100	0-10

Type "C" Underdrain:

Sieve Designation	% by Weight Passing Square Mesh Sieves
1”	100
3/4”	90-100
3/8”	0-75
No. 4	0-25
No. 10	0-5

Filter Fabric Lined Trench: 3"- 6" coarse aggregate.
Filter fabric in accordance with SECTION 31 32 19.23.

   3. Shall conform to AASHTO T 27

E. French Drain Stone:
   1. Hard, durable rock.
   2. Gradations:

Sieve Designation	% by Weight Passing Square Mesh Sieves
6 inch	90-100
1½ inch	0-40
No. 4	0-5

   3. Shall conform to AASHTO T 27 except that the total material sampled shall be sieved and the minimum weight of the sample will be 120 lbs.

F. 3/4"- Crushed Stone: Crushed Stone shall be a uniform material, containing angular pieces, as are those which come from a mechanical crusher. Gradation requirements shall be as follows:

Sieve Designation	% by Weight Passing Square Mesh Sieve
1"	98-100
3/4"	0-30
No. 200	0-3

G. Impervious Dam Material: As applicable, impervious dam material shall be uniform natural or selected cohesive soil with minimum of 30 percent of the material passing a No. 200 sieve. It

shall not contain vegetation, masses of roots, individual roots larger than 12". long or 1/2". in diameter or other porous or organic matter.

H. Unsuitable Soil Materials: Shall be those defined in AASHTO M145, soil classification Groups A-2-6, A-2-7, A-4, A-5, A-6, and A-7; also, peat and other highly organic soils.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Place bedding material, initial backfill, impervious dam material and fill below pipe bedding in layers of uniform thickness as specified or shown on the Drawings. Maximum lift thickness shall be as specified or shown on the drawings, but not greater than 12".

B. Thoroughly compact each layer by means of a suitable vibrator or mechanical tamper. Conform to the requirements of the geotechnical report, but in no case shall compaction be less than 95 percent of the fill material's maximum dry density determined in accordance with ASTM D1557.

C. In excavations below normal depth or where unsuitable materials are excavated, gravel borrow shall be used unless ground water makes such usage not practical; if such is the case, then screened stone shall be used.

D. No stone two (2) inches in diameter or larger shall be allowed within six (6) inches of the pipe.

E. Where soft silt and clay soils are encountered the trench shall be excavated 6" below the normal bedding and backfilled with six (6) inches of compacted sand.

F. No stone or rock greater than 12" measured at any point shall be placed in the trench backfill.

G. Bed from specified depth below pipe to top of pipe to support pipe and prevent damage. Unless otherwise specified in plan, detail, or applicable section, the following schedule gives the minimum bedding requirements for various types of pipe. Dimensions refer to distance below bottom of pipe.

D.I. Pipe	6" min. gravel borrow.
Concrete pipe	6" min. gravel borrow.
Culverts and Storm Drain Pipe	6" min. gravel borrow.
PVC or ABS Pipe	6" min. screened stone.
P.E. Pipe	6" min. screened stone.

H. Unless otherwise specified in plan, detail, or applicable section, the following schedule gives the minimum initial backfill requirements for various types of pipes.

D.I. Pipe	Gravel borrow; 6" min. over top of pipe.
Concrete Pipe	Gravel borrow; 6" min. over top of pipe.
Culverts and Storm Drain Pipe	Gravel borrow; 6" min. over top of pipe.
PVC or ABS	Screened stone; 6" min. over the top of the pipe.
P.E. Pipe	Screened stone; 6" min. over the top of the pipe.

END OF SECTION 31 05 13

SECTION 31 05 16
AGGREGATES FOR EARTHWORK

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Building perimeter construction and backfilling, pond embankment construction and site structure backfilling.

B. Fill under slabs-on-grade.

C. Consolidation and compaction.

1.2 RELATED SECTIONS

A. Section 31 23 16 - Excavation.

1.3 REFERENCES

A. ANSI/ASTM C136 - Method for Sieve Analysis of Fine and Coarse Aggregates.

B. ANSI/ASTM D698 - Test Methods for Moisture-Density Relations of Soils and Soil-Aggregate Mixtures, Using 5.5 lb (2.49 kg) Rammer and 12” (304.8 mm) Drop.

C. ASTM D922 - Test Method for Density of Soil and Soil Aggregate in Place by the Nuclear Methods. (Shallow Depth)

D. ANSI/ASTM D1556 - Test Method for Density of Soil in Place by the Sand-Cone Method.

PART 2 - PRODUCTS

2.1 FILL MATERIAL (as applicable)

A. Common Borrow: MDOT 703.18: (Only for site construction - not for building construction). Place and compact materials in continuous layers not exceeding 8”of compacted depth, compacted to 95 percent of its maximum dry density, in accordance with ASTM D1557 (modified proctor density).

B. Structural Backfill: Furnish in accordance with geotechnical report or specific plan requirements. Gravel Borrow: as specified in the geotechnical report, these plans, or MDOT 703.20: Place at over excavations below slabs and footings. Place over native material after organic soils are removed to raise subgrade below slabs and footings. Utilize per Geotechnical Report, as applicable. As a minimum, construct a 12” layer in a single 12” lift or lifts, and compacted to 95 percent of its maximum dry density, in accordance with ASTM D1557 (modified proctor density). In the case of footings set higher than original grade of competent mineral soil, first compact native material, use structural backfill to establish and compact fill slopes at 1:1 slopes from the edges of footings (entire backfill areas for retaining walls).

C. Granular Backfill: Per MDOT 703.22 for utility excavations and backfilling operations.

D. Crushed Stone: Per MDOT 703.31 for utility excavations and backfilling operations, except that 100 percent shall pass the 2" sieve.

E. Detention Pond Embankment: Excavated or imported clay silt material, graded, free of lumps larger than 3", rocks larger than 2", and debris. Material shall have at least 20% fines, more than 20% by weight passing the No. 200 sieve, and shall be compacted to a minimum of 95% modified proctor density in 9"-12" maximum lifts. The contractor may utilize glacial marine soil excavated on site with the approval of the owner's representative.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify fill materials to be reused are acceptable.

B. Owner's designated representative shall observe the excavation and accept suitable borrow material for placement as pond embankment material. Sandy layers shall be excluded from use as embankment fill.

C. Verify foundation perimeter drainage installation has been inspected.

3.2 PREPARATION

A. Generally, compact subgrade to density requirements for subsequent backfill materials. The foundation and slab base soil should be placed directly on the existing proof-rolled native mineral soil. Proof rolling should consist of making three passes in a north-south direction followed by three passes in an east-west direction using a large (minimum three ton at drum static weight) vibratory roller in slab areas and narrow roller vibratory trench rollers at footings (all passes in same direction).

B. Cut out soft areas of subgrade not capable of insitu compaction. Fill and compact to density equal to or greater than requirements for subsequent backfill material.

3.3 BACKFILLING

A. Backfill and compact areas to contours and elevations with unfrozen materials.

B. Backfill and compact where footing elevations are higher than suitable native mineral soil with structural backfill below and at 1:1 slope from edge of footing (level for retaining walls). Structural fill should be placed in a maximum of 12" lifts and be compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557, Modified Proctor Density

C. Backfill and compact pond embankment areas as early as possible to allow maximum time for settlement before shaping overflow structures.

D. Systematically backfill and compact to allow maximum time for natural settlement. Do not backfill over porous, wet, frozen or spongy subgrade surfaces. Work shall be scheduled so that the pond embankment shall be constructed three months prior to final setting of elevation sensitive components, such as the emergency spillway, allowing maximum time for settlement to occur.

E. Place and compact materials in continuous layers not exceeding 6" compacted depth. Pond Embankment requirements: Pond embankment sections shall be constructed from 8" to 12" lifts. At each lift, a bulldozer or similar equipment shall mechanically break down clods of clay-silt material as each lift is shaped. The owner's representative shall verify that no sand layers remain in each lift. Unsuitable material shall be replaced. Each lift shall be compacted with a sheepsfoot roller to 90 percent modified proctor density. Water shall be added as may be required to reach compaction.

F. Employ a placement method that does not disturb or damage foundation perimeter drainage, foundation damp proofing, and utilities in trenches.

G. Maintain optimum moisture content of backfill materials to attain required compaction density.

H. Make changes gradual. Blend slope into level areas.

I. Remove surplus backfill materials from site.

3.4 FIELD QUALITY CONTROL

A. Compaction testing will be performed in accordance with ANSI/ASTM D1556, ANSI/ASTM D1557, and ANSI/ASTM D698.

B. If tests indicate Work does not meet specified requirements, remove Work, replace and retest at no cost to Owner.

3.5 PROTECTION OF FINISHED WORK

A. Recompact fills subjected to vehicular traffic. Place and compact additional material of like kind and to equal compaction to re-establish suitable finished or subgrade.

END OF SECTION 31 05 16

SECTION 31 10 00
SITE CLEARING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
1. Clearing includes, but is not limited to, removal of trees, brush, stumps, wooded growth, grass, shrubs, poles, posts, signs, fences, culverts and other vegetation and minor structures; the protection of designated wooded growth; the storage and protection of minor structures and materials which are to be replaced; and the disposal of nonsalvageable structures and materials, and necessary preliminary grading.

B. Limits of Work:
1. Perform clearing and grubbing work within the areas required for construction, or as shown on the Drawings, to a depth of l2 inches below the existing grade.
2. Perform additional clearing and grubbing work within areas and to depths which, in the opinion of the Engineer, interfere with excavation and/or construction, or are otherwise objectionable.

C. Work Not Included:
1. Clearing and grubbing work performed for the convenience of the Contractor will not be considered for payment.

1.2 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
1. Dispose of combustible material by burning only when permitted by and in accordance with all applicable local and state laws, ordinances and code requirements.

B. Remove and dispose of nonsalvageable structures and material in accordance with all applicable local and state laws, ordinances and code requirements.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Provide all materials required to complete the work.

B. All timber and wood shall become the property of the Contractor unless other agreements are made between the Owner and the Contractor.

C. Repair any damage to structures to the complete satisfaction of the Owner and Engineer.

PART 3 - EXECUTION

3.1 PREPARATION

A. Carefully preserve and protect from injury all trees and/or shrubs not to be removed.

B. Right-of-way:
1. Where excavation is required on public or private rights-of-way containing trees, shrubs, other growth, or any structure or construction, obtain the Engineer's direction concerning the extent to which such obstacles can be cleared or stripped prior to performing the Work.
2. In all rights-of-way, remove only those particular growths or structures which are, in the opinion of the Engineer, essential for construction operations.
3. All other removals or damage shall be replaced or restored at the Contractor's expense.

3.2 PERFORMANCE

A. Clearing:
1. Remove and dispose of all trees, brush, slash, stubs, bushes, shrubs, plants, debris and obstructions within the area to be cleared, except any areas that may be designated as "Selective Clearing", and except as otherwise shown on the Drawings or as directed by the Engineer.
2. Remove all stumps unless otherwise directed by the Engineer.
3. Dispose of material to be removed daily as it accumulates.
4. Take special care to completely dispose of all elm trees and branches immediately after cutting either by burial in approved locations or, when permitted, by burning in areas well removed from standing elm growth.

B. Protection of Wooded Growth:
1. Fell trees toward the center of the area being cleared to protect trees and shrubs to be left standing.
2. Cut up, remove and dispose of trees unavoidably falling outside the area to be cleared.
3. Employ skilled workmen or tree surgeons to trim and repair all trees that are damaged but are to be left standing and paint all cut surfaces with an approved bituminous paint.

C. Selective Clearing:
1. When shown on the Drawings and when directed by the Engineer, perform selective clearing work to preserve natural tree cover.
2. Perform selective clearing work only under the direction and supervision of the Engineer.
3. Remove all dead and uprooted trees, brush, roots and other material which, in the opinion of the Engineer, are objectionable.
4. Cut flush with the ground and remove only those trees indicated by the Engineer.
5. Employ skilled workmen or tree surgeons to carefully trim all branches requiring cutting on trees to be left standing and to paint all cut surfaces with an approved bituminous paint.
6. Paint tree roots which are cut and are to be left exposed to the weather with an approved bituminous paint.

D. Grubbing:
1. Perform grubbing work beneath new roads, driveways, walks, seeded areas and other areas and as directed by the Engineer.
2. Grub out all sod, vegetation and other objectionable material to a minimum depth of l2 inches below the existing grade.
3. Completely remove all stumps, including major root systems.

E. Disposal:
1. Remove from the site and dispose of material not being burned.

2. Provide an approved disposal area unless otherwise specified.

F. Burning:
1. Dispose of combustible materials by burning only if approved by local and state officials.
2. Employ competent workmen to perform burning work in such a manner and at such locations that adjacent properties, trees and growth to remain, overhead cables, wires and utilities will not be jeopardized.
3. Do not leave fires unguarded.
4. Do not burn poison oak, poison ivy or other plants of similar nature.
5. Do not use tires or other combustible waste material to augment burning.
6. Burn combustible materials daily as the work progresses.
7. The Contractor shall be responsible for all damage caused by burning and shall be responsible for obtaining all necessary permits for burning.

3.3 REPLACEMENT OF MATERIALS

A. Paving, Curbing and Miscellaneous Material:
1. Remove all paving, subpaving, curbing, gutters, brick, paving block, granite curbing, flagging and minor structures that are over the area to be filled or excavated.
2. Remove and replace bituminous asphaltic and portland cement concrete in accordance with the appropriate sections of these Specifications.
3. Properly store and preserve all material to be replaced in a location approved by the Engineer.

B. Shrubs and Bushes:
1. Remove, store, and replace ornamental shrubs and bushes to be preserved in accordance with accepted horticultural practices.

C. Topsoil:
1. When applicable, carefully remove, store, and protect topsoil in accordance with the appropriate section of this division.

D. Responsibility:
1. Replace, at no additional cost to the Owner, materials lost or damaged because of careless removal or neglectful or wasteful storage, disposal or use of these materials.

END OF SECTION 31 10 00

SECTION 31 23 16
EXCAVATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Perform the following items of work, as shown on the Drawings and specified herein:
1. Excavate and furnish all material necessary to establish suitable finished grades for subgrade preparation, cut slope or embankment construction, as required to complete the work of this Contract, including the furnishing and compaction of additional material as needed.
2. Completely remove from the site all excavated material which is not approved by the Engineer for use as embankment material. This provision does not apply to topsoil which will remain the property of the Owner.
3. Establish subgrades as indicated on the Drawings and specified hereunder.
4. Perform cutting and removal of existing pavements to the extent indicated on the Drawings and as required for the work under this Contract.
5. Protect all trees, shrubs and plantings not designated on the Drawings to be removed, for the duration of the Contract.
6. Protect all utilities on the site for the duration of the work.

B. Related Work Specified Elsewhere:
1. Quality Control

1.2 DEFINITIONS

A. The work involved includes removal, haul and disposal of materials to prepare for construction and the placing and compaction of material to construct embankments.

B. Excavation shall be designated as common, rock, unclassified or muck.

1. Common excavation shall consist of removal of earth, of boulders, solid mortared stone masonry and concrete masonry when each is less than two cubic yard in volume and of rock which can be removed with ordinary excavating machinery. Grubbing shall be considered as common excavation.
2. Rock excavation shall consist of removal of solid rock which cannot be excavated without the use of explosives or ripping equipment and of boulders, solid mortared stone masonry and concrete masonry having a volume of two cubic yard or more.
3. Unclassified excavation shall consist of removal of materials without consideration to their composition.

4. Muck excavation shall consist of excavation of soils and organic materials which are not suitable for use in embankment.

C. Embankment construction shall consist of constructing roadway embankments, including preparation of the areas upon which they are to be placed; site grading around buildings and structures; the construction of parking areas, lawns, berms, and dikes; the placing and compacting of approved material within areas where unsuitable material has been removed; and the placing and compacting of embankment material in holes, pits and other depressions within the roadway area or construction site limits.

D. Related Work Specified Elsewhere (When Applicable):
1. Stripping and Stockpiling of Topsoil; Trench Excavation-Earth; Trench Excavation-Ledge; Borrow and Bedding Material; Trench Backfilling, Compaction, Control and Testing; Temporary Erosion Control and Dewatering are specified elsewhere in this division.

1.3 QUALITY ASSURANCE

A. Requirements of Regulatory Agencies:
   1. All work shall be performed and completed in accordance with all local, state or federal regulations.
   2. The General Contractor shall secure all necessary permits from, and furnish proof of acceptance by, the local and state departments having jurisdiction and shall pay for all such permits, except as specifically stated elsewhere in the Contract Documents.

B. Grade and Elevations:
   1. The Contractor shall establish the lines and grades in conformity with the Drawings and maintain same to properly perform the contract installation.

1.4 JOB CONDITIONS

A. Disposition of Utilities:
   1. The locations of utilities shown on the plans are approximate as determined from physical evidence on or above the surface of the ground and from information supplied by the utilities. The Engineer in no way warranties that these locations are correct. It shall be the responsibility of the Contractor to determine the actual locations of any utilities within the project area.
   2. Rules and regulations governing the respective utilities shall be observed in executing all work in this section. Active utilities shall be adequately protected from damage, and removed or relocated only as indicated or specified. Inactive and abandoned utilities encountered in excavation and grading operations shall be removed, plugged or capped. Report in writing to the Engineer, the locations of such abandoned utilities. Extreme care shall be taken when performing work in the vicinity of existing utility lines, utilizing hand excavation in such areas, as far as practicable. If, in the progress of excavation, any utility should become damaged and result in any damage to public or private property, the General Contractor shall restore to the original condition, at no additional cost to the Owner, anything which has been damaged or disturbed.

PART 2 – PRODUCTS

2.1 DEFINITIONS OF GRAVEL, SAND, AND SILT CLAY

A. The terms "gravel", "coarse sand," "fine sand" and "silt-clay," as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions, are defined as follows:
   1. Gravel - Material passing sieve with 75 mm (3-inch) square openings and retained on the 2.00 mm (No. 10) sieve.
   2. Coarse Sand - Material passing the 2.00 mm (No. 10) sieve and retained on the 0.425 mm (No. 40) sieve.
   3. Fine Sand - Material passing the 0.425 mm (No. 40) sieve and retained on the 0.075 mm (No. 200) sieve.
   4. Silt-Clay (Combined silt and clay) - Material passing the 0.075 mm (No. 200) sieve.
   5. Boulders (retained on 77 mm (3-inch) sieve) should be excluded from the portion of the sample to which the classification is applied, but the percentage of such material, if any, in the sample should be recorded.
   6. The term "silty" is applied to fine material having plasticity index of 10 or less and the term "clayey" is applied to fine material having plasticity index of 11 or greater.

2.2 SOIL MATERIALS

A. Use of Excavated Material:

1. To the extent they are needed, all suitable materials from the specified excavation may be used in the construction of required embankment and slope protective devices (riprap).
2. Surplus excavated materials suitable for filling operations shall be stockpiled for future use as directed by the Owner's. This specific location will be determined at the start of construction.
3. Unsuitable material shall consist of grubbings or other materials which contain rock of size exceeding specifications, organic materials, or other materials of a deleterious nature as deemed by the Engineer. Silts, clays and granular materials with more than 8% passing the number 200 sieve shall be considered unsuitable for embankment in the Frost Penetration Zone under paved areas when sufficient water supply is available to cause heaving.

B. Common borrow shall consist of approved material required for the construction of embankments or for other portions of the work as designated and shall be obtained from a source off-site, except as otherwise noted. Common borrow shall be free from frozen material, clay, perishable rubbish, peat, organic and other deleterious materials.

C. Gravel borrow shall be free of rocks with a maximum dimension over six inches, frozen material and other unsuitable material. That portion passing a three-inch square mesh sieve shall contain no more than 70% passing a 1/4 inch mesh sieve and not more than 10% passing a number 200 mesh sieve.

D. Rock fill shall consist of rock for use in embankments which consists of hard durable particles broken to various sizes that will form a compact embankment with a minimum of voids. It shall contain no particles or fragments with a maximum dimension in excess of the compacted thickness of the layer being placed.

E. Embankment material shall consist of suitable approved common excavation and/or common, or gravel borrow. Rock excavation may be used as embankment material if it is thoroughly mixed with common excavation and/or common borrow to eliminate voids.

F. Crushed stone shall consist of clean, angular rock with a blended size range of 3/8" to 1 1/2".

PART 3 - EXECUTION

3.1 SAFETY

A. Comply with applicable local, state or federal safety regulations or in the absence thereof, with the provisions of the Manual of Accident Prevention in Construction of the Associated General Contractors of America, Inc.

B. Provide shoring, sheeting and/or bracing at excavations as required to prevent cave-ins of excavation, and to assure complete safety of existing structures, utilities and pavements that are to remain in place.

C. Remove sheeting and shoring and bracing, as backfilling operations progress, taking all necessary precautions to prevent failure of excavation sides. Where sheeting is to be left in place, it shall not be within 2 feet of subgrade.

3.2 COMMON EXCAVATION

A. The Contractor shall excavate material encountered to establish required grade elevations.
   1. Unauthorized Excavation:

a. Unauthorized excavation consists of removal of materials beyond indicated subgrade elevations or dimensions without specific direction of the Engineer. Unauthorized excavation, as well as remedial work directed by the Engineer, shall be at the Contractor's expense.
b. The Contractor shall backfill and compact unauthorized excavations as specified for authorized excavations of the same classification, unless otherwise directed by the Engineer.

2. Additional Excavation:
   a. When excavation has reached required subgrade elevations, notify the Engineer who will make an inspection of conditions.
   b. If unsuitable bearing materials are encountered at the required subgrade elevations, carry excavations deeper and replace the excavated material as directed by the Engineer.
   c. Removal of unsuitable material and its replacement as directed will be paid on the basis of contract conditions relative to changes in work.

B. Common excavation areas shall be maintained in such condition that the excavation will be well drained.

C. Roadway excavation, in general, shall proceed in a direction upgrade. Subgrades shall be promptly rolled to prevent absorption of water.

3.3 EXCAVATION FOR UTILITY SERVICES

A. Water, telephone, data, fire alarm, storm drainage, electric services, utility structures, sanitary sewer piping, manholes, and catch basins will be installed under the work of the respective Sections.

3.4 MINIMUM LIMITS FOR EARTH EXCAVATION

A. Earth excavation must be carried to the following limits, unless otherwise indicated herein or on the drawings or authorized by the Engineer
   1. Subgrades for site work shall be as follows:
      a. Areas to receive topsoil - Four (4) inches below finish grades.
      b. Utility structures - Bottom of structure or as shown on the site details and eighteen (18) inches outside wall extremities.
      c. On-site bituminous concrete paved surfaces, as noted on the Drawings.
      d. Off-site paved areas, as noted on the Drawings.
      e. Unspecified site improvements - To bottom elevation of item plus ample working space on all sides.
   2. In non-specified areas - To the lines indicated on the Drawings plus proper side clearance for construction.

3.5 ROCK EXCAVATION

A. In open excavations material will be classified as rock only when the following conditions prevail:
   1. When the natural compound, natural mixture, and/or chemical element cannot be broken and removed from its existing position and state by a 3/4-yard backhoe or D8 dozer and requires the use of drills, or the use of explosives.
   2. Boulders or old concrete foundations in excess of 2 cubic yards.
   3. Anything other is "earth" insofar as removal of the material to be excavated is concerned.
   4. NOTE: When during the process of excavation, rock is encountered such material shall be uncovered and exposed, and the Engineer shall be notified by the Contractor, before proceeding further. The areas in question shall then be measured as stipulated in paragraph B, following. The Contractor shall not proceed with excavation of material

claimed as rock until the material has been classified by the Engineer. Should the Contractor proceed with the excavation without notifying the Engineer, or prior to the survey, he shall forfeit his right to extra payment in the subject area.

B. The Contractor will provide qualified personnel, acceptable to both the Owner and the Engineer, to take cross-sections of rock before removal of same, and to provide computations of cross-sections within the payline limits.

C. Excavate rock, encountered in grading areas within the contract, to depths as follows:
1. Under pavements and surfaced areas - To six inches below the required subgrade for such areas.
2. Under lawn areas - to two feet below finished grade, unless approved otherwise by the Engineer.

D. Blasting - Obtain written permission and approval of method from the local authorities before proceeding with rock excavation. Explosives shall be stored, handled, and employed in accordance with the provisions of the "Manual of Accident Prevention in Construction: of the Associated General Contractors of America, Inc.

3.6 COLD WEATHER PROTECTION

A. Protect excavations against freezing when atmospheric temperature is less than 35 degrees F.

3.7 COMPACTION

A. General: Control soil compaction during construction to the satisfaction of the Engineer and/or Resident Project Representative by providing compaction to at least the minimum percentage of maximum density as specified for each area classification.

B. Conform to the recommendations of the Owner’s geotechnical report.

C. Percentage of Maximum Density Requirements: Unless otherwise specified, compact soil to not less than the following percentages of maximum dry density for soils which exhibit a well-defined moisture density relationship (determined in accordance with ASTM D1557) and to not less than the following percentages of relative dry density (determined in accordance with ASTM D2049) for soils which do not exhibit a well- defined moisture density relationship.
1. Lawn or Vegetated Areas: Compact top 6 inches of subgrade and each layer of backfill or fill material to 90 percent maximum dry density as determined by AASHTO T-180, Method C or D.
2. Pavements: Compact top 12 inches of excavation subgrade and each layer of fill material to 95 percent maximum dry density as determined by AASHTO T-180, Method C or D.

D. Moisture Control: Where subgrade or a layer of soil material must be moisture conditioned before compaction, uniformly apply water to surface of subgrade or layer of soil material at a rate such that free water does not appear on surface during or subsequent to compaction operations.

E. Remove and replace, or scarify and air dry, soil material that is too wet to permit compaction to specified density.

F. Soil material that has been removed because it is too wet to permit compaction may be stockpiled or spread and allowed to dry.

3.8 EMBANKMENT

A. Compaction Equipment

1. Provide sufficient equipment units of suitable types to spread, level and compact fills promptly upon delivery of materials.
2. The Contractor may use any compaction equipment or device which he finds convenient or economical, but the Engineer retains the right to disapprove equipment which, in his opinion, is of inadequate capacity or unsuited to character of material being compacted.
3. The Contractor shall be responsible for the proper placement and compaction of backfill material. Any settlement that occurs shall be repaired by the Contractor at his own cost and expense. If pipeline and/or structures are damaged or displaced, they shall be repaired at the Contractor's expense.

B. Areas to be filled or backfilled shall be free of construction debris, refuse, compressible or decayable materials and standing water.

C. Notify the Engineer when excavations are ready for inspection. Filling and backfilling shall not be started until conditions have been approved by the Engineer.

D. Place acceptable soil materials in layers to required subgrade elevations, for each area classification listed below.
1. In excavations, use satisfactory excavated or borrow material.
2. Under grassed areas, use satisfactory excavated or borrow material.
3. Under pavements, use satisfactory excavated or borrow material or combination of both.

E. Grub areas a depth of 12" where fills are to be less than five feet in depth as shown on the Drawings.

F. When existing ground surface has a density less than that specified under "Compaction" for the particular area classification, break up the ground surface, pulverize, moisture-condition to the optimum moisture content, and compact to required depth and percentage of maximum density.

G. Placement and Compaction: Place fill materials in layers no thicker than 10 inches.

H. Compact each layer to required percentage of maximum dry density or relative dry density for each area classification.

I. Do not place backfill or fill material on surfaces that are muddy, frozen, or contain frost or ice.

J. Place backfill and fill materials evenly to required elevations adjacent to structures. Take care to prevent wedging action of fill against structures by carrying the material uniformly around structure to approximately the same elevation in each lift.

K. When water and sewer piping is laid in filled areas, place the fill before any pipe is placed, and compact as specified to a depth or not more than two feet above the proposed top of the pipe. A trench shall then be excavated to the required grade, and of sufficient width to permit thorough tamping of the fill under the bells and around the pipe.

L. At the end of each day’s work the embankment shall be shaped and rolled to minimize infiltration of water.

3.9 GRADING

A. General: Uniformly grade areas within limits of construction. Smooth finished surface within specified tolerances.
1. Lawn or Unpaved Areas: Finish areas to receive topsoil to within not more than 0.10 feet above or below the required subgrade elevations.

2. 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 the required subgrade elevation.

3.10 MAINTENANCE

A. Protection of Graded Areas: Protect newly graded areas from traffic and erosion. Keep free of trash and debris.

B. Repair and re-establish grades to specified tolerances in settled, eroded or rutted areas.

C. Reconditioning Compacted Areas: Where completed compacted areas are disturbed by subsequent construction operations or adverse weather, reshape, and compact to required density prior to further construction.

3.11 DISPOSAL OF EXCESS AND WASTE MATERIALS

A. Removal from Owner's Property: Remove waste materials, including unacceptable excavated material, trash and debris, and dispose of it off the Owner's property. This provision does not apply to stockpiled topsoil which shall remain on site unless written authorization for its removal is provided by the Engineer.

END OF SECTION 31 23 16

SECTION 31 23 16.13
TRENCHING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
1. Trench excavation work in earth includes the removal of sand, gravel, existing sewers and manholes, ashes, loam, clay, swamp muck, trolley tracks, soft or disintegrated rock or hard pan which can be removed with a backhoe, or a combination of such materials, and boulders measuring less than one cubic yard for the installation of pipes and appurtenant structures.
2. All trench excavation shall be classed as earth or ledge.

B. Related Work - Specified Elsewhere:
1. Traffic regulation and pedestrian protection is specified in the appropriate division.
2. Clearing, removal and replacement of paving, trench excavation ledge, borrow and bedding, material, manholes, and catch basins, trench backfilling, compaction, control and testing, when applicable, are specified in the appropriate sections in this division.
3. Pipe and pipe fittings, valves, gates, and hydrants, when applicable, are specified the applicable sections.

1.2 JOB CONDITIONS

A. Utilities:
l. The locations of utilities shown on the plans are approximate as determined from physical evidence on or above the surface of the ground and from information supplied by the utilities. The Engineer in no way warranties that these locations are correct. It shall be the responsibility of the Contractor to determine the actual locations of any utilities within the project area.
2. Rules and regulations governing the respective utilities shall be observed in executing all work in this section. Active utilities shall be adequately protected from damage, and removed or relocated only as indicated or specified. Inactive and abandoned utilities encountered in excavation and grading operations shall be removed, plugged or capped only with written authorization from the Utility Company. Report in writing to the Engineer, the locations of such abandoned utilities. Extreme care shall be taken when performing work in the vicinity of existing utility lines, utilizing hand excavation in such areas, as far as practicable. If, in the progress of excavation, any utility should become damaged and result in any damage to public or private property, the General Contractor shall restore to the original condition, at no additional cost to the Owner, anything which has been damaged or disturbed.

B. Existing Structures:
l. Perform excavation in such a manner that will prevent any possibility of undermining and disturbing the foundations of any existing structures and any work previously completed under this Contract.
2. Where existing buildings and other structures are in proximity to the proposed construction, exercise extreme caution and utilize sheeting, bracing, and whatever other precautionary measures, that may be required.

C. Repairing Damage:
1. Repair, or have repaired, all damage to existing utilities, structures, lawns, other public and private property which results from construction operations, at no additional expense

to the Owner, to the complete satisfaction of the Engineer, the utility company, the property owners and the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. The Contractor shall not have any right of property in any suitable materials taken from any excavation. Do not remove any such materials from the construction site without the approval of the Engineer. This provision shall in no way relieve the Contractor of his obligations to remove and dispose of any material determined by the Engineer to be unsuitable for backfilling.

B. Unsuitable Material:
1. If, in the opinion of the Engineer, the material encountered above the indicated grade, shown on the Drawings, for excavation is unsuitable material, remove the material to the widths and depths as directed by the Engineer. Replace this material as specified in the "Trench Backfilling, Compaction, Control and Testing" section of this division.
2. If, in the opinion of the Engineer, the material encountered at or below the grade shown on the Drawings for excavation is unstable material, remove the material to the full width of the trench and to a minimum depth of twelve inches below the pipe. Replace this material with thoroughly compacted suitably screened gravel bedding material.
3. All excavated materials designated by the Engineer as unsuitable shall become the property of the Contractor and disposed of at locations acceptable to or designated by the Owner, at no additional cost to the Owner.

C. Embankment Material:
1. Obtain prior approval and instructions from the Engineer prior to undertaking the excavation for pipe placement of any fill material that has been in an embankment less than one year.

PART 3 - EXECUTION

3.1 PERFORMANCE

A. General:
1. Unless otherwise specifically directed or permitted by the Engineer, begin excavation at the low end of sewer and storm lines and proceed upgrade.
2. Perform excavation for force mains and water mains in a logical sequence.

B. Amount of Excavation:
1. Trench width: As shown on the Drawings.
2. Trench depth: As shown on the Drawings.
3. Open Excavation:
   a. The extent of open excavation shall be controlled by prevailing conditions.
   b. Open excavation shall, at all times, be confined to the limits prescribed by the Engineer.
   c. No trenches shall be left open during non-working hours unless adequate provisions are made to prevent injury to the work or persons. Appropriate barricades and warning devices shall be used to alert the public of hazardous areas.
4. Unauthorized Excavation:
   a. Backfill to the specified grade, any excavation beyond the limits stated above and as shown on the Drawings (unless specifically ordered by the Engineer) with thoroughly compacted gravel borrow or screened gravel.

b. Backfilling unauthorized excavation shall be at no additional cost to the Owner.

C. Shoring and Bracing:
1. As the excavation progresses, install such shoring and bracing necessary to prevent caving and sliding and to meet the requirements of the state and OSHA safety standards.

END OF SECTION 31 23 16.13

SECTION 31 25 13
EROSION CONTROLS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. The work under this section shall include provision of all labor, equipment, materials and maintenance of temporary erosion control devices as specified herein, as shown on the Drawings and as directed by the Engineer.
   2. Erosion control measures shall be provided as necessary to correct conditions that develop prior to the completion of permanent erosion control devices or as required to control erosion that occurs during normal construction operations.
   3. Construction operations shall comply with all federal, state and local regulations pertaining to erosion control.
   4. After award of the Contract, prior to commencement of construction activities, meet with the Engineer to discuss erosion control requirements and develop a mutual understanding relative to details of erosion control.

B. Related Work Specified Elsewhere:
   1. Site work is specified in appropriate sections of this Division.
   2. Provisions stipulated in Environmental Protection.

C. Design Criteria:
   1. Conduct all construction in a manner and sequence that causes the least practical disturbance of the physical environment. Protect existing vegetation designated to remain.
   2. Stabilize disturbed earth surfaces in the shortest time and employ such temporary erosion control devices as may be necessary until such time as adequate soil stabilization has been achieved.

1.2 SUBMITTALS

A. The Contractor shall furnish the Engineer, in writing, his work plan giving proposed locations for storage of topsoil and excavated material before beginning construction. A schedule of work shall accompany the work plan. Acceptance of this plan will not relieve the Contractor of the responsibility of completion of the work as specified.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Baled Hay:
   1. At least 14" by 18" by 30" securely tied to form a firm bale, staked as necessary.

B. Sand Bags:
   1. Heavy cloth bags of approximately one cubic foot capacity filled with sand or gravel.

C. Mulches:
   1. Loose hay, straw, peat moss, wood chips, bark mulch, crushed stone, wood excelsior, or wood fiber cellulose. Provide specified item by type and use as and where specified.
   2. Type and use shall be as specified by the "Maine Erosion and Sedimentation Control Handbook for Construction - Best Management Practices" prepared by the Maine DEP and the Soil and Water Conservation Commission herein after referred to as the BMP.

D. Mats and Nettings:
   1. Twisted Craft paper, yarn, jute, excelsior wood fiber mats, glass fiber and plastic film.
   2. Type and use shall be as specified on the plan and consistent with the BMP manual.

E. Permanent Seed:
   1. Conservation mix appropriate to the predominant soil conditions as specified in the BMP and subject to approval by the Engineer.

F. Temporary Seeding:
   1. Use species appropriate for soil conditions and season as specified in the BMP and subject to approval by the Engineer.

H. Water:
   1. The Contractor shall provide water and equipment to control dust, as directed by the Engineer.

I. Filter Fabrics:
   1. Filter fabric shall be of one of the commercially available brands such as Mirafi, Typar or equivalent. Fabric types for particular applications shall be approved by the Engineer prior to installation.

J. Silt Fence:
   1. Consistent with BMPs.

K. Bark Mulch Berm:
   1. Consistent with BMPs.

L. Stone Check Dam:
   1. Consistent with BMPs.

2.2 CONSTRUCTION REQUIREMENTS

A. Temporary Erosion Checks:
   1. Temporary erosion checks shall be constructed in ditches and other locations as necessary. Stones shall be used for check dams as specified.
   2. Baled hay or sediment barrier may be used to fit local conditions.

B. Temporary Berms:
   1. Temporary barriers shall be constructed along the toe of embankments when necessary to prevent erosion and sedimentation.

C. Temporary Seeding:
   1. Areas to remain exposed for a time exceeding 15 days shall receive temporary seeding as depicted on the plans. In the absence of a plan callout, temporary seeding shall be conducted per the current Maine Erosion and Sediment Control Best Management Practices (BMPs) Manual for Designers and Engineers.

D. Construct silt fence in accordance with details provided prior to soil disturbance.

E. Mulch All Areas Receiving Seeding as depicted on the plans. In the absence of a plan callout, temporary seeding shall be conducted per the current Maine Erosion and Sediment Control Best Management Practices (BMPs) Manual for Designers and Engineers.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Temporary Erosion Checks:
   1. Temporary erosion checks shall be constructed in ditches and at other locations designated by the Engineer. The Engineer may modify the Contractor's arrangement of silt fences, bales and bags to fit local conditions.
   2. Baled hay, silt fences, or sandbags, or some combination, may be used in other areas as necessary to inhibit soil erosion.
   3. Siltation fence, if called for in the plans, shall be located and installed as shown.
   4. Sedimentation ponds shall be sited and constructed to the grades and dimensions as shown on the Drawings and will include drainage pipe and an emergency spillway.

B. Maintenance: Erosion control features shall be installed prior to excavation wherever appropriate. Temporary erosion control features shall remain in place and shall be maintained until a satisfactory growth of grass is established. The Contractor shall be responsible for maintaining erosion control features throughout the life of the construction contract. Maintenance will include periodic inspections by the Owner or Engineer for effectiveness of location, installation and condition with corrective action taken by the Contractor as appropriate.

C. Removing and Disposing of Materials:
   1. When no longer needed, material and devices for temporary erosion control shall be removed and disposed of as approved by the Engineer.
   2. When removed, such devices may be reused in other locations provided they are in good condition and suitable to perform the erosion control for which they are intended.

END OF SECTION 31 25 13

SECTION 31 32 19.23
GEOTEXTILE LAYER SEPARATION

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. Furnish all materials and install filter fabric of the types, dimensions and in the location(s) shown on the Drawings and specified herein.

B. Related Work Specified Elsewhere:
   1. Temporary Erosion Control, Riprap and Stone Ditch Protection, and Gabions and Revet Mattresses are specified in the appropriate sections of this Division.

1.2 QUALITY ASSURANCE

A. A competent laboratory must be maintained by the manufacturer of the fabric at the point of manufacture to insure quality control.

B. During all periods of shipment and storage, the fabric shall be wrapped in a heavy duty protective covering to protect the fabric from direct sunlight, ultraviolet rays, temperatures greater than 140^{o}F, mud, dirt, dust and debris.

1.3 SUBMITTALS

A. Manufacturer shall furnish certified test reports with each shipment of material attesting that the fabric meets the requirements of this Specification.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Filter fabric for use in stabilization, drainage, underdrains, erosion control, landscaping and beneath structures shall be formed in widths of not less than six (6) feet and shall be as specified on the plans. In the absence of a plan callout, fabric shall meet the requirements of Table 1. Both woven and non-woven geotextiles are acceptable; however no "slit-tape" woven fabrics will be permitted for drainage, underdrain, and erosion control applications.

Table 1 - Geotextile Minimum

Mechanical Property	Test Method	Permissible Value
Grab Tensile Strength (both directions)	ASTM D4632	120 pounds
Grab Elongation	ASTM D4632-86	50 percent
CBR Puncture Strength	ASTM D6241	310 pounds
Trapezoid Tear Strength	ASTM D4533-85	60 pounds
Water Flow Rate	ASTM D4491-85	135 gal/min/sf
Equivalent Opening Size	ASTM D4751	80 (EOS)
Coefficient of Permeability	ASTM D4491-85	0.2 cm/sec
UV Resistance	ASTM D4355	70% Strength Retained

The geotextile shall have property values expressed in "typical" values that meet or exceed the values stated above as determined by the most recent test methods specified above.

B. Filter fabric for use in reinforcement and under riprap shall be as specified on the plans. In the absence of a plan callout, fabric shall meet the requirements of Table 2. Woven and non-woven geotextiles are acceptable.

Table 2 - Geotextile Minimum

Mechanical Property	Test Method	Permissible Value
Grab Tensile Strength (both directions)	ASTM D4632	200 pounds
Grab Elongation	ASTM D4632-86	15 percent
CBR Puncture Strength	ASTM D3787	700 pounds
Trapezoid Tear Strength	ASTM D6431	75 pounds
UV Resistance	ASTM D4355	70% Strength Retained
Equivalent Opening Size	ASTM D4751	between #20 and #100 (EOS) U.S. Std. Sieve number(s)

The geotextile shall meet or exceed the "typical" values stated above as determined by the most recent test methods specified above.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install filter fabric as shown on the drawings or as directed in appropriate specifications in this division or in accordance with manufacturer's instructions or as directed by the Engineer.

END OF SECTION 31 32 19.23

SECTION 31 37 00
RIPRAP

PART 1 - GENERAL

1.1 DESCRIPTION

A. This work consists of furnishing all plant, labor, equipment, and materials and performing all work necessary to place a protective covering of erosion-resistant material on the slopes of embankments, edges of pavement, inlets, slopes of channels, or as directed by the Engineer. The work shall be done in accordance with these Specifications and in conformity with the lines and grades shown on the Drawings or established by the Engineer.

B. Types of riprap included in this specification:
   1. Dumped Riprap - Dumped riprap consists of stone dumped in place on a prepared slope of either a filter blanket or a filter fabric backing to form a well-graded mass with a minimum of voids.
   2. Filter Blanket - A filter blanket consists of one (1) or more layers of graded material placed on the bank before placing the riprap in order to prevent the bank material from passing through the riprap protection. The thickness and gradation of filter blanket will be shown on the plans.
   3. Filter Fabric Backing - A filter fabric backing consists of a filter fabric overlain by a layer of coarse aggregate placed on the bank before placing the riprap to prevent the bank material from passing through the riprap protection. Filter fabric backing shall be used in lieu of a filter blanket where specifically called for on the plans or where approved by the Engineer.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Definition of the materials:
   1. Dumped Riprap:
      a. Stone used for dumped riprap shall be hard, durable, angular in shape; resistant to weathering and to water action; free from overburden, spoil, shale and organic material; and shall meet the gradation requirements for the class specified. Neither breadth nor thickness of a single stone should be less than one-third its length. Rounded stone or boulders shall not be accepted without written permission of the Engineer. Shale and stone with shale seams are not acceptable. The minimum weight of the stone shall be 155 pounds per cubic foot as computed by multiplying the specific gravity (bulksaturated-surface-dry basis, AASHTO Test T 85) times 62.4 pounds per cubic foot.
      b. Each load of riprap shall be reasonably well graded from the smallest to the maximum size specified. Stones smaller than the specified 10 percent size and spalls shall not be permitted in an amount exceeding 10 percent by weight of each load.
   2. Filter Blanket - The filter blanket shall consist of one (1) or more layers of screened gravel of the thickness as shown on the plans. The gradation of materials in the filter blanket shall be as shown on the Drawings. All material comprising the filter blanket shall be composed of tough, durable particles, reasonably free from thin, flat and elongated pieces, and shall contain no organic matter, nor soft friable particles in quantities excess of that approved by the Engineer.
   3. Filter Fabric Backing:
      a. Coarse Aggregate:

1) The coarse aggregate shall be composed of tough, durable particles, reasonably free from thin, flat, and elongated pieces, and shall contain no organic matter, nor soft friable particles in quantities excess of that approved by the Engineer.

b. Filter Fabric:

1) The filter fabric shall be formed in widths of not less than six (6) feet.

2) Manufacturer: Thrace-Linq 150EX or approved equal.

PART 3 - EXECUTION

3.1 CONSTRUCTION DETAILS

A. Slopes to be protected by riprap shall be free of brush, trees, stumps, and other objectionable material and be dressed to a smooth surface. All soft or spongy material shall be removed to the depth shown on the Drawings or as directed by the Engineer and replaced with approved material. Filled areas will be compacted thoroughly. A toe trench shall be dug and maintained until the riprap is placed.

1. Dumped Riprap
   a. Stone for riprap shall be placed on the prepared slope or area in a manner which will produce a reasonably well-graded mass of stone with the minimum practicable percentage of voids. The entire mass of stone shall be placed in conformance with the lines, grades, and thicknesses shown on the Drawings. Riprap shall be placed to its full course thickness in one operation and in such a manner as to avoid displacing the underlying material. Placing of riprap in layers, or by dumping into chutes, or by similar methods likely to cause segregation will not be permitted.
   b. The larger stones shall be well distributed and the entire mass of stone shall conform to the gradation specified on the Drawings. All material going into riprap protection shall be so placed and distributed so that there will be no large accumulations of either the larger or smaller sizes of stone.
   c. It is the intent of these Specifications to produce a compact riprap protection in which all sizes of material are placed in their proper proportions. Hand placing or rearranging of individual stones by mechanical equipment may be required to the extent necessary to secure the results specified.
   d. Unless otherwise authorized by the Engineer, the riprap protection shall be placed in conjunction with the construction of the embankment with only sufficient lag in construction of the riprap protection as may be necessary to allow for proper construction of the portion of the embankment protected and to prevent mixture of embankment and riprap. The riprap protection shall be maintained until accepted, and any material displaced by any cause shall be replaced.
   e. Riprap stone shall not be dropped from a height greater than one (1) foot onto the filter blanket.
2. Filter Blanket:
   a. A filter blanket shall be placed on the prepared slope or area to the full specified thickness using methods which will not cause segregation of particle sizes within the bedding. The surface of the finished layer should be reasonably even and free from mounds or windrows.
3. Filter Fabric Backing:
   a. A filter fabric shall be placed in the manner and at the locations shown in the Drawings or as directed by the Engineer. At the time of installation, fabric shall be rejected if it has defects, rips, holes, flaws, deterioration or damage incurred during manufacture, transportation or storage. The fabric shall be placed with the long dimension parallel to the centerline of the channel or shoreline unless otherwise directed by the Engineer, and shall be laid smooth and free of tension, stress, folds, wrinkles, or creases. The strips shall be placed to provide a minimum width of 36 inches of overlap for each joint. Overlap joints and seams shall be measured as a single layer

of cloth. Securing pins with washers shall be inserted through both strips of overlapped cloth at not greater than the following intervals along a line through the midpoint of the overlap.

Pin Spacing	Slope
2 feet	Steeper than 3:1
3 feet	3:1 to 4:1
5 feet	Flatter than 4:1

The fabric shall be turned down and buried two (2) feet at all exterior limits.

b. Additional pins regardless of location shall be installed as necessary to prevent any slippage of the filter fabric. The fabric shall be placed so that the upstream strip of fabric will overlap the downstream strip. Should the Engineer direct that the fabric be placed with the long dimension perpendicular to the centerline of the channel or shoreline, the lower strip of fabric shall overlap the next higher strip. Each securing pin shall be pushed through the fabric until the washer bears against the fabric and secures it firmly to the foundation. The fabric shall be protected at all times during construction from contamination by surface runoff and any fabric so contaminated shall be removed and replaced with uncontaminated fabric. Any damage to the fabric during its installation or during placement of riprap shall be replaced by the Contractor. The work shall be scheduled so that the filter blanket shall be covered with riprap as soon as possible following filter blanket placement. Any damage to the filter material during placement of riprap shall be corrected prior to proceeding with the work.
c. Securing pins for anchoring filter fabric shall be 3/16 inch steel bars, pointed at one end and fabricated with a head to retain a steel washer having an outside diameter of not less than 1.5 inches. The length of the pin shall not be less than 18 inches.
d. A layer of coarse aggregate shall be placed on the filter fabric to the full specified thickness using methods which will not cause segregation of particle sizes. The surface of the finished layer shall be reasonably even and free from mounds or windrows.

END OF SECTION 31 37 00

SECTION 32 05 23
CEMENT AND CONCRETE FOR EXTERIOR IMPROVEMENTS

PART 1 - GENERAL

1.1 SUMMARY

A. Section Includes:
1. Site work concrete
2. Integrally Colored Concrete
3. Curb, gutter, and combination curb and gutter
4. Pedestrian Pavement: Sidewalks and steps
5. Vehicular Pavement: Parking and loading areas, maintenance yards, and driveways
6. Equipment Pads: Transformers, propane tanks, irrigation field controllers

1.2 APPLICABLE PUBLICATIONS

A. Comply with references to extent specified in this section.

B. American Association of State Highway and Transportation Officials (AASHTO):
1. M31M/M31-15 - Deformed and Plain Carbon-Steel Bars for Concrete Reinforcement.
2. M55M/M55-09 - Steel Welded Wire Reinforcement, Plain, for Concrete, Single User.
3. M147-65 - Materials for Aggregate and Soil-Aggregate Subbase, Base, and Surface Courses.
4. M148-05 - Liquid Membrane-Forming Compounds for Curing Concrete.
5. M171-05 - Sheet Materials for Curing Concrete.
6. M182-05(2012) - Burlap Cloth Made from Jute or Kenaf and Cotton Mats.
7. M213-01(2010) - Preformed Expansion Joint Fillers for Concrete Paving and Structural Construction (Nonextruding and Resilient Bituminous Types).
8. M233-86 - Boiled Linseed Oil Mixture for Treatment of Portland Cement Concrete.
9. T99-15 - Moisture-Density Relations of Soils Using a 2.5-kg. (5.5-lb) Rammer and a 305-mm (12-in.) Drop.
10. T180-15 - Moisture-Density Relations of Soils Using a 4.54-kg (10-lb) Rammer and a 457-mm (18-in.) Drop.

C. American National Standards Institute (ANSI):
1. B101.3 - Wet DOCF of Common Hard Surface Floor Materials (Including Action and Limit Thresholds for Suitable Assessment of the Measured Values).

D. ASTM International (ASTM):
1. A775/A775M-16 - Epoxy-Coated Steel Reinforcing Bars.
2. C94/C94M-16 - Ready-Mixed Concrete.
3. C143/C143M-15a - Slump of Hydraulic Cement Concrete.
4. C979/C979M-16 - Pigments for Integrally Colored Concrete. //
5. C1116/C1116M-10a - Fiber-Reinforced Concrete.
6. D5893/D5893M-10 - Cold Applied, Single Component, Chemically Curing Silicone Joint Sealant for Portland Cement Concrete Pavements.
7. D6690-15 - Joint and Crack Sealants, Hot Applied, for Concrete and Asphalt Pavements.

1.3 SUBMITTALS

A. Submittal Drawings:
   1. Show size, configuration, and fabrication and installation details
   2. Show reinforcing
   3. Include jointing plan for concrete pavements, curbs and gutters

B. Manufacturers' Literature and Data:
   1. Description of each product
      a. Expansion joint filler
      b. Hot poured sealing compound
      c. Reinforcement
      d. Curing materials
   2. Installation instructions

C. Test Reports: Certify products comply with specifications.
   1. Job-mix formula.
   2. Select subbase materials.

D. Certificates: Certify products comply with specifications.
   1. Expansion joint filler.
   2. Reinforcement.
   3. Curing materials.
   4. Concrete protective coating.

E. Select subbase job-mix design: Report the following:
   1. Material sources.
   2. Gradation.
   3. Plasticity index.
   4. Liquid limit.
   5. Laboratory compaction curves indicating maximum density at optimum moisture content.

1.4 QUALITY ASSURANCE

A. Installer Qualifications:
   1. Regularly installs specified products.
   2. Installed specified products with satisfactory service on five similar installations.
      a. Project Experience List: Provide contact names and addresses for completed projects.

B. Preconstruction Testing:
   1. Engage independent testing laboratory to perform tests and submit reports.
      a. Deliver samples to laboratory in number and quantity required for testing.
   2. Concrete mix design.

1.5 DELIVERY

A. Deliver products in manufacturer's original sealed packaging.

B. Mark packaging, legibly. Indicate manufacturer's name or brand, type, color, and manufacture date.

C. Deliver steel reinforcement to prevent damage.

D. Before installation, return or dispose of products with damaged or opened packaging and distorted or damaged steel reinforcement.

E. Bulk Products: Deliver bulk products away from buildings, utilities, pavement, and existing turf and planted areas. Maintain dry bulk product storage away from contaminants.

1.6 STORAGE AND HANDLING

A. Store products indoors in dry, weathertight facility.

B. Protect products from damage during handling and construction operations.

1.7 FIELD CONDITIONS

A. Place concrete as specified under Article 3.4 E., for Cold Weather Placement and Article 3.4 D., for Hot Weather Placement of Section 03 30 53, SHORT FORM CAST-IN-PLACE CONCRETE.

1.8 WARRANTY

A. Construction Warranty: FAR clause 52.246-21, "Warranty of Construction."

PART 2 - PRODUCTS

2.1 CONCRETE

A. Concrete: Type C, air-entrained as specified in Section 03 30 53, SHORT FORM CAST-IN-PLACE CONCRETE, except as follows:

TYPE	MAXIMUM SLUMP*
Curb & Gutter	75 mm (3 inches)
Pedestrian Pavement	75 mm (3 inches)
Vehicular Pavement	50 mm (2 inches) (Machine Finished) 100 mm (4 inches) (Hand Finished)
Equipment Pad	75 to 100 mm (3 to 4 inches)
* For concrete to be vibrated: Slump as determined by ASTM C143/C143M. Tolerances as established by ASTM C94/C94M.	

2.2 REINFORCEMENT

A. Steel Reinforcement: Type, amount, and locations as shown on drawings and as specified.

B. Epoxy-Coated Steel Reinforcement: ASTM A775/A775M.

C. Welded Wire-Fabric: AASHTO M55M/M55.

D. Dowels: Plain steel bars complying with AASHTO M31M/M31.

E. Tie Bars: Deformed steel bars complying with AASHTO M31M/M31.

F. Fiber Reinforcement: Polypropylene fibers designed for use in concrete pavement, complying with ASTM C1116/C116M, Type III, 1/2 to 1 1/2 inches long. Include five (5) lbs. per one (1) cu. yd. of concrete in batch.

2.3 SELECT SUBBASE (WHERE REQUIRED)

A. Subbase: Select granular material composed of sand, sand-gravel, crushed stone, crushed or granulated slag, with or without soil binder, or combinations of these materials conforming to AASHTO M147, Grading E or F.
   1. Materials meeting other gradations than that noted will be acceptable whenever gradations are within tolerance of three to five percent, plus or minus, of single gradation established by job-mix formula.

B. Subbase Material: Compacted, dense-graded course, meeting specified density requirement.

2.4 FORMS

A. Forms: Metal or wood, straight and suitable in cross-section, depth, and strength to resist springing during depositing and consolidating of concrete.

B. Tolerance: 1/8 inch maximum variation from straight line in any 10 foot long section, in either a horizontal or vertical direction.

C. Wood Forms: Minimum two (2) inches thick (nominal), free from warp, twist, loose knots, splits, or other defects. Provide approved flexible or curved forms for forming radii.

2.5 CONCRETE CURING MATERIALS

A. Concrete Curing Materials: Comply with one of the following:
   1. Burlap: AASHTO M182, weighing 7 oz./sq. yd. dry.
   2. Impervious Sheeting: AASHTO M171.
      a. Polyethylene: Minimum 0.1 mm (4 mils) thick.
   3. Liquid Membrane Curing Compound: AASHTO M148 without paraffin or petroleum and approved by pigment manufacturer for use with colored concrete.

2.6 EXPANSION JOINT FILLERS

A. Expansion Joint Filler: AASHTO M213.

2.7 ACCESSORIES

A. Sealants:
   1. Concrete Paving Expansion Joints: ASTM D5893/D5893M, Type SL, single component, self-leveling, silicone joint sealant.
   2. Concrete Paving Joints: ASTM D6690, Type IV, hot-applied, single component joint sealant.

B. Concrete Protective Coating: AASHTO M233 linseed oil mixture.

2.8 PIGMENTS

A. Pigments: Pure, concentrated mineral pigments especially processed for mixing into concrete and complying with ASTM C979/C979M.

B. Packaging: Provide pigments in pre-measured Mix-Ready disintegrating bags for project site mixing.

2.9 CEMENT, SAND, AGGREGATES AND OTHER ADDITIVES

A. Cement, Sand and Aggregate Color: As required to match colors.

B. Provide silicon carbide or aluminum oxide grains as required to match colors.

2.10 PATTERN STAMPING TOOLS AND MATERIALS

A. Tools: Mat-type stamping tools. Pattern per City of Rockland.

B. Release Agent: As recommended by pattern tool manufacturer and compatible with integral pigments.

C. Release Film: 0.05 mm (2 mil) polyethylene sheet.

PART 3 - EXECUTION

3.1 PREPARATION

A. Examine and verify substrate suitability for product installation.

B. Protect existing construction and completed work from damage.

C. Prepare, construct, and finish subgrade as specified in the Contract Documents.

D. Maintain subgrade in smooth, compacted condition, complying with required section and established grade until succeeding operation has been accomplished.

3.2 SELECT SUBBASE (WHERE REQUIRED)

A. Mixing: Proportion select subbase by weight or by volume in quantities so final approved job-mixed formula gradation, liquid limit, and plasticity index requirements will be met after subbase course has been placed and compacted. Add water in approved quantities, measured by weight or volume, to produce uniform blend.

B. Placing:
   1. Place mixed material on prepared subgrade in uniform layer to required contour and grades, to eight (8) inches (maximum) loose depth that, when compacted, will produce layer of required thickness.
   2. When required compacted thickness exceeds six (6) inches, place subbase material in equal thickness layers. Remove unsatisfactory areas and replace with satisfactory mixture, or mix material in placement area.
   3. Adding thin layers of material to top layer in order to meet grade will not be permitted.

4. When subbase elevation is 1/2 inch or more below grade, excavate top layer and replace with new material to a minimum of three (3) inches compacted thickness.

C. Compaction:
1. Perform compaction with approved hand or mechanical equipment well suited to material being compacted.
2. Moisten or aerate material as required to provide moisture content that will readily facilitate obtaining specified compaction with equipment used.
3. Compact each subbase layer to minimum 95 percent or 100 percent of maximum density as specified by AASHTO T180 or AASHTO T99, respectively.

D. Tolerances:
1. Test completed subbase for grade and cross section with straight edge.
2. Surface Variation: Maximum 10 mm (3/8 inch) each layer.
3. Variation from Indicated Thickness: Maximum 13 mm (1/2 inch).

E. Protection:
1. Maintain finished subbase in smooth and compacted condition until concrete is placed.
2. When subsequent construction operations or adverse weather disturb approved compacted subbase, excavate and reconstruct subbase with new material meeting specified requirements, at no additional cost to Government.

3.3 SETTING FORMS

A. Form Substrate:
1. Compact form substrate to uniformly support forms along entire length at grade as shown on drawings.
2. Correct substrate imperfections or variations by cutting or filling and compacting.

B. Form Setting:
1. Set forms sufficiently in advance of concrete placement to permit performance and approval of operations required with and adjacent to form lines.
2. Set forms to indicated line and grade and use stakes, clamps, spreaders, and braces to prevent movement in any direction.
3. Tolerances: Conform to line and grade with 3 mm (1/8 inch) tolerance when checked with straightedge, with maximum 6 mm (1/4 inch) deviation from true line at any point.
4. Remove forms when removal will not damage concrete and when required for finishing.
5. Clean and oil forms before each use.

C. Land Surveyor: Establish and control alignment and form grade elevations // or concrete slipforming machine operations //.
1. Make necessary corrections to forms immediately before placing concrete.
2. When any form has been disturbed or any subgrade or subbase has become unstable, reset and recheck form before placing concrete.

3.4 PLACING REINFORCEMENT

A. Keep reinforcement free of dirt, oil, rust, scale or other substances preventing concrete bond.

B. Install reinforcement as shown on drawings.

C. Support and securely tie reinforcing steel to prevent displacement during concrete placement.

D. Obtain COR's approval of reinforcement placement before placing concrete.

E. Synthetic Fiber in Flatwork: Uniformly disperse in concrete mixture at 3 kg/cu. m (5 lbs./cu. yd.) minimum rate.

3.5 MIXING PIGMENTS

A. Mix pigments according to manufacturer's instructions. Mix until pigments are uniformly dispersed throughout mixture and bags disintegrated.

3.6 PLACING CONCRETE - GENERAL

A. Preparation:
   1. Remove debris and other foreign material from between forms.
   2. Uniformly moisten subgrade, base, or subbase without standing water.

B. Convey concrete from mixer to final location without segregation or loss of ingredients. Deposit concrete to minimize handling.

C. During placement, consolidate concrete by spading or vibrating to minimize voids, honeycomb, and rock pockets.
   1. Vibrate concrete against forms and along joints.
   2. Avoid excess vibration and handling causing segregation.

D. Place concrete continuously between joints without bulkheads.

E. Install construction joint whenever concrete placement is suspended for more than 30 minutes and at end of each day's work.

F. Workmen or construction equipment coated with foreign material will not be permitted to walk or operate in concrete during placement and finishing operations.

3.7 PLACING CONCRETE FOR CURB AND GUTTER, PEDESTRIAN PAVEMENTS, AND EQUIPMENT PADS

A. Place concrete in one layer conforming to cross section shown on drawings after consolidating and finishing.

B. Deposit concrete near joints without disturbing joints. Do not place concrete directly onto joint assemblies.

C. After concrete has been placed in forms, use a strike-off guided by side forms to bring surface to proper section to be compacted.

D. Consolidate concrete thoroughly by tamping and spading, or with approved mechanical finishing equipment.

E. Finish concrete surface to grade with wood or metal float.

F. Construct concrete pads and pavements with sufficient slope to drain, preventing standing water.

3.8 PLACING CONCRETE FOR VEHICULAR PAVEMENT

A. Deposit concrete into forms as close as possible to its final position.

B. Place concrete rapidly and continuously between construction joints.

C. Strike off concrete and thoroughly consolidate with finishing machine, vibrating screed, or by hand-finishing.

D. Finish surface to elevation and crown as shown on drawings.

E. Deposit concrete near joints without disturbing joints. Do not place directly onto joint assemblies. Do not place adjacent lanes/areas without COR's approval.

F. Curb-Forming Machines: Curb-forming machines for constructing // integral curbs // curbs // and gutter // will be approved based on trial use on project. If equipment produces unsatisfactory results, discontinue use and accomplish work by hand method construction as specified. Remove unsatisfactory work and reconstruct full length between regularly scheduled joints. Legally dispose of removed portions off project site.

3.9 CONCRETE FINISHING - GENERAL

A. Follow operation sequence below, unless otherwise indicated on drawings:
   1. Consolidating, floating, straight-edging, troweling, texturing, and joint edging.
   2. Maintain finishing equipment and tools in clean and approved condition.

3.10 CONCRETE FINISHING - CURB AND GUTTER

A. Gutter and Curb Top:
   1. Round edges of gutter and curb top with edging tool to 6 mm (1/4 inch) radius or as otherwise shown on drawings.
   2. Float surfaces and finish with smooth wood or metal float until true to grade and section and uniform texture.
   3. Finish surfaces longitudinally, while still wet, with bristle type brush.

B. Curb Face:
   1. Remove curb form and immediately rub curb face with wood or concrete rubbing block and water until blemishes, form marks, and tool marks have been removed.
   2. Brush curb face, while still wet, to match gutter and curb top.

C. Tolerances: Except at grade changes or curves, when tested with 3000 mm (10 foot) straightedge.
   1. Variation from Indicated Plane and Grade:
      a. Gutter: Maximum 3 mm (1/8 inch).
      b. Curb Top and Face: Maximum 6 mm (1/4 inch).

D. Replace curbs and gutters within joint boundary when curbs and gutters exceed specified tolerances.

E. Correct depressions causing standing water.

F. Visible surfaces and edges of finished free of blemishes, form marks, and tool marks, and uniform in color, shape, and appearance.

3.11 CONCRETE FINISHING PEDESTRIAN PAVEMENT

A. Sidewalks, Wheelchair Curb Ramps, Plaza Areas, Steps, etc:
   1. Finish concrete surfaces to grade and cross-section with metal float, troweled smooth and finished with a broom, moistened with clear water.
   2. Broom surfaces transverse to traffic direction.
   3. Carefully finish slab edges, including at formed joints, with edger with radius per Contract Documents.
   4. Unless otherwise indicated, edge transverse joints before brooming. Use brooming to eliminate flat surface produced by edger. Produce uniform corrugations, maximum 1/16 inch deep.
   5. Provide surface uniform in color and free of surface blemishes, form marks, and tool marks.
   6. Paving Tolerances:
      a. Variation from Indicated Plane: Maximum 3/16 inch in 10 feet.
      b. Variation from Indicated Thickness: Maximum 1/4 inch.
   7. Replace paving within joint boundary when paving exceeds specified tolerances.

B. Step Treads, Risers, and Sidewalls: Finish as specified for pedestrian pavement, except as follows:
   1. Remove riser forms sequentially, starting with top riser.
   2. Rub riser face with wood or concrete rubbing block and water. Remove blemishes, form marks, and tool marks. Use outside edger to round tread corner; use inside edger to finish corner at bottom of riser.
   3. Apply neat, uniform finish to treads, risers and sidewall.
      a. Risers and Sidewall: Brush finish.
   4. Treads: Stiff brush finish to provide slip-resistant surface complying with ANSI B101.3.
   5. Step Tolerance:
      a. Variation from Indicated Plane: Maximum 3/16 inch in 10 feet.

3.12 CONCRETE FINISHING - VEHICULAR PAVEMENT

A. Longitudinally float pavement surface with float minimum 10 feet long and 6 inches wide, properly stiffened to prevent flexing and warping. Operate float from foot bridges in sawing motion parallel to direction in which pavement is being laid from one side of pavement to the other, and advancing maximum half float length.

B. After longitudinal floating, but while concrete is still plastic, eliminate minor irregularities in pavement surfaces by metal floats, 5 feet long, and straightedges 10 feet long. Make the final finish and float entire pavement surface with straightedges.

C. Test surface trueness with 10 foot straightedge successively held parallel and at right angles to direction in which pavement is being laid and entire area, as required, to detect variations. Advance straightedge along pavement in successive stages of maximum one half straightedge length. Correct irregularities and refinish surface.

D. Pavement Tolerances:
   1. Variation from Indicated Plane: Maximum 1/4 inch in 10 feet tested parallel and perpendicular to traffic direction at maximum five (5) foot intervals.
   2. Variation from Indicted Thickness: Maximum 1/4 inch.

E. Finish pavement edges and joints with edging tool.

F. Broom finish concrete surface after bleed water dissipates and before concrete hardens with approved fiber broom, minimum 18 inches wide.
   1. Gently broom surface transverse to traffic direction from edge to edge.
      a. Use brooming to eliminate flat surface produced by edger.
      b. Produce uniform corrugations, maximum 1/8 inch deep.

G. Align finish surfaces where new and existing pavements abut.

3.13 CONCRETE FINISHING - EQUIPMENT PADS

A. Strike pad surface to elevation shown on drawings.

B. Provide smooth, dense float finish, free from depressions or irregularities.

C. Carefully finish pad edges with edger having radius as shown on drawings.

D. After removing forms, rub pad edge faces with wood or concrete rubbing block, removing blemishes, form marks, and tool marks and providing uniform color.

E. Pad Tolerances:
   1. Variation from Indicated Plane: Maximum 1/8 inch in 10 feet.

F. Correct irregularities when pads exceed specified tolerances.

3.14 SPECIAL FINISHES

A. Exposed Aggregate Finish:
   1. Prepare concrete base 3/8 to 1/2 inch lower than the finish grade.
   2. Evenly spread aggregate over concrete base surface and embed by use of hand float, straight edge, or darby.
   3. Apply concrete mix and mark off surface as indicated with surface joints at least 3/8 inch deep. Level off finish to a true surface and compact with wood float, working as little as possible so that coarse material will remain at the top. Before finish has set, treat top surface with cement retarding material. When body of concrete finish has set, remove retarded surface film by wire brushes and fine water spray to remove the mortar from the top of the colored aggregate. Continue washing and brushing until flush water runs clear and there is no noticeable cement film left on the aggregate.

B. Colored Concrete: Add integral color pigment to the concrete paving mix at the batch plant. Introduce sufficient quantities of carbon black and mineral oxide pigment to produce the color specified by the Owner.

3.15 JOINTS - GENERAL

A. Place joints, as depicted herein and where shown on drawings.
   1. Conform to details shown in the Contract Documents.
   2. Install joints perpendicular to finished concrete surface.

B. Make joints straight and continuous from edge to edge of pavement.

3.16 CONTRACTION JOINTS

A. Cut joints to depth as shown with grooving tool or jointer of radius as shown in the Contract Documents or by sawing with blade to produce required width and depth.

B. Construct joints in by inserting 1/8 inch steel plates conforming to cross sections.
   1. Keep plates in place until concrete holds its shape.

C. Finish joint edges with edging tool having radius as shown in the Contract Documents.

D. Score pedestrian pavement with standard grooving tool or jointer.

3.17 EXPANSION JOINTS

A. Form expansion joints with preformed expansion joint filler material of thickness shown on drawings.
   1. Without dowels, locate joints around perimeter of structures and features abutting site work concrete.
   2. Create complete, uniform separation between structure and site work concrete.

B. Extend expansion joint material full depth of concrete with top edge of joint filler below finished concrete surface where sealant is indicated on drawings.

C. Cut and shape material matching cross section.

D. Anchor with approved devices to prevent displacing during placing and finishing operations.

E. Round the edges of joints with an edging tool.

3.18 CONSTRUCTION JOINTS

A. Locate construction joints between slabs of pavement as shown on drawings.

B. Place transverse construction joints of type shown, where indicated, and whenever concrete placement is suspended for more than 30 minutes.

C. Provide butt-type joint with dowels if joint occurs at planned joint location.

D. Provide keyed joints with tiebars if joint occurs in middle third of typical joint interval.

3.19 FORM REMOVAL

A. Keep forms in place minimum 12 hours after concrete placement. Remove forms without damaging concrete.

B. Do not use bars or heavy tools against concrete to remove forms. Promptly repair damaged concrete found after form removal.

3.20 CONCRETE

A. Concrete Protection:
   1. Protect unhardened concrete from rain and flowing water.
   2. Ensure sufficient curing and protection materials are available and ready for use before concrete placement begins.
   3. Protect concrete to prevent pavement cracking from ambient temperature changes during curing period.
      a. Replace pavement damaged by curing method allowing concrete cracking.
      b. Employ another curing method as directed by COR.

B. Cure concrete for minimum seven (7) days by one of the following methods appropriate to weather conditions preventing moisture loss and rapid temperature change:
   1. Burlap Mat: Provide minimum two layers kept saturated with water during curing period. Overlap mats minimum of six (6) inches.
   2. Impervious Sheeting: Provide waterproof paper, polyethylene-coated burlap, or polyethylene sheeting.
      a. Wet exposed concrete surface with fine water spray and cover with sheet materials.
      b. Overlap sheets minimum 12 inches.
      c. Securely anchor sheet materials preventing displacement.

C. Liquid Membrane Curing Compound:
   1. Protect joints indicated to receive sealants preventing contamination from curing compound.
   2. Insert moistened paper or fiber rope into joint or cover joint with waterproof paper.
   3. Apply curing compound before concrete dries.
   4. Apply curing compound in two coats at right angles to each other.
   5. Application Rate: Maximum 200 sq. ft./gal., both coats.
   6. Immediately reapply curing compound to surfaces damaged during curing period.

3.21 CONCRETE PROTECTIVE COATING

A. Apply protective coating of linseed oil mixture to exposed-to-view concrete surfaces, drainage structures, and features that project through, into, or against concrete exterior improvements to protect the concrete against deicing materials.

B. Complete backfilling and curing operation before applying protective coating.

C. Dry and thoroughly clean concrete before each application.

D. Apply two coats, with maximum coverage of 50 sq. yds./gal. for first coat, and maximum 70 sq. yds./gal. for second coat, except apply commercially prepared mixture according to manufacturer's instructions.

E. Protect coated surfaces from vehicular and pedestrian traffic until dry.

F. Do not heat protective coating, and do not expose the protective coating to open flame, sparks, or fire adjacent to open containers or applicators. Do not apply material at temperatures lower than 50 degrees F (10 degrees C).

3.22 FIELD QUALITY CONTROL

A. Field Tests are to be performed by testing agency and protocol approved by COR.

3.23 CLEANING

A. After completing curing:
   1. Remove curing material, except liquid membrane.
   2. Sweep the concrete clean.
   3. Seal all joints after removing foreign matter from joint.
   4. Clean concrete of debris and construction equipment as soon as curing and joint sealing have been completed.

B. Remove and legally dispose of debris, rubbish, and excess material from project site.

3.24 PROTECTION

A. Protect exterior improvements from traffic and construction operations.
   1. Prohibit traffic on paving for minimum seven (7) days after placement, or longer as directed by the City of Rockland.

B. Remove protective materials immediately before acceptance.

C. Repair damage.
   1. When directed by the City of Rockland or the Engineer, replace concrete containing cracking, fractures, spalling, and other defects within joint boundary, at no additional cost to Owner.

END OF SECTION 32 05 23

SECTION 32 11 23
AGGREGATE BASE COURSES

PART 1 - GENERAL

1.1 DESCRIPTION

A. The aggregate base and subbase courses for use below pavement shall be composed of layers of aggregate of different gradations.

B. Related Work Specified Elsewhere (When Applicable):
   1. Excavation and Embankment, Bituminous Concrete Paving.

1.2 SUBMITTALS

A. Contractor shall certify that materials comply with the specification requirements by submitting either laboratory test results or certificates of compliance.

1.3 QUALITY ASSURANCE

A. Compact aggregate base and subbase course materials to a density of at least 95 percent of the maximum density as determined in accordance with ASTM D-1557, Method D.

B. Work shall be halted when the Engineer or Resident Project Representative is not satisfied with the apparent results of the Contractor's compaction operation. A testing laboratory acceptable to the Engineer shall then be obtained by the Owner to determine, by conducting density tests, if the Contractor is complying with these compaction specifications.
   1. If the test results fail to meet the requirements of these Specifications, the Contractor shall undertake whatever action is necessary, to obtain the required compaction. The cost of the testing service will be borne by the Contractor and no allowance will be considered for delays in the performance of the work.
   2. If the test results pass and meet the requirements of these Specifications, the direct invoice cost of the testing service will be borne by the Owner, but no allowance will be considered for delays in the performance of the work.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregate subbase course shall be gravel consisting of hard, durable particles which are free from vegetable matter, lumps or balls of clay and other deleterious substances. The gradation of the portion which will pass a three inch sieve shall meet the grading requirements of the following tables:

Table 1 - Gradation Requirements - Aggregate Subbase Course:

Sieve Designation	Furnish only when specified Percent by Weight Passing Square Mesh Sieve Type D
½"	35-80
¼"	25-65
No. 40	0-30
No. 200	0-7.0

B. Aggregate for base shall be screened or crushed gravel of hard durable particles free from vegetable matter, lumps or balls of clay and other deleterious substances. The gradation of the part that passes a 3" sieve shall meet the grading requirements of the following table:

Table 2 - Gradation Requirement - Aggregate Base Course

Sieve Designation	Percent by Weight Passing Square Mesh Sieves Type A (Crushed) Aggregate	Type B (Screened) Aggregate
1/2"	45-70	35-75
1/4"	30-55	25-60
No. 40	0-20	0-25
No. 200	0-6.0	0-6.0

C. Gradation tests shall conform to AASHTO Method T-27, except that the material may be separated on the 1/2" sieve. The subbase shall not contain particles of rock which will not pass the six (6) inch square mesh sieve. Type A aggregate for base shall not contain particles of rock which will not pass the two (2) inch square mesh. Type B aggregate for base shall not contain particles of rock which will not pass the four (4) inch sieve. Type C aggregate for base shall not contain particles of rock which will not pass the six (6) inch square mesh sieve.

PART 3 - EXECUTION

3.1 PLACING

A. The subbase course may be constructed full depth in two lifts provided compaction is achieved. Fine grading the lower layer will not be required.

B. Aggregate base course shall be placed full depth in one lift.

3.2 SHAPING AND COMPACTING

A. All layers of aggregate subbase course shall be compacted to the required density immediately after placing. As soon as the compaction of any layer has been completed, the next layer shall be placed.

B. The Contractor shall bear full responsibility for and make all necessary repairs to the base and subbase courses and the subgrade until the full depth of the base and subbase courses is placed and compacted. Repairs shall be considered incidental to other contract items and shall be made at no cost to the Owner.

C. If the top of any layer of the aggregate base or subbase course becomes contaminated by degradation of the aggregate or addition of foreign materials, the contaminated material shall be removed and replaced with the specified material at the Contractor's expense.

D. The top of any aggregate subbase course layer shall be scarified and loosened for a minimum depth of one inch immediately prior to the placing of the next layer of aggregate base course. This scarifying shall be considered incidental to placing the course, and no separate payment will be made.

3.3 SURFACE TOLERANCE

A. The completed surface of the aggregate base and subbase courses shall be shaped and maintained to a tolerance, above or below the required cross sectional shape, of 3/8” for aggregate base course and 1/2” for aggregate subbase.

END OF SECTION 32 11 23

SECTION 32 12 16
ASPHALT PAVING

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Asphaltic concrete paving and surface sealer; wearing binder or base course.

1.2 RELATED SECTIONS

A. Section 32 11 23 - Aggregate Base and Subbase.

B. Section 31 23 16 – Excavation and Trenching.

1.3 REFERENCES

A. MS-2 – Asphalt Mix Design Methods; The Asphalt Institute (AI).

B. MS-3 - Asphalt Plant Manual - The Asphalt Institute (AI).

C. MS-8 - Asphalt Paving Manual - The Asphalt Institute (AI).

D. MS-19 - Basic Asphalt Emulsion Manual, The Asphalt Institute (AI).

E. Maine Department of Transportation (MeDOT) Standard Specifications (November, 2014 Edition).

1.4 QUALITY ASSURANCE

A. Perform Work in accordance with AI Manual MS-8.

B. Mixing Plant: Conform to AI Manual MS-3.

C. Obtain materials from same source throughout.

1.5 ENVIRONMENTAL REQUIREMENTS

A. Do not place asphalt when base surface temperature is less than 40^{o}F, or surface is wet or frozen.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregate for Binder Course Mix: MeDOT 19 mm, unless otherwise noted.

B. Aggregate for Wearing Course Mix: MeDOT 12.5 mm, unless otherwise noted.

C. Fine Aggregate: In accordance with MeDOT standards.

2.2 ACCESSORIES

A. Tack Coat (if required): Homogeneous, medium curing, liquid asphalt. In accordance with MeDOT standards.

2.3 ASPHALT PAVING MIX

A. Binder Course: in accordance to MeDOT standard specifications.

B. Wearing Course: in accordance to MeDOT standard specifications.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that compacted aggregate base course is dry and ready to support paving and imposed loads.

B. Verify gradients and elevations of base are correct.

3.2 BASE

A. Section 32 11 23 - Aggregate Base Course forms the base construction for work of this Section.

3.3 PLACING ASPHALT PAVEMENT - DOUBLE COURSE

A. Place binder course to specified compacted thickness.

B. Place wearing course to specified compacted thickness.

C. Compact pavement by rolling. Do not displace or extrude pavement from position. Hand compact in areas inaccessible to rolling equipment.

D. Develop rolling with consecutive passes to achieve even and smooth finish, without roller marks.

3.4 TOLERANCES

A. Flatness: Maximum variation of 1/8” measured with 10’ straight edge.

B. Scheduled Compacted Thickness: Within 1/4”.

C. Variation from True Elevation: Within 1/8”.

3.5 PROTECTION

A. Prevent machinery from contracting finished pavement.

END OF SECTION 32 12 16

SECTION 32 16 13.33
ASPHALT CURBS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. This work shall consist of constructing a hot-mixed, hot-laid bituminous concrete curb on a completed bituminous surface and hand sealed in accordance with these Specifications and within reasonable close conformity to the lines and grades shown on the Drawings or established by the Engineer.

B. Related Work Specified Elsewhere:
   1. SECTION 32 12 16 Asphalt Concrete Paving.

1.2 QUALITY ASSURANCE

A. Use only materials which are furnished by a bulk bituminous concrete producer which is regularly engaged in production of hot-mix, hot laid bituminous concrete and approved for use by the MDOT.

1.3 SUBMITTALS

A. Certificates:
   1. Provide certificates in lieu of laboratory test reports.
   2. Certify that materials comply with Specification requirements.
   3. Signed by bituminous concrete producer and Contractor.

1.4 JOB CONDITIONS

A. Weather Limitations:
   1. Bituminous concrete curbs shall not be placed on a wet surface.
   2. Construct between the dates of May 1 and November 22, and then only when the air temperature in the shade is 40°F or above.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Aggregates:

   1. Coarse aggregate (retained on the No. 8 sieve):
      a. Crushed stone or crushed gravel.
      b. Clean tough durable fragments free from an excess of flat, elongated, soft or disintegrated pieces and free from stone coated with dirt or other objectionable matter.
      c. Deleterious particles shall not exceed eight percent.
      d. Fifty percent (50%) of crushed gravel used shall have at least one fractured face.

   2. Fine aggregate (passing the No. 8 sieve):
      a. Natural or prepared sand.

b. Hard, tough grains, free from injurious amounts of clay, loam or other deleterious substances.
c. Absorption as determined by AASHTO T 84-77 shall not exceed three percent by weight.

3. Gradation:

Sieve Designation	Percent by Weight Passing Square Mesh Sieves
3/4 inch	100
1/2 inch	85-100
No. 4	65-80
No. 8	50-65
No. 50	18-30
No. 200	5-15

B. Mineral Filler:
1. Shall meet the requirements of AASHTO 17-77 (Mineral Filler for Bituminous Paving Mixtures).

C. Bituminous Materials:
1. Asphalt cement shall be Type AC-20 and shall meet the requirements of AASHTO M 226-78 (Viscosity Graded Asphalt Cement).
2. Content as percent of mix shall be 6.0 - 9.0.

D. Bituminous Hand Sealing:
1. Shall meet the requirements of subsection 702.12 of the State of Maine Department of Transportation Standard Specifications Highways and Bridges, Latest Edition.
2. Shall be black.

PART 3 - EXECUTION

3.1 PERFORMANCE

A. Conditioning of the Existing Surface:
1. Thoroughly clean of all objectionable material.
2. Apply a light tack coat of 0.08 to 0.20 gallons per 15 linear feet of curb area.

B. Equipment:
1. Self propelled machine with a material hopper, distributing screw and adjustable curb forming devices capable of laying and compacting the bituminous mix to the lines, grades, and cross section as shown on the Drawings and in an even homogeneous manner free of honeycombs.

C. Placing:
1. Place mix at temperature between 275 - 325°F.
2. Regulate forward movement of machine to ensure adequate compaction.
3. Where conditions necessitate joints in curb, they shall be constructed to ensure bond between old and new sections of the curb. Prior to placing the new curb material, the old joint shall be tack coated.

C. Curing:
1. Protect from traffic until the heat of the mix has dissipated and the mix has obtained the proper hardness.

D. Sealing:
   1. Applied in two (2) coats:
      a. First coat diluted by up to 50 percent water and applied at a rate of 0.25 to 0.50 gallons per square yard.
      b. Second coat diluted only enough to make workable and applied at a rate of 0.25 to 0.50 gallons per square yard.

E. Backfilling:
   1. Backfill immediately after mix has obtained the proper degree of hardness.

END OF SECTION - 32 16 13.33

SECTION 32 17 23
PAVEMENT MARKINGS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. This work shall consist of providing final reflective pavement lines and markings after paving (paint).

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pavement Marking Paint:
   1. Ready-mixed white and yellow traffic paint shall conform to the requirements of AASHTO M248-74, Type N or F.

PART 3 - EXECUTION

3.1 GENERAL

A. The Contractor shall apply all pavement markings in accordance with the latest edition of the Manual on Uniform Traffic Control Devices and within temperature and ambient conditions approved by the manufacturer.

B. Lines shall be provided as shown on the plans or directed by the Engineer.

3.3 PREPARATION OF SURFACE FOR PAVEMENT MARKING PAINT

A. The Contractor shall, immediately before applying pavement marking paint, ensure that the existing surface is dry and free from dirt, grease, oil or other foreign matter.

3.4 APPLICATION OF PAVEMENT MARKING PAINT

A. Paint shall be applied with a minimum wet thickness of 15 mm.

END OF SECTION 32 17 23

SECTION 32 32 23
SEGMENTAL BLOCK RETAINING WALL

PART 1 – GENERAL

1.1 DESCRIPTION

A. Work includes designing, furnishing and installing segmental block retaining wall units to the lines and grades shown on the Drawings, as specified in the Shop Drawings and supplemental specifications. Also included are furnishing and installing appurtenant materials required for construction of the complete wall system.

B. The Contractor is solely responsible for safety. The Engineer and Owner shall not be responsible for means or methods of construction or for safety of workers or of the public.

1.2 REFERENCES

A. ASTM C1372 - Standard Specifications for Segmental Retaining Wall Units

B. ASTM C136 - Standard Test Method for Sieve Analysis of Fine and Coarse Aggregate

C. ASTM D4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils

D. ASTM D698 - Standard Test Method for Laboratory Compaction Characteristics of Soil Using Standard Effort

E. ASTM D4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method

F. ASTM D5262 - Standard Test Method for Evaluating the Unconfined Creep Behavior of Geosynthetics

G. ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

H. ASTM D6638 - Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)

I. NCMA Test Method SRWU-2 - Determination of Shear Strength Between Segmental Concrete Units

J. NCMA - "Design Manual for Segmental Retaining Walls"

1.3 SUBMITTALS

A. A complete wall design for the height, location, loading and site conditions depicted on the Drawings is required. Submit for review two (2) sets of Shop Drawings for the retaining wall system prepared by a qualified Professional Engineer registered in the state of Maine. The Shop Drawings shall indicate the design parameters, layout, height, and geogrid reinforcement (if any) of the retaining wall system. Upon request, design calculations shall also be submitted.

B. If colored or architectural units are to be used in the project, a representative sample shall be reviewed for approval by the Architect, Engineer or Owner.

C. If geogrid reinforcement is required by the Shop Drawings, submit supplemental specifications, manufacturer's literature, and test data for geogrids to be used in the wall system. Test data shall include connection strength data for segmental units and geogrids to be used, determined in accordance with ASTM D6638, as well as geogrid tensile strength and creep data in accordance with ASTM D4595 and ASTM D5262.

D. Submit grain size test results in accordance with ASTM C136 for aggregates to be used for the wall base, for unit fill, and for select reinforced fill (if any).

E. Submit test results on borrow soil to be used for backfill and for the reinforced fill (if allowed) including Atterberg limits and Proctor by ASTM D4318 and ASTM D698.

1.4 DELIVERY, STORAGE, and HANDLING

A. Contractor shall check the materials upon delivery to assure that proper materials have been received.

B. Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the wall or the reinforced soil embankments.

C. Contractor shall prevent excessive mud, concrete, adhesives and other substances that may adhere from coming in contact with the materials.

D. Exposed faces of segmental units shall be free of chips, cracks, or stains.

PART 2 – MATERIALS

2.1 WALL UNITS

A. Segmental wall units shall be precast concrete elements made from Portland cement, water and aggregate. Product shall be a regularly available product by a company, vendor, and/or fabricator that has been in existence for more than 10 years. The Contractor shall furnish a design prepared by a qualified Professional Engineer registered in the state of Maine for the specified design and site conditions.

B. Units shall be manufactured in accordance with ASTM C1372.

C. Reinforcing grid shall be a compatible design component and integral with the block design.

D. Backfill zone material shall be installed in accordance to the design and Shop Drawings.

E. Appurtenant components, caps, end units, steps, etc. shall be designed, furnished and configured by the same manufacturer for a complete installation.

2.2 PRODUCT

A. Acceptable product:
   1. **Keystone Standard Straight Split**

2.3 DRAINAGE

A. Internal and external drainage shall be evaluated by the Professional Engineer who is responsible for the final wall design. Piping locations and sizes noted in the Shop Drawings are a minimum.

2.2 GEOGRID

A. If geogrid reinforcement is required, it shall be installed in accordance with the Shop Drawings or as detailed in the supplemental specificaitons. Substitution of a different type of geogrid shall not be allowed unless approved by the Professional Engineer who is responsible for the final wall design.

2.3 WALL BASE/LEVELING PAD

A. The wall base and leveling pad shall be constructed in accordance to the design, Shop Drawings and supplemental specifications to the lines and elevations depicted on the Drawings.

B. Where additional fill is needed, Contractor shall submit sample and specifications to the Engineer for approval.

2.4 UNIT FILL

A. Unit fill shall be a clean coarse aggregate with high angularity. The unit fill shall be screened 100 percent crushed aggregate meeting the following gradation:

US Standard Sieve Size	Percent Passing
1-1/2"	100
3/4"	60-100
#4	0-40
#200	0-5

2.5 BACKFILL

A. Backfill material shall be selected and specified as suitable with the specified block, anticipated loading condition, and selected geogrid type, placement, and embedment length by the vendor's designer.

B. All other backfill behind and in front of the wall shall consist of suitable on-site soil or imported borrow approved by the Geotechnical Engineer. Backfill shall generally consist of sands, silts, or lean clays with a liquid limit less than 45 and a plasticity index less than 20. Fat clay soils, cobbles, and large rock should generally be avoided unless approved by the Geotechnical Engineer based on local conditions. Frozen soils, excessively wet or dry soils, debris, and deleterious materials should not be used.

2.6 PERFORATED DRAIN PIPE

A. Drain pipe shall be used unless specifically excluded on the design plans. The drain pipe should be perforated or slotted PVC or corrugated HDPE pipe corresponding to the standards for underdrain. The drain should be connected to storm drains or daylighted at low points and periodically along the wall alignment.

2.7 GEOTEXTILE FABRIC

A. Contractor is to provide and install geotextile fabric in accordance with and as indicated on the Drawings or Shop Drawings.

2.8 GUARD RAIL, HAND RAIL AND FALL PROTECTION

A. If shown on the Drawings or Shop Drawings, the Contractor shall integrate the wall design, provide and install guardrail, handrail, and/or fall protection as necessary.

PART 3 – EXECUTION

3.1 EXCAVATION

A. Excavate as required for installation of the wall system.

B. Slope or shore excavation as necessary for safety and for conformance with applicable OSHA requirements.

3.2 WALL BASE

A. Foundation soils shall be excavated to the dimensions shown on the Drawings and Shop Drawings. Foundation soil shall be observed and reported to the Professional Engineer responsible for the final wall design to confirm the bearing soils are similar to the design conditions or assumptions.

B. Construct the wall base to the lines and grades shown on the Drawings and Shop Drawings. Place granular base material to the minimum dimensions shown. Overexcavated areas shall be filled with additional granular base material. Compact the base to provide a hard and level surface to support the wall units. Base material shall be compacted to a minimum of 95 percent of the maximum dry density (ASTM D698, Standard Proctor).

C. Prepare and smooth the granular material to ensure complete contact of the first course with the base.

3.3 GEOGRID

A. Place Geogrid in the specified lengths and at the specified depths, following manufacturer's instructions. Compact all backfill material in lifts between grid layers.

3.4 UNIT INSTALLATION

A. Place the first course of units directly on the wall base. Check units for level and alignment. Adjacent units should be in contact. If possible, begin placing units at the lowest section of the wall.

B. Fill all voids between and within the blocks with granular unit fill. The unit fill shall extend a minimum of six (6) inches behind the tails of the facing units unless a geotextile filter is placed on the back of the blocks.

C. Place backfill behind the units in maximum loose lifts of eight (8) inches and compact. If select granular fill is required, it should extend the full length of the geogrid reinforcement. Compact all fill to a minimum of 95 percent of the maximum dry density (ASTM D698, Standard Proctor). For cohesive soils, the moisture content at the time of compaction should be adjusted to within -3 and +4 percent of optimum. Place backfill in successive lifts until level with the top of the facing unit.

D. Remove all excess aggregate and other materials from the top of the units before laying up the next course.

E. For geogrid reinforced walls, place the correct geogrid at the locations and elevations shown on the Drawings or Shop Drawings per manufacturer's recommendations.

F. Provide temporary swales to divert runoff away from wall excavation and away from face.

G. Install guardrail, handrail, and fall protection per manufacturer's instructions.

H. Final grade above and below the retaining wall shall provide for positive drainage and prevent ponding. Protect completed wall from other construction. Do not operate large equipment or store materials above the wall that exceed the design surcharge loads.

END OF SECTION 32 32 23

SECTION 32 90 00
LANDSCAPE FINISHES

PART 1 - GENERAL

1.1 RELATED DOCUMENTS

A. Drawings and general provisions of Contract including General and Supplementary Conditions and Division 1 specification sections, apply to Work of this section.

1.2 SECTION INCLUDES

A. Restoration of disturbed areas with new or preserved plant material to replace removed, damaged, and dead plant material from within the work area. Work includes inventory and assessment of trees, shrubs, and flowering plants to be preserved or replaced, preparation of soil, placement of plant life, seed, sod, and fertilizer, mulching, watering, maintenance and warranty work.

1.3 QUALITY CONTROL

A. Nursery: Company specializing in growing and cultivating the plant life specified in this Section.

B. Sod Producer: Company specializing in sod production & harvesting; certified by the State of Maine.

C. Plant Materials: Comply with recommendations of ANSI Z60.1.

D. Maintenance Services: Performed by installer.

1.4 WARRANTY

A. Provide one year warranty, including one continuous growing season, under provisions of Section 01 00 00 including coverage of plants from death or unhealthy conditions.

B. Replacements: Plants of same size and species as specified, planted in the next growing season, with a new warranty beginning on date of replacement.

1.5 MAINTENANCE SERVICE

A. Maintain seeded areas or sodded areas and plant life immediately after placement until grass and plants are well established and exhibit a vigorous growing condition for two cuttings.

PART 2 – PRODUCTS

2.1 GRASS

A. Seed Mixture: As enumerated

B. Sod: ASPA Certified Nursery grown; cultivated grass sod; with strong fibrous root system.

C. Machine cut sod with minimum 1/2” and maximum 1” topsoil base.

2.2 TREES, PLANTS, AND GROUND COVER

A. Trees Plants and Ground Cover: Species and size as indicated by observing and collecting inventory of existing plants within work area, and replacement sizes as recommended by horticultural vendor, grown in climatic conditions similar to those in locality of the Work.

B. Provide balled and burlapped trees and shrubs.

2.3 SOIL AND SOIL MODIFICATION MATERIALS

A. Topsoil: Fertile, agricultural soil, typical for locality, capable of sustaining vigorous plant growth, free of subsoil, clay or impurities, plants, weeds and roots.

B. Fertilizer: Fifty percent of the elements derived from organic sources, to the following proportions: Nitrogen 5 percent, phosphoric acid 10 percent, soluble potash 5 percent.

2.4 FINISH MATERIALS

A. Wood Pegs: Softwood, sufficient size and length to ensure anchorage of sod on slope.

B. Mesh: Interwoven biodegradable fiber.

C. Edging: Decay resistant wood, treated softwood or redwood.

D. Drip Strip Stone: Washed natural stone, 3/4” to 1-1/2” size.

E. Mulch: Dark Pine Brown native bark

F. Weed Barrier: 4 oz, woven, needle punched polypropylene fabric.

PART 3 - EXECUTION

3.1 EXAMINATION AND PREPARATION

A. Verify that required underground utilities are in proper location.

B. Prepare subsoil to eliminate uneven areas. Maintain profiles and contours. Make changes in grade gradual. Blend slopes into level areas. Remove stones over 1-1/2” in any dimension. Remove sticks, roots, rubbish and other extraneous matter.

C. Scarify subsoil to a depth of 3”.

3.2 PLACING TOPSOIL

A. Spread topsoil to a minimum depth of 4 inches compacted thickness. Rake smooth.

B. Grade topsoil to eliminate rough, low or soft areas, and to ensure positive drainage.

C. Place topsoil into pits and beds intended for plant root balls to a minimum thickness of 6”.

D. Apply fertilizer in accordance with manufacturer's instructions.

3.3 SEEDING

A. Apply seed or Hydroseed with a seed slurry at a rate of 4 lb/1000ft^2 evenly in two intersecting directions.

B. Immediately following seeding, apply agricultural mulch to a loose thickness of 1-1/2".

C. Apply water with a fine spray immediately after each area has been mulched.

3.4 MULCHING

A. Place mulch over weed barrier to uniform thickness (3" minimum).

C. On slopes 1:2 and steeper, place mesh over finished surface.

3.5 PLANTING

A. Set plants in pits or beds partly filled with prepared topsoil mixture. Backfill with topsoil mixture.

B. Saturate soil with water when the pit or bed is half full of topsoil and again when full.

C. Stake and guy trees immediately after planting.

D. Mulch trees and shrubs with 3" minimum thickness of bark mulch.

E. Apply anti-desiccant agent to plantings.

F. Prune trees and shrubs in accordance with horticultural practice.

3.6 MAINTENANCE

A. Mow grass at regular intervals to maintain maximum height of 2-1/2". Do not cut more than 1/3 of grass blade at any one mowing.

B. Water to prevent grass and soil from drying out.

C. Control growth of weeds. Apply treatments in accordance with manufacturer's instructions and Owner's policies.

END OF SECTION 32 90 00

SECTION 32 92 19
SEEDING

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, place, and test topsoil, seed, lime, and fertilizer where shown on the drawings and protect and maintain seeded areas disturbed by construction work, as directed by the Engineer.

B. Related Work Specified Elsewhere (When Applicable): Earthwork, excavation, backfill, compaction, site grading and temporary erosion control are specified in the appropriate Sections of this Division.

1.2 SUBMITTALS AND TESTING

A. Seed:
1. Furnish the Engineer with duplicate signed copies of a statement from the vendor, certifying that each container of seed delivered to the project site is fully labeled in accordance with the Federal Seed Act and is at least equal to the specification requirements.
2. This certification shall appear in, or with, all copies of invoices for the seed.
3. The certification shall include the guaranteed percentages of purity, weed content and germination of the seed, and also the net weight and date of shipment. No seed may be sown until the Contractor has submitted the certificates and certificates have been approved.
4. Each lot of seed shall be subject to sampling and testing, at the discretion of the Engineer, in accordance with the latest rules and regulations under the Federal Seed Act.

B. Topsoil:
1. Inform the Engineer, within 30 days after the award of the Contract, of the sources from which the topsoil is to be furnished.
2. Obtain representative soil samples, taken from several locations in the area under consideration for topsoil removal, to the full stripping depth.
3. Have soil samples tested by an independent soils testing laboratory, approved by the Engineer, and directed by owner at owners expense.
4. Have soil samples tested for physical properties and pH (or lime requirement), for organic matter, available phosphoric acid, and available potash, in accordance with standard practices of soil testing.
5. Approval, by the Engineer, to use topsoil for the work will be dependent upon the results of the soils tests.

C. Lime & Fertilizer:
1. Furnish the Engineer with duplicate copies of invoices for all lime and fertilizer used on the project showing the total minimum carbonates and minimum percentages of the material furnished that pass the 90 and 20 mesh sieves and the grade furnished.
2. Each lot of lime and fertilizer shall be subject to sampling and testing at the discretion of the Engineer.
3. Sampling and testing shall be in accordance with the official methods of the Association of Official Agricultural Chemists.
4. Upon completion of the project, a final check may be made comparing the total quantities of fertilizer and lime used to the total area seeded. If the minimum rates of application have not been met, the Engineer may require the Contractor to distribute additional quantities of these materials to meet the minimum rates.

1.3 DELIVERY, STORAGE & HANDLING

A. Seed:
1. Furnish all seed in sealed standard containers, unless exception is granted in writing by the Engineer.
2. Containers shall be labeled in accordance with the United States Department of Agriculture's rules and regulations under the Federal Seed Act in effect at the time of purchase.

B. Fertilizer:
1. Furnish all fertilizer in unopened original containers.
2. Containers shall be labeled with the manufacturer's statement of analysis.

1.4 JOB CONDITIONS

A. Topsoil: Do not place or spread topsoil when the subgrade is frozen, excessively wet or dry, or in any condition otherwise detrimental, in the opinion of the Engineer, to the proposed planting or to proper grading. Do not use excessively wet topsoil.

B. Seeding:
1. Planting Seasons: The recommended seeding time is from April 1 to September 15. The Contractor may seed at other times. Regardless of the time of seeding, the Contractor shall be responsible for each seeded area until it is accepted.
2. Weather Conditions:
   a. Do not perform seeding work when weather conditions are such that beneficial results are not likely to be obtained, such as drought, excessive moisture, or high winds.
   b. Stop the seeding work when, in the opinion of the Engineer, weather conditions are not favorable.
   c. Resume the work only when, in the opinion of the Engineer, conditions become favorable, or when approved alternate or corrective measures and procedures are placed into effect.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Seed:
1. Provide the grass or plant material seed mixture specified on the drawings. When unspecified, provide a mix approved by the Engineer, having the following composition:
   a. Roadside Mixture:
      50 percent Creeping Red Fescue
      15 percent Kentucky Bluegrass
      5 percent White Clover
      2 percent Red Top
      3 percent Birdsfoot Trefoil
      25 percent Annual Ryegrass
   b. Alternate Mixture:
      50 percent Creeping Red Fesque
      30 percent Kentucky Bluegrass
      20 percent Annual Ryegrass
2. Do not use seed which has become wet, moldy, or otherwise damaged in transit or during storage.

B. Topsoil:
1. Provide the quantity of topsoil necessary, in the opinion of the Engineer, to complete the work.
2. Provide topsoil that is natural, friable clay-loam soil possessing the characteristics of representative soils in the vicinity which produce heavy growths of crops, grass, or other vegetation.
3. Provide topsoil which is reasonably free from subsoil, brush, objectionable weeds, other litter, clay lumps, stones, stumps, roots, objects larger than 2" in diameter, and toxic substances which might be harmful to plant growth or be a hindrance to grading, planting, and maintenance operations.
4. Obtain topsoil from naturally well drained areas.

C. Lime:
1. Provide lime which is ground limestone containing not less than 85% of total carbonate and of such fineness that 90% will pass a No. 20 sieve and 50% will pass a No. l00 sieve.
2. Coarser materials will be acceptable provided the specified rates of application are increased proportionately on the basis of quantities passing a No. l00 sieve. No additional payment will be made to the Contractor for the increased quantity.

D. Fertilizer:
1. Provide a commercial fertilizer approved by the Engineer.
2. Provide fertilizer containing the following minimum percentage of nutrients by weight:
10 % Available phosphoric acid
10 % Available potash
10 % Available nitrogen (75% of the nitrogen shall be organic)

PART 3 - EXECUTION

3.1 PREPARATION

A. Equipment:
1. Provide all equipment necessary for the proper preparation of the ground surface and for the handling and placing of all required materials.
2. Demonstrate to the Engineer that the equipment will apply materials at the specified rates.

B. Soil: Perform the following work prior to the application of lime, fertilizer or seed.
1. Scarify the subgrade to a depth of 2" to allow the bonding of the topsoil with the subsoil.
2. Apply topsoil to a depth of 4" or as directed on areas to be seeded.
3. Trim and rake the topsoil to true grades free from unsightly variations, humps, ridges or depressions.
4. Remove all objectionable material and form a finely pulverized seed bed.

3.2 PERFORMANCE

A. Grading:
1. Grade the areas to be seeded as shown on the Drawings or as directed by the Engineer.
2. Leave all surfaces in even and properly compacted condition.
3. Maintain grades on the areas to be seeded in true and even conditions, including any necessary repairs to previously graded areas.

B. Placing Topsoil:
1. Uniformly distribute and evenly spread topsoil on the designated areas.
2. Spread the topsoil in such a manner that planting work can be performed with little additional soil preparation or tillage.
3. Correct any irregularities in the surface resulting from topsoiling or other operations to prevent the formation of depressions where water may stand.

4. Thoroughly till the topsoil to a depth of at least 3” by plowing, discing, harrowing, or other approved method until the condition of the soil is acceptable to the Engineer.

C. Placing Fertilizer:
   1. Distribute fertilizer uniformly at a rate determined by the soils test over the areas to be seeded.
   2. Incorporate fertilizer into the soil to a depth of at least 3” by discing, harrowing, or other methods acceptable to the Engineer.
   3. The incorporation of fertilizer may be a part of the tillage operation specified above.
   4. Distribution by means of an approved seed drill equipped to sow seed and distribute fertilizer at the same time will be acceptable.

D. Placing Lime:
   1. Uniformly distribute lime immediately following or simultaneously with the incorporation of fertilizer.
   2. Distribute lime at a rate determined from the pH test, to a depth of at least 3” by discing, harrowing, or other methods acceptable to the Engineer.

E. Seeding:
   1. Level out any undulations or irregularities in the surface resulting from tillage, fertilizing, liming or other operations before starting seeding operations.
   2. Hydroseeding:
      a. Hydroseeding may be performed where approved and with equipment approved by the Engineer.
      b. Sow the seed over designated areas at a minimum rate of 5 lbs per 1000 ft^2.
      c. Seed and fertilizing materials shall be kept thoroughly agitated in order to maintain a uniform suspension within the tank of the hydroseeder.
      d. The spraying equipment must be designed and operated to distribute seed and fertilizing materials evenly and uniformly on the designated areas at the required rates.
   3. Drill Seeding:
      a. Drill seeding may be performed with approved equipment having drills not more than 2” apart.
      b. Sow the seed uniformly over the designated areas to a depth of l/2” and at a rate of 5 lbs per l,000 ft^2.
   4. Broadcast Seeding:
      a. Broadcast seeding may be performed by equipment approved by the Engineer.
      b. Sow the seed uniformly over the designated areas at a rate of 5 pounds per l,000 square feet.
      c. Sow half the seed with the equipment moving in one direction and the remainder of the seed with the equipment moving at right angles to the first sowing.
      d. Cover the seed to an average depth of l/2” by means of a brush harrow, spike-tooth harrow, chain harrow, cultipacker, or other approved devices.
      e. Do not perform broadcast seeding work during windy weather.

F. Compacting:
   1. Seeded areas must be raked lightly after sowing unless seeding is to be directly followed by application of an approved mulch.
   2. Compact the entire area immediately after the seeding operations have been completed.
   3. Compact by means of a cultipacker, roller, or other equipment approved by the Engineer weighing 60 to 90 lbs per linear foot of roller.
   4. If the soil is of such type that a smooth or corrugated roller cannot be operated satisfactorily, use a pneumatic roller (not wobbly wheel) that has tires of sufficient size to obtain complete coverage of the soil.

5. When using a cultipacker or similar equipment, perform the final rolling at right angles to the prevailing slopes to prevent water erosion, or at right angles to the prevailing wind to prevent dust.

3.3 PROTECTION & MAINTENANCE

A. Protection:
   1. Protect the seeded area against traffic or other use.
   2. Erect barricades and place warning signs as needed.

B. Maintenance:
   1. Properly care for the seeded areas during the period when the grass is becoming established.
   2. The protection period shall extend for 12 months after the completion of the entire project, unless the desired cover, in the opinion of the Engineer, is established in a shorter period of time.

3.4 ACCEPTANCE

A. At final acceptance of the project all areas shall have a close stand of grass with no weeds present and no bare spots greater than three inches (3") in diameter over greater than five percent (5%) of the overall seeded area.

END OF SECTION 32 92 19

SECTION 33 05 13
MANHOLES AND STRUCTURES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Construct precast manholes, covers, frames, brick masonry, precast of field constructed inverts and apply waterproofing in conformance with the dimensions, elevations, and locations shown on the Drawings and as specified herein.

1.2 QUALITY ASSURANCE

A. Precast Manhole Base, Barrel and Top Sections:
   1. Conform to ASTM C478-97 except as modified herein, and on the Drawings.
   2. Average strength of 4,000 psi at 28 days.
   3. Testing:
      a. Determine concrete strength by tests on six (6) inch by 12-inch vibrated test cylinders cured in the same manner as the bases, barrels and tops.
      b. Have tests conducted at the manufacturer's plant or at a testing laboratory approved by the City of Rockland.
      c. Have not less than two (2) tests made for each 100 vertical feet of precast manhole sections.

B. Manhole Steps
   1. Acceptable Manufacturers:
      a. Aluminum Company of America.
      b. Reliance Steel Products, Inc.
      c. M. A. Industries, Inc.
      d. Or equivalent.

C. Frames and Covers:
   1. Acceptable Manufacturers:
      a. Etheridge Foundry Co.
      b. Neenah Foundry Co.
      c. E. L. LeBaron Foundry Company.
      d. Or equivalent.

D. Masonry:
   1. Brick: Shall comply with the ASTM Standard Specifications for Sewer Brick (made from clay or shale), Designation C32, for Grade SS, hard brick.
   2. Cement: ASTM C-150
   3. Hydrated Lime: ASTM C-207
   4. Sand: ASTM C33

E. Waterproofing:
   1. Acceptable Manufacturers:
      a. Minwax Fibrous Brush Coat, Minwax Co., N.Y., N.Y.
      b. Tremco 121 Foundation Coating, Tremco Mfg. Co., Newark, N.J.
      c. Or approved equal.

1.3 SUBMITTALS

A. Submit shop drawings and manufacturer's literature to City of Rockland's approved representative for approval.

B. Precast Manhole Sections: Field verify angles, dimensions, and elevations prior to casting. Submit test results and receive approval from the City of Rockland's representative prior to delivery to the site.

PART 2 - PRODUCTS

2.1 PRECAST MANHOLE SECTIONS

A. Dimensions, shall be as shown on the Drawings:
   1. Base & Riser Sections:
      a. Diameter: As shown on the Drawings.
      b. Length: As required.
      c. Wall Thickness: Not less than five (5) inches.
      d. Joints: Bell-and-spigot or tongue-and-groove formed on machine rings to insure accurate joint surfaces.
      e. Constructed to support an HS-20 wheel loading.

   2. Tops:
      a. Diameter: Eccentric cone type, 24 inches I.D. at top, 48 inches I.D. at bottom unless otherwise shown on the Drawings.
      b. Length: four (4) feet.
      c. Wall thickness: Not less than five (5) inches at the base, tapering to not less than eight (8) inches at the top.
      d. Joints: Bell-and-spigot or tongue-and-groove formed on machine rings to insure accurate joint surfaces.
      e. Exterior face of cone sections shall not flare out beyond the vertical.
      f. Constructed to support an HS-20 wheel loading.

   3. Flat Slab Tops:
      a. Location: Where shallow installations do not permit the use of a cone-type top and where indicated on the Drawings.
      b. Slab thickness: Not less than six (6) inches.
      c. Constructed to support an HS-20 wheel loading.

B. Openings:
   1. Provide openings in the risers to receive pipes entering the manhole.
   2. Make openings at the manufacturing plant.
   3. Size: To provide a uniform annular space between the outside wall of pipe and riser.
   4. Location: To permit setting of the entering pipes at the correct elevations.
   5. Openings shall have a flexible watertight union between pipe and the manhole base.
      a. Cast into the manhole base and sized to the type of pipe being used.
      b. Type of flexible joint being used shall be approved by the City of Rockland. Install materials according to the Manufacturer's instructions.
         1. Lock Joint Flexible Manhole Sleeve made by Interpace Corporation.
         2. Kor N Seal made by National Pollution Control System, Inc.
         3. Press Wedge II made by Press-Seal Gasket Corporation.
         4. A-Lok Manhole Pipe Seal made by A-Loc Corporation.
         5. Or equivalent.

C. Joints:
   1. Joint gaskets to be flexible self-seating butyl rubber joint sealant installed according to manufacturer's recommendations. For cold weather applications, use adhesive with joint sealant as recommended by manufacturer. Acceptable Materials:
      a. Kent-Seal No. 2
      b. Ram-Nek

c. Or equivalent.

2. Joints between precast sections shall conform to related standards and manufacturer's instructions.
3. All manholes greater than six (6) ft. diameter and all manholes used as wet wells, valve pits and other dry-pit type structures shall be installed with exterior joint collars. The joint collar shall be installed according to the manufacturer's instructions. Acceptable materials:
   a. MacWrap exterior joint sealer as manufactured by Mar-Mac Manufacturing Company.
   b. Or equivalent.

D. Waterproofing:
1. The exterior surface of all manholes shall be given two (2) coats of bituminous waterproofing material at an application rate of 75 to 100 square feet per gallon, per coat.
2. The coating shall be applied after the manholes have cured adequately and can be applied by brush or spray in accordance with the manufacturer's written instruction.
3. Sufficient time shall be allowed between coats to permit sufficient drying so that the application of the second coat has no effect on the first coat.

E. Frost Protective Wrapping:
1. The frost protective wrap shall be constructed of an ultraviolet resistant polyethylene material and shall be a minimum thickness of six (6) mils.

2.2 FRAMES AND COVERS

A. Standard Units:
1. Made of cast iron conforming to ASTM A48-76, Class 30 minimum.
2. Have machined bearing surfaces to prevent rocking.
3. Castings shall be smooth with no sharp edges.
4. Constructed to support an HS-20 wheel loading.
5. Dimensions and Style shall conform to the Drawings, Standard castings differing in non-essential details are subject to approval by the City of Rockland:
   a. Covers - solid with “SEWER” in three (3) inch letters diamond pattern.
   b. Frame - 24-inch diameter clear opening, with flange bracing ribs.
6. Minimum weight of frame and cover shall be 430 lbs.

B. Water Tight Units:
1. Same features as above for Standard Units, with 22-inch diameter minimum clear opening.
2. Sealing features:
   a. Inner lid held by a bronze tightening bolt in a locking bar.
   b. Neoprene gasket
   c. Water tight pick hole.
3. Minimum weight of frame and cover shall be 510 lbs.

2.3 MANHOLE STEPS

A. Aluminum or polyethylene coated steel safety type designed with a minimum concentrated live load of 300 pounds.

B. Thoroughly clean all surfaces to be embedded with a suitable cleaning agent to ensure that the surfaces are free from all foreign matter such as dirt, oil and grease.

C. Aluminum surfaces to be embedded shall be given a protective coating of an approved heavy-bodied bituminous material. The steps shall become thoroughly dry before being placed into the concrete.

D. All steps shall be factory cast into walls of the precast section so as to form a continuous ladder with a distance of 12-inches between steps.

2.4 MASONRY

A. Brick:
1. Sound, hard, uniformly burned, regular and uniform in shape and size, compact texture, and satisfactory to the City of Rockland approved representative.
2. Immediately remove rejected brick from the work.

B. Mortar:
1. Composition (by volume):
a. 1 part Portland Cement.
b. 1/2 part hydrated lime.
c. 4-1/2 parts sand.
2. The proportion of cement to lime may vary from 1:1/4 for hard brick to 1:3/4 for softer brick, but in no case shall the volume of sand exceed three (3) times the sum of the volume of cement and lime.

C. Cement shall be Type II Portland Cement.

D. Hydrated lime shall be Type S.

E. Sand:
1. Shall consist of inert natural sand.
2. Grading:

Sieve	Percent Passing
3/8”	100
No. 4	95-100
No. 8	80-100
No. 16	50-85
No. 50	10-30
No. 100	2-10
Fineness Modulus	2.3 - 3.1

PART 3 - EXECUTION

3.1 PERFORMANCE

A. Precast Manhole Sections:
1. Perform jointing in accordance with manufacturer's recommendations and as approved by the City of Rockland.
2. Install riser sections and tops level and plumb.
3. Make all joints watertight.
4. When necessary, cut openings carefully to prevent damage to barrel sections and tops. Replace damaged manhole sections and tops at no additional cost to the Owner.
5. When manhole steps are included in the Work, install barrel sections and tops so that steps are in alignment.

B. Drop Manholes:
1. The difference in elevation between the invert of the inlet pipe to the invert of the outlet pipe shall not exceed 24 inches without use of a drop structure.
2. Where difference in elevation exceeds 24 inches, construct a drop manhole as shown on the Drawings or as directed by the City of Rockland approved representative.

C. Adjust to Grade:
   1. Adjust tops of manholes to grade with brick masonry.
   2. Concrete rings are not acceptable for adjusting to grade.

D. Pipe Connections to Manholes: Connect pipes to manholes with joint design and materials approved by the City of Rockland representative.

E. Invert Channels:
   1. Smooth and semicircular in shape conforming to the inside of the adjacent sewer section.
   2. Make changes in direction of flow with smooth curves having a radius as large as permitted by the size of the manhole.
   3. Stop the pipes at the inside face of the manhole where changes of direction occur.
   4. Form invert channels with brick.
   5. Shape invert to make smooth transition in vertical grade.
   6. Slope the floor of the manhole to the flow channel, as shown on the Drawings

F. Masonry:
   1. Laying Brick:
      a. Use only clean bricks in brickwork for manholes.
      b. Moisten the brick by suitable means until they are neither so dry as to absorb water from the mortar nor so wet as to be slippery when laid.
      c. Lay each brick in a full bed and joint of mortar without requiring subsequent grouting, flushing, or filling, and thoroughly bond as directed.
      d. Construct all joints in a neat workmanlike manner. Construct the brick surfaces inside the manholes so they are smooth with no mortar extending beyond the bricks and no voids in the joints. Maximum mortar joints shall be 1/2-inch.
      e. Outside faces of brick masonry shall be plastered with mortar from 1/4-inch to 3/8-inch thick.
      f. Completed brickwork shall be watertight.
   2. Curing:
      a. Protect brick masonry from drying too rapidly by using burlaps which are kept moist, or by other approved means.
      b. Protect brick masonry from the weather and frost as required.

G. Frames and Covers:
   1. Set all frames in a full bed of mortar, true to grade and concentric with the manhole opening.
   2. Completely fill all voids beneath the bottom flange to make a watertight fit.
   3. Place a ring of mortar at least one (1) inch thick around the outside of the bottom flange, extending to the outer edge of the manhole all around its circumference.
   4. Clean the frame seats before setting the covers in place.

H. Plugging and Patching:
   1. Fill all exterior cavities with non-shrink grout and with bituminous waterproofing once the concrete and mortar has set.
   2. Touchup damaged water proofing.

I. Cleaning:
   1. Thoroughly clean manholes, steps, frames and covers of all debris and foreign matter.

J. Bedding and Backfilling:
   1. Bedding of manholes shall be six (6) inches of 3/4" screened stone.
   2. Backfill a minimum of 18 inches all around manhole with crushed stone.

K. Frost Protective Wrap:
1. The Contractor shall comply with the manufacturer's instructions for the particular conditions of installations in each case.
2. Clean each manhole exterior of all dirt and remove any sharp protrusions.
3. Apply two (2), six (6) inch wide vertical strips of bituminous waterproofing material and/or duct tape from the top to bottom of the manhole per layer.
4. Prior to installing pipe through each manhole or valve pit, wrap each manhole to the maximum depth of frost penetration, but not less than five (5) feet below grade, with four (4) layers of the polyethylene material by beginning the wrap at the adhesive strip and proceeding around the manhole, valve pit, etc., continuously by overlapping the adhesive strip by 24 inches on the final layer. Cut the polyethylene wrap in areas where piping exits the manhole. The size of the cut is to be equivalent to the pipe's outside diameter.
5. Tuck and pleat the polyethylene wrap at the top of each manhole in a continuous manner, minimizing the size of each fold. Extend the polyethylene wrap past the top of the manhole frame and temporarily tuck the remainder inside the frame, until final backfill and paving.
6. In paved areas, cut the polyethylene wrap flush with the manhole rim after the pavement is in place.
7. In unpaved areas, pull the polyethylene wrap together, and tie around frame with galvanized wire.
8. Protect the installed frost barrier from harmful weather exposures and from possible physical abuses, where possible by prompt installation of concealing work or, where that is not possible, by temporary covering or enclosure.
9. Backfill around the manhole/frost barrier with material as outlined in Division 31-Earthwork.

3.2 MANHOLE TESTING

A. General:
1. Perform either a vacuum test or a combination of the exfiltration and infiltration tests on all manholes.
2. All testing must be performed in the presence of the City of Rockland approved representative.
3. Suitably plug all pipes entering each manhole and brace plugs to prevent blow out.

B. Exfiltration Tests After Backfilling:
1. Fill each manhole with water to the top of the manhole frame.
2. A period of up to two (2) hours may be permitted, if the Contractor so wishes, to allow for absorption.
3. At the end of the absorption period, refill each manhole with water to the top of the manhole frame and begin the four (4) hour test period.
4. At the end of the four (4) hour test period, refill each manhole to the top of the manhole frame and measure the volume of water added. The leakage for each manhole shall not exceed 1/16 gallon per foot of diameter per vertical foot (above groundwater) per four (4) hour period.

C. Infiltration Tests:
1. When the groundwater is above the bottom of the manhole, infiltration testing may be performed on that portion of the manhole below water level.
2. After a 15-minute period, if no water is visibly moving down the interior surfaces of a manhole, the portion of the manhole below groundwater may be considered to be satisfactorily watertight.
3. The remaining portion above the groundwater level must be tested for exfiltration as specified above.

D. Vacuum Test:
   1. The manhole shall be tested by a vacuum test after assembly of the manhole, connection piping and backfilling.
   2. Plug all lifting holes completely with non-shrink grout.
   3. Properly tighten all boot clamps and brace all plugs to prevent them from being sucked into the manhole.
   4. Install the testing equipment according to the manufacturer's instructions.
   5. A vacuum of 10 inches of Hg shall be drawn on the manhole and the loss of one (1) inch of Hg vacuum timed. The manhole shall be considered to have passed the test if the time for the loss of one (1) inch Of Hg vacuum is two (2) minutes or longer.
   6. If the manhole fails the initial test, the Contractor shall locate the leak(s) and make repairs. The manhole shall be retested until a satisfactory test result is obtained.
   7. If a satisfactory vacuum test cannot be obtained, the manhole shall be water exfiltration tested and repaired as necessary.

C. Manhole Repairs:
   1. Correct leakage by reconstruction, replacement of gaskets and/or other methods as approved by the City of Rockland representative.
   2. The use of lead-wool or expanding mortar will not be permitted.

D. After the manholes have been backfilled and prior to final acceptance, any signs of leaks or weeping visible inside the manholes shall be repaired and the manhole made watertight.

END OF SECTION 33 05 13

SECTION 33 05 16
UTILITY STRUCTURES

PART 1 - GENERAL

1.1 WORK OF OTHER SECTIONS

A. Excavation: Section 31 23 16

1.2 APPLICABLE STANDARDS

A. General: Comply with standards specified in this Section.

1.3 QUALIFICATIONS OF INSTALLERS

A. Use adequate numbers of skilled workers who are thoroughly trained and experienced in the necessary crafts and who are completely familiar with the specified requirements and the methods needed for proper performance of the work of this Section.

1.4 PRODUCT HANDLING

A. Protection: Use all means necessary to protect the materials of this Section before, during and after installation and to protect the work and materials of all other trades.

B. Protection of Utilities: Protect existing utilities as specified in the appropriate sections.

C. Delivery and Storage: Deliver all materials to the job site in their original containers with all labels intact and legible at time of use. Store utility structures in strict accordance with the manufacturers' recommendations, as approved by the ENGINEER.

D. Replacements: In the event of damage, immediately make all repairs and replacements necessary to the approval of the Engineer and at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Foundation (perimeter-inside and out) drains shall be sized as per plan, no less than four (4) inch diameter perforated rigid ABS pipe, SDR 35. All perimeter drains shall be covered with filter fabric. Fabric to be laid as shown in the Drawings. Pipe shall have 5/8" holes and be "underdrain" type pipe.

B. Foundation drain outfalls shall be sized as per plan, no less than four (4) inch diameter solid rigid ABS pipe, SDR 23.5, sloped to drain. Stone-in end of drainage pipes with drainage fill material in order to protect pipe from freeze-up but allow drainage.

C. Polyvinyl Chloride (PVC) Pipe: Pipe and fittings shall comply with ASTM D 3034, rated SDR 35. Pipe shall be continually marked with manufacturer’s name, pipe size, cell classification, SDR rating, and ASTM D 3034 classification. Pipe joints shall be integrally molded bell ends in accordance with ASTM D 3034, Table 2, with factory supplied elastomeric gaskets and lubricant. PVC shall not be used for any drainage pipe, which will be permanently exposed to sunlight.

D. Storm drain pipe shall be HDPE dual wall solid wall or perforated drainage pipe as shown or directed. Pipe shall have a smooth interior and be fitted with a bell and gasket joint assembly. Pipe shall be ADS N-12 ST IB, soil tight. Storm drain accessories shall include catch basin assemblies where indicated with cast iron grate and HDPE flared end for pipe inlet(s) and outlet equal to Nyloplast ADS Inlet and Outlet Adaptors.

2.2 DRAINAGE STRUCTURES

A. General: Construct drainage structures of precast reinforced concrete to the dimensions and profiles capacities as approved by the Engineer. Provide metal frames, covers or gratings, and fixed ladders as shown.

B. Mortar: Comply with ASTM C270, Type M, for mortar for pipe joints and connections to drainage structures, and for manhole construction. Place within one hour after addition of water. Hydrated lime complying with ASTM C141, Type B, may be added to the mixture of sand and cement in an amount equal to 25 percent of the volume of cement. Provide a quantity of water in the mixture sufficient to produce a stiff workable mortar, clean and free from harmful acids, alkalis, and organic impurities.

C. Reinforcing Bars and Dowels: Intermediate grade billet steel; comply with ASTM A615, Grade 40.

D. Frames and Covers or Grating: Standard black finish, or as selected by the Owner and approved by the Engineer, supplied as a total unit, sized as indicated on the Drawings. Provide all items from the same manufacturer.

E. Precast Concrete Catch Basins: Shall be designed to assure slope through the structure.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine the areas and conditions under which work of this Section will be performed. Correct conditions detrimental to the timely and proper completion of the work. Do not proceed until unsatisfactory conditions have been corrected.

3.2 EXCAVATING, TRENCHING, AND BEDDING FOR PIPES

A. General: Provide excavating, trenching and bedding for storm drains in accordance with the provisions of the appropriate section and as follows:

B. Movement of Construction Machinery: Use all means necessary to avoid displacement of, and injury to, the pipe and structures while compacting by rolling or operating equipment parallel with the pipe. Movement of equipment over a culvert or storm drain at any stage of construction is solely at the risk of the Contractor.

C. Bedding: Provide a bedding surface for the pipe with a firm foundation of uniform density throughout the entire length of the pipe. Bed pipes carefully in a soil foundation accurately shaped and rounded to conform to the lower one-quarter of the outside perimeter of the circular pipe, or set the pipe in a bed of sand. Tamp bedding when necessary. Provide bell holes and depressions for pipe joints of only the length, depth, and width required for properly making the particular joint.

3.3 PLACING PIPE

A. General: Carefully examine each pipe prior to placing. Promptly set aside all defective and damaged pipe. Clearly identify all defects. Do not install defective or damaged pipe.

B. Place all pipe to the grades and alignment shown in the Drawings, with a tolerance of 1:1000 vertical and 1:500 horizontal.

C. Provide all required equipment for lowering pipe safely into the trenches.

D. Do not place pipe in water, or place pipe when trench or weather is unsuitable for such work.

E. Concrete Pipe: Lay by proceeding upgrade with the spigot ends of bell-and-spigot pipe, and the tongue ends of tongue-and-groove pipe pointing in the direction of flow.

F. Asphalt Coated Corrugated Metal Pipe: The pipe shall be laid upgrade, beginning at the lower end of the pipeline. Pipelines shall be laid to grades and alignment shown on the Drawings or as directed by the Engineer.

G. Aluminized Type II Pipe: The pipe shall be laid upgrade, beginning at the lower end of the pipeline. Pipelines shall be laid to grade and alignment shown on the Drawings or as directed by the Engineer.

H. The pipe shall be laid in the prepared bed with the outside laps of circumferential joints pointing upgrade. Paved or partially lined culverts shall be laid with the lining on the bottom. The longitudinal laps parallel to the centerline of the pipe shall be placed on the sides of the pipeline with outside laps pointing down. Each section or joint of pipe shall be securely attached to the adjoining section or joint of pipe with connecting bands or other approved type of joint. The bands shall be tightly drawn or connected so that a rigid joint will be formed. Damage to the bituminous coating shall be repaired by applying hot asphalt to the exposed metal before any backfill is placed.

3.4 PIPE ASSEMBLY, JOINTS, TERMINAL TREATMENT

A. Joining Concrete Pipe:
   1. Wipe the inside of the joint clean and smooth. In pipe too small for a person to work inside, perform wiping by dragging a suitable swab or long handled brush through the pipe as installation progresses. Protect the mortar bead on the outside from air and sun with suitable covering until cured.
   2. Cement mortar bell and spigot joint: Bed the first pipe to the established grade line, with the bell end placed upstream. Clean surface of bell with wet brush, and fill lower portion with mortar to such depth as to bring the inner surface of the abutting pipes flush and even. Clean the spigot end of each subsequent pipe with a wet brush, and uniformly match into the bell so that sections are closely fitted. After laying each section, fill remainder of joint with mortar, and form a bead around the outside of the joint with mortar. If mortar can slump before setting, wrap or bandage the outside of the joint with cheesecloth to retain mortar in place.
   3. Flexible watertight joints: Make flexible watertight joints with rubber gaskets for concrete pipe. Design joints and use gaskets complying with ASTM C443 and shore durometer hardness, Type A, 40-55 in lieu of hardness specified. Allow no more than one splice, except two splices are acceptable in rubber gaskets larger than 140 cm (54"). Install gaskets and joint materials in accordance with the manufacturer's recommendations as approved by the Engineer. Affix gaskets and jointing materials to the pipe not more than 24 hours prior to installation of the pipe. Align the pipe with the previously installed pipe,

and pull the joint together. If, while making the joint, the gasket or jointing material becomes loose and can be seen through the exterior joint recess when joint is pulled to within one (1) inch of closure, remove pipe and remake joint.

B. Asphalt Coated Corrugated Metal Pipe or Aluminized Type II Pipe: Provide couplings and fittings per manufacturer's recommendation.

C. Joining Pipe of Different Sizes: Provide reducer fittings of the required sizes and configurations. Use saddle connection when branch lines join a main or collector main. Use eccentric collar joint when the slope of the pipe is less than one (1) percent.

D. Hand Laid Riprap: Shall be placed at ends of culverts, properly graded and compacted as called for. Riprap shall be approximately true to the required slope line and grade and be uniform in appearance. Hand laid riprap or hand laid riprap face shall be random rubble, hand laid for the full depth in one operation to secure interlocking of all face stones and stones placed as backing.
   1. Larger stones shall be laid at the base of the ditch. The stones shall be laid in close contact with the longer axis perpendicular to the plane of the slope and so as to stagger joints. All the openings between the stones shall be filled with spall or gravel and rocks securely rammed into place.

E. Catch Basins: Constructed of bricks or concrete blocks shall have a Portland cement concrete base. When concrete blocks are used, all joints shall be no greater than 1/2 inch thickness, completely filled with mortar and neatly tooled on the inside of the structure. When bricks are used, every fourth course shall consist of headers. The flat concrete top shall be eight (8) inches to 12 inches, H20 loading, 24 inch square centered opening. The joints shall be no greater than 1/2" thickness, completely filled with mortar, and neatly tooled on the inside of the structure.

F. Catch basins of precast sections shall be placed to the required grade on compacted foundation material of uniform density. Cement concrete blocks may be used around the inlet and outlet pipes and either blocks or precast sections used for the remaining upper section of the structure. All joints between precast sections shall be mortared as specified for concrete blocks. Brick or block walls shall not be less than eight (8) inches thick.

G. Metal frames and traps, when called for, shall be set in a full mortar bed. Castings shall be set accurately to the correct elevation so that no subsequent adjustment will be necessary.

H. Pipe sections connecting to catch basins with sumps shall be firmly connected to the structure wall with no part of the pipe projecting more than six (6) inches inside the wall. When a section of culvert has to be cut, the end shall be finished in a workmanlike manner. When bituminous-coated culvert is cut, it shall be repainted with bituminous material.

3.5 BACKFILLING

A. General: Backfill in accordance with the Drawings and as specified herein. Take all necessary care to assure thorough compaction of fill under haunches of the pipe, without damage or misalignment of the pipe. Place marker tape at all installations. When approved by the Engineer, sheeting and portions of bracing used may be left in place. Do not leave untreated sheeting in place beneath structures or pavements.

B. Backfilling Pipe in Fill Sections: For pipe placed in fill sections, after the backfill has reached at least 12 inches above the top of the pipe, place the remainder of the fill by compacting in layers not exceeding eight (8) inches in compacted depth.

C. Compaction: Backfill over and around the pipe, backfill around and adjacent to all other drainage structures, and compact to the minimum densities specified in the appropriate section.

3.6 CLEANUP AND REPAIR

A. Upon completion of installation, each structure shall be cleaned of any accumulation of silt, debris, or foreign matter of any kind and shall be kept clear of such accumulation until final acceptance of the work.

B. Any pipe which is not in true alignment or which shows any undue settlement after being laid shall be taken up and re-laid at no additional cost to the Owner.

C. Prior to placing backfill, damaged areas of coupling bands and pipe shall be repaired with the type of coating used on the original pipe. Pipe on which the coating has been damaged to such an extent that satisfactory field repairs cannot be made shall be removed and replaced without additional cost to the Owner.

3.7 TESTING AND INSPECTION

A. General: Provide all equipment and personnel necessary, and make all tests required to demonstrate that the work has been completed in strict accordance with the design and the specified requirements.

B. Closing in Uninspected Work: Do not cause or allow any of the work of the Section to be covered up or enclosed until after it has been completely tested, inspected, and approved by the Engineer.

C. Hydrostatic Tests of Watertight Joints: Make a hydrostatic test on each watertight joint type proposed. Test one sample joint of each type. If a sample joint fails because of faulty workmanship, test an additional sample joint. During the test period, protect the joint from high temperatures that might soften or adversely affect the jointing materials.

D. Demonstrate that joints in reinforced and non-reinforced concrete pipe comply with ASTM C443. Test at an internal hydrostatic pressure of 10 psi for 24 hours.

E. Only joints within the building area and within 10 feet of the building exterior walls or face need be tested for water tightness.

END OF SECTION 33 05 16

SECTION 33 11 00
WATER UTILITY DISTRIBUTION PIPING

PART 1- GENERAL

1.1 DESCRIPTION

A. Utility of Record: The Maine Water Company 855 Rockland Street, Rockport, ME 04856, (207) 236-8428. Comply with all requirements, secure all permits as required by the Maine Water Company. Coordinate all phases of water utility work with Maine Water Company.

1.2 REFERENCES

A. AMERICAN WATER WORKS ASSOCIATION (AWWA)
1. AWWA B300 (2010; Addenda 2011) Hypochlorites
2. AWWA B301 (2010) Liquid Chlorine
3. AWWA C104/A21.4 (2016) Cement-Mortar Lining for Ductile-Iron Pipe and Fittings for Water
4. AWWA C105/A21.5 (2010) Polyethylene Encasement for Ductile-Iron Pipe Systems
5. AWWA C110/A21.10 (2012) Ductile-Iron and Gray-Iron Fittings for Water
6. AWWA C111/A21.11 (2012) Rubber-Gasket Joints for Ductile-Iron Pressure Pipe and Fittings
7. AWWA C115/A21.15 (2011) Flanged Ductile-Iron Pipe With Ductile-Iron or Gray-Iron Threaded Flanges
8. AWWA C151/A21.51 (2009) Ductile-Iron Pipe, Centrifugally Cast, for Water
9. AWWA C153/A21.53 (2011) Ductile-Iron Compact Fittings for Water Service
10. AWWA C200 (2012) Steel Water Pipe - 6 In. (150 mm) and Larger
11. AWWA C203 (2008) Coal-Tar Protective Coatings and Linings for Steel Water Pipelines - Enamel and Tape - Hot-Applied
12. AWWA C205 (2012) Cement-Mortar Protective Lining and Coating for Steel Water Pipe - 4 In. (100 mm) and Larger - Shop Applied
13. AWWA C206 (2011) Field Welding of Steel Water Pipe
14. AWWA C207 (2013) Standard for Steel Pipe Flanges for Waterworks Service-Sizes 100 mm through 3600 mm 4 in. through 144 in.
15. AWWA C208 (2012) Standard for Dimensions for Fabricated Steel Water Pipe Fittings
16. AWWA C209 (2013) Cold-Applied Tape Coatings for the Exterior of Special Sections, Connections and Fitting for Steel Water Pipelines
17. AWWA C210 (2007) Standard for Liquid Epoxy Coating Systems for the Interior and Exterior of Steel Water Pipelines
18. AWWA C300 (2016) Reinforced Concrete Pressure Pipe, Steel-Cylinder Type
19. AWWA C301 (2014) Prestressed Concrete Pressure Pipe, Steel-Cylinder Type
20. AWWA C303 (2008) Concrete Pressure Pipe, Bar-Wrapped, Steel-Cylinder Type
21. AWWA C500 (2009) Metal-Seated Gate Valves for Water Supply Service
22. AWWA C502 (2014) Dry-Barrel Fire Hydrants
23. AWWA C503 (2014) Wet-Barrel Fire Hydrants
24. AWWA C504 (2015) Standard for Rubber-Seated Butterfly Valves
25. AWWA C508 (2009; Addenda A 2011) Swing-Check Valves for Waterworks Service, 2 In. (50 mm) Through 24 In. (600 mm) NPS
26. AWWA C509 (2015) Resilient-Seated Gate Valves for Water Supply Service
27. AWWA C511 (2007) Standard for Reduced-Pressure Principle Backflow Prevention Assembly
28. AWWA C512 (2007) Air-Release, Air/Vacuum, and Combination Air Valves for Waterworks Service
29. AWWA C515 (2015) Reduced-Wall, Resilient-Seated Gate Valves for Water Supply Service
30. AWWA C600 (2010) Installation of Ductile-Iron Water Mains and Their Appurtenances
31. AWWA C602 (2011) Cement–Mortar Lining of Water Pipelines in Place—4 In. (100 mm) and Larger
32. AWWA C604 (2011) Installation of Buried Steel Water Pipe—4 In. (100 mm) and Larger

33. AWWA C605 (2013) Underground Installation of Polyvinyl Chloride (PVC) Pressure Pipe and Fittings for Water
34. AWWA C606 (2015) Grooved and Shouldered Joints
35. AWWA C651 (2014) Standard for Disinfecting Water Mains
36. AWWA C700 (2015) Standard for Cold Water Meters - Displacement Type, Bronze Main Case
37. AWWA C701 (2015) Cold-Water Meters - Turbine Type for Customer Service
38. AWWA C702 (2015) Cold-Water Meters - Compound Type
39. AWWA C703 (2015) Cold-Water Meters - Fire Service Type
40. AWWA C704 (2015) Propeller-Type Meters for Waterworks Applications
41. AWWA C706 (2010) Direct-Reading, Remote-Registration Systems for Cold-Water Meters
42. AWWA C707 (2010; R 2016) Encoder-Type Remote-Registration Systems for Cold-Water Meters
43. AWWA C800 (2014) Underground Service Line Valves and Fittings
44. AWWA C900 (2016) Polyvinyl Chloride (PVC) Pressure Pipe, and Fabricated Fittings, 4 In. Through 60 In. (100 mm Through 1,500 mm)
45. AWWA C905 (2010; Errata 2012; Errata 2013) Polyvinyl Chloride (PVC) Pressure Pipe and Fabricated Fittings 14 In. Through 48 In. (350 mm through 1,200 mm) for Water Transmission and Distribution
46. AWWA C906 (2015) Polyethylene (PE) Pressure Pipe and Fittings, 4 In. (100 mm) through 65 In., (1,575 mm) for Water Distribution and Transmission
47. AWWA C909 (2016) Molecularly Oriented Polyvinyl Chloride (PVCO) Pressure Pipe, 4 In. (100 mm) and Larger
48. AWWA C950 (2013) Fiberglass Pressure Pipe
49. AWWA M11 (2004; 4th Ed; Errata 2013) Manual: Steel Water Pipe: A Guide for Design and Installation
50. AWWA M23 (2002; 2nd Ed) Manual:PVC Pipe - Design and Installation
51. AWWA M45 (2013; 3rd Ed) Fiberglass Pipe Design
52. AWWA M55 (2006) PE Pipe - Design and Installation
53. AWWA M9 (2008; Errata 2013) Manual: Concrete Pressure Pipe

B. ASME INTERNATIONAL (ASME)
1. ASME B16.1 (2015) Gray Iron Pipe Flanges and Flanged Fittings Classes 25, 125, and 250
2. ASME B16.15 (2013) Cast Copper Alloy Threaded Fittings Classes 125 and 250
3. ASME B16.18 (2012) Cast Copper Alloy Solder Joint Pressure Fittings
4. ASME B16.22 (2013) Standard for Wrought Copper and Copper Alloy Solder Joint Pressure Fittings
5. ASME B16.26 (2013) Standard for Cast Copper Alloy Fittings for Flared Copper Tubes
6. ASME B16.3 (2011) Malleable Iron Threaded Fittings, Classes 150 and 300
7. ASME B16.4 (2011) Standard for Gray Iron Threaded Fittings; Classes 125 and 250
8. ASME B18.2.2 (2015) Nuts for General Applications: Machine Screw Nuts, Hex, Square, Hex Flange, and Coupling Nuts (Inch Series)
9. ASME B18.5.2.1M (2006; R 2011) Metric Round Head Short Square Neck Bolts
10. ASME B18.5.2.2M (1982; R 2010) Metric Round Head Square Neck Bolts

C. ASTM INTERNATIONAL (ASTM)
1. ASTM A126 (2004; R 2014) Standard Specification for Gray Iron Castings for Valves, Flanges, and Pipe Fittings
2. ASTM A307 (2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
3. ASTM A47/A47M (1999; R 2014) Standard Specification for Ferritic Malleable Iron Castings
4. ASTM A48/A48M (2003; R 2012) Standard Specification for Gray Iron Castings
5. ASTM A53/A53M (2012) Standard Specification for Pipe, Steel, Black and Hot-Dipped, Zinc-Coated, Welded and Seamless
6. ASTM A536 (1984; R 2014) Standard Specification for Ductile Iron Castings
7. ASTM A563 (2015) Standard Specification for Carbon and Alloy Steel Nuts
8. ASTM A563M (2007; R 2013) Standard Specification for Carbon and Alloy Steel Nuts (Metric)

9. ASTM A746 (2009; R 2014) Standard Specification for Ductile Iron Gravity Sewer Pipe
10. ASTM B32 (2008; R 2014) Standard Specification for Solder Metal
11. ASTM B42 (2015a) Standard Specification for Seamless Copper Pipe, Standard Sizes
12. ASTM B61 (2015) Standard Specification for Steam or Valve Bronze Castings
13. ASTM B62 (2015) Standard Specification for Composition Bronze or Ounce Metal Castings
14. ASTM B88 (2016) Standard Specification for Seamless Copper Water Tube
15. ASTM B88M (2016) Standard Specification for Seamless Copper Water Tube (Metric)
16. ASTM C150/C150M (2016; E 2016) Standard Specification for Portland Cement
17. ASTM C94/C94M (2016a) Standard Specification for Ready-Mixed Concrete
18. ASTM D1599 (2014; E 2015) Resistance to Short-Time Hydraulic Failure Pressure of Plastic Pipe, Tubing, and Fittings
19. ASTM D1784 (2011) Standard Specification for Rigid Poly(Vinyl Chloride) (PVC) Compounds and Chlorinated Poly(Vinyl Chloride) (CPVC) Compounds
20. ASTM D1785 (2012) Standard Specification for Poly(Vinyl Chloride) (PVC), Plastic Pipe, Schedules 40, 80, and 120
21. ASTM D2241 (2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Pressure-Rated Pipe (SDR Series)
22. ASTM D2464 (2015) Standard Specification for Threaded Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
23. ASTM D2466 (2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 40
24. ASTM D2467 (2015) Standard Specification for Poly(Vinyl Chloride) (PVC) Plastic Pipe Fittings, Schedule 80
25. ASTM D2564 (2012) Standard Specification for Solvent Cements for Poly(Vinyl Chloride) (PVC) Plastic Piping Systems
26. ASTM D2657 (2007; R 2015) Heat Fusion Joining Polyolefin Pipe and Fittings
27. ASTM D2774 (2012) Underground Installation of Thermoplastic Pressure Piping
28. ASTM D2855 (2015) Standard Practice for Making Solvent-Cemented Joints with Poly(Vinyl Chloride) (PVC) Pipe and Fittings
29. ASTM D3035 (2015) Polyethylene (PE) Plastic Pipe (DR-PR) Based on Controlled Outside Diameter
30. ASTM D3139 (1998; R 2011) Joints for Plastic Pressure Pipes Using Flexible Elastomeric Seals
31. ASTM D3261 (2016) Standard Specification for Butt Heat Fusion Polyethylene (PE) Plastic Fittings for Polyethylene (PE) Plastic Pipe and Tubing
32. ASTM D3839 (2014) Underground Installation of "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe
33. ASTM D4161 (2014) "Fiberglass" (Glass-Fiber-Reinforced Thermosetting-Resin) Pipe Joints Using Flexible Elastomeric Seals
34. ASTM F1483 (2012) Oriented Poly(Vinyl Chloride), PVCO, Pressure Pipe
35. ASTM F1674 (2011) Standard Test Method for Joint Restraint Products for Use with PVC Pipe
36. ASTM F2164 (2013) Standard Practice for Field Leak Testing of Polyethylene (PE) and Crosslinked Polyethylene (PEX) Pressure Piping Systems Using Hydrostatic Pressure
37. ASTM F402 (2005; R 2012) Safe Handling of Solvent Cements, Primers, and Cleaners Used for Joining Thermoplastic Pipe and Fittings
38. ASTM F477 (2014) Standard Specification for Elastomeric Seals (Gaskets) for Joining Plastic Pipe
39. ASTM F714 (2013) Polyethylene (PE) Plastic Pipe (SDR-PR) Based on Outside Diameter

D. FOUNDATION FOR CROSS-CONNECTION CONTROL AND HYDRAULIC RESEARCH (FCCCHR)

E. FCCCHR List (continuously updated) List of Approved Backflow Prevention Assemblies

F. FCCCHR Manual (10th Edition) Manual of Cross-Connection Control

G. MANUFACTURERS STANDARDIZATION SOCIETY OF THE VALVE AND FITTINGS INDUSTRY (MSS)
   1. MSS SP-80 (2013) Bronze Gate, Globe, Angle and Check Valves

H. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
   1. NFPA 1961 (2013) Standard on Fire Hose
   2. NFPA 1963 (2014) Standard for Fire Hose Connections
   3. NFPA 24 (2013) Standard for the Installation of Private Fire Service Mains and Their Appurtenances

I. NSF INTERNATIONAL (NSF)
   1. NSF 372 (2011) Drinking Water System Components - Lead Content
   2. NSF/ANSI 14 (2016a) Plastics Piping System Components and Related Materials
   3. NSF/ANSI 61 (2016) Drinking Water System Components - Health Effects

J. U.S. DEPARTMENT OF DEFENSE (DOD)
   1. UFC 3-600-01 (2016; with Change 1) Fire Protection Engineering for Facilities

K. UNDERWRITERS LABORATORIES (UL)
   1. UL 246 (2011; Reprint Feb 2013) Hydrants for Fire-Protection Service
   2. UL 262 (2004; Reprint Oct 2011) Gate Valves for Fire-Protection Service
   3. UL 312 (2010; Reprint Mar 2015) Check Valves for Fire-Protection Service
   4. UL 789 (2004; Reprint Feb 2013) Standard for Indicator Posts for Fire-Protection Service

L. UNI-BELL PVC PIPE ASSOCIATION (UBPPA)
   1. UBPPA UNI-PUB-08 (2010) Tapping Guide for PVC Pressure Pipe)

1.3 QUALITY CONTROL

A. Regulatory Requirements
   1. Comply with NSF/ANSI 61 and NSF 372 for materials for potable water piping, components and specialties for domestic water; comply with lead content requirements for "lead-free" plumbing as defined by the U.S. Safe Drinking Water Act.
   2. Comply with NSF/ANSI 14 for plastic potable water piping and components. Provide plastic pipe and fittings, bearing the seal of the National Sanitation Foundation (NSF) for potable water service from the same manufacturer.
   3. Comply with NFPA 24 for materials, installation, and testing of fire main piping and components.

B. Backflow Tester Certificate
   1. Prior to testing, submit to the City of Rockland and Maine Water certification issued by the State or local regulatory agency attesting that the backflow tester has successfully completed a certification course sponsored by the regulatory agency.
   2. Backflow Prevention Training Certificate
      a. Submit a certificate recognized by the State or City of Rockland that states the Contractor has completed at least 10 hours of training in backflow preventer installations. The certificate must be current.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Delivery and Storage
   1. Inspect materials delivered to site for damage.
   2. Unload and store with minimum handling and in accordance with manufacturer's instructions.
   3. Store materials on site in enclosures or under protective covering.
   4. Store plastic piping, jointing materials and rubber gaskets under cover out of direct sunlight.
   5. Do not store materials directly on the ground.

6. Keep inside of pipes, fittings, valves, hydrants, and other accessories free of dirt and debris.

B. Handling
1. Handle pipe, fittings, valves, hydrants, and other accessories in accordance with manufacturer's instructions and in a manner to ensure delivery to the trench in sound undamaged condition.
2. Avoid injury to coatings and linings on pipe and fittings; make repairs if coatings or linings are damaged.
3. Do not place other material, hooks, or pipe inside a pipe or fitting after the coating has been applied.
4. Inspect the pipe for defects before installation.
5. Carry, do not drag pipe to the trench.
6. Use of pinch bars and tongs for aligning or turning pipe will be permitted only on the bare ends of the pipe.
7. Clean the interior of pipe and accessories of foreign matter before being lowered into the trench and keep them clean during laying operations by plugging.
8. Replace material found to be defective before or after laying with sound material without additional expense to the Owner.
9. Store rubber gaskets that are not to be installed immediately, under cover out of direct sunlight.
10. Handle ductile iron pipe, fittings, and accessories in accordance with AWWA C600.
11. Handle PVC and PVCO pipe, fittings, and accessories in accordance with AWWA C605.
12. Handle PE pipe, fittings, and accessories in accordance with AWWA M55.
13. Handle steel pipe, fittings and accessories in accordance with AWWA C604.

PART 2 - PRODUCTS

2.1 SYSTEM DESCRIPTION

A. Water Transmission Mains
1. Provide water transmission mains of cement lined ductile iron (CLDI).
2. Provide water main accessories and valves as specified by The Maine Water Company and where indicated in the Drawings.

B. Water Distribution Mains
1. Provide water distribution mains of cement lined ductile iron (CLDI), per The Maine Water Company standards and specifications, as indicated in the Drawings.
2. Provide water main accessories and valves as specified by Maine Water and where indicated in the Drawings.

C. Water Service Lines
1. Provide water service lines, as indicated in the Contract Documents, from water distribution main to building service per City of Rockland and The Maine Water Company standards and specifications.
2. Provide water service lines of copper pipe, CLDI, or polyethylene (PE) per City of Rockland and The Maine Water Company standards and specifications as indicated on the Drawings and Contract Documents.
3. Provide water service line appurtenances as specified by The Maine Water Company and where indicated in the Drawings.

2.2 PIPE, FITTINGS, JOINTS AND COUPLINGS

A. Submit manufacturer's shop drawings, except submit both drawings and cuts for push-on, and rubber-gasketed bell-and-spigot joints.
1. Include information concerning gaskets with submittal for joints and couplings.

B. Ductile-Iron Piping
   1. Unless otherwise shown on the Drawings, the minimum thickness of ductile iron pipe shall be Class 52 wall thickness, per The Maine Water Company standards and specifications.
      a. Pipe for use with sleeve type couplings shall have plain ends (without bells or beads) cast or machined at right angles to the axis.
      b. Pipe shall be double thickness cement lined and seal coated unless noted otherwise on the Drawings and except for air piping lines which shall be completely unlined.
      c. Pipe for use with split type couplings shall have ends with cast or machined shoulders or grooves that meet the requirements of the manufacturer of the couplings.
      d. Factory applied bituminous coatings shall be furnished on the exterior of all underground piping unless specified otherwise.
   2. Joints (as shown on Drawings or as specified):
      a. Flanged:
         i. Provide specially drilled flanges when required for connection to existing piping or special equipment.
         ii. Flanges shall be long-hub screwed tightly on pipe by machine at the foundry prior to facing and drilling.
         iii. Gaskets:
            (1) Ring type of rubber with cloth insertion.
            (2) Thickness of gaskets 12-inches in diameter and smaller: 1/16 inch.
            (3) Thickness of gaskets larger than 12-inches in diameter: 3/32 inch.
            (4) On high temperature applications such as air lines, the gaskets shall be suitable for service from 40^{o}F to 200^{o}F.
         iv. Fasteners:
            (1) Make joints with bolt, studs with a nut on each end, or one tapped flanged with a stud and nut.
            (2) The number and size of bolts shall meet the requirements of the applicable ANSI standard.
            (3) Nuts, bolts, and studs shall be Grade B meeting the requirements of ASTM A307.
            (4) After jointing, coat entire joint with bituminous material compatible with pipe coating unless other coating is required by this contract.
         v. When applicable, provide and install flange clamps as shown on the Drawings.
      b. Push-on and Mechanical Joint:
         i. The plain ends of push-on pipes shall be factory machined to a true circle and chamfered to facilitate fitting the gasket.
         ii. Provide gaskets manufactured from a composition material suitable for exposure to the fluid to be contained within the pipe. On high temperature applications such as air lines, the gaskets shall be suitable for service from 40*F to 200*F.
         iii. Bolts and nuts for buried mechanical joints shall be made of A588 steel.
      c. Grooved split ring couplings, sleeve couplings, flexible joints and couplings, shall be supplied as specified in "Couplings and Connectors" Section.
      d. Joint Bracing:
         i. Provide joint bracing to prevent the piping from pulling apart under pressure as required and as shown on the Drawings.
         ii. Types of bracing:
            (1) Pipe and fittings furnished with approved lugs or hooks cast integrally for use with socket pipe clamps, tie rods, or bridles. Bridles and tie rods shall be a minimum of 3/4 inch diameter except where they replace flange bolts of a smaller size, in which case they shall be fitted with a nut on each side of the pair of flanges. The clamps, tie rods, and bridles shall be coated with bituminous paint in buried installations and shall be coated with the same coatings as the piping system in interior installations after assembly or, if necessary, prior to assembly.
            (2) Mechanical joint ductile iron pipe retainer glands.

(a) Ductile iron.
(b) Ductile iron or A588 steel set screws.
(c) Working pressure 350 psi, up to 8 inches; 250 psi, 8 inches to 16 inches.
(d) Test pressure two times working pressure.

(3) Megalug by Ebba Iron
(4) Other types of bracing as shown on the Drawings.

C. Plastic Piping
1. Do not use plastic pipe when it will be subject to temperature in excess of 37.8 degrees C or 100 degrees F in installed usage or exposed to a source of heat from adjacent lines or equipment.

D. PVC Piping
1. Do not include PVC plastic water main pipe when pipe of greater strength than Pressure Class 305 is required.

G. Polyethylene (PE) Pipe
1. Polyethylene (PE) pipe is subject to oxidative degradation by many variables including pH, the concentration and type of disinfectant, water temperature, installation procedure and conditions.
a. Disinfectants like chlorine, chloramines, chlorine dioxide, ozone and others may create an Oxidation Reduction Potential (ORP) in PE Pipe.
b. Contractor shall confirm with Maine Water the PE pipe is acceptable for the intended application.
2. Joints and Jointing Materials
a. Mechanical Joint: DIOD Mechanical joint adapter and gaskets for mechanical joints for joint connections between pipe and metal fittings, valves, and other accessories, AWWA C111/A21.11.
b. Butt Fusion: Jointing is to comply with ASTM D2657, Butt Fusion. No offset in alignment between adjacent pipe joints of fittings is permitted.

H. Copper Pipe and Tubing
1. Copper Pipe and Associated Fittings
a. Pipe, ASTM B42, regular, threaded ends.
b. Provide lead-free brass or bronze fittings, ASME B16.15, 825 kPa 125 pound.
2. Copper Tubing and Associated Fittings
a. Tubing per ASTM B88M ASTM B88, Type K.
b. Fittings for solder-type joint, ASME B16.18 or ASME B16.22
c. Fittings for compression-type joint, ASME B16.26, flared tube type.

I. Pipe Anchorage
1. Provide pipe anchorage designed for a minimum working pressure of 2.4 MPa 350 psi, and/or in accordance with The Maine Water Company and City of Rockland standards and specifications.
2. Provide concrete thrust blocks (reaction backing), restrained joints, restraint devices with gripper wedges incorporated into a follower gland and specifically designed for the pipe material and meeting the requirements of AWWA C110/A21.10 and per the standards and specifications of The Maine Water Company and City of Rockland.

2.3 VALVES AND VALVE BOXES

A. Contractor is to provide and install gate valves, indicator posts, valve boxes and valve pits in the locations depicted in the Drawings and in accordance with City of Rockland and The Maine Water Company standards and specifications.
B. Valve Boxes
1. The valve box shall be ductile iron, slip type two-piece integral base, 5-1/4 inch shaft. Top

section with flanges.
2. Cast or Ductile iron, with the word "Water" cast in covers.
3. Belled Base Section.
4. Installation as shown on the Drawings and/or as specified herein.
   a. When installation is complete, no pressure shall be exerted by valve box on the water main or on the valve.
   b. Be of such length as required without full extension. Minimum lap six (6) inches.

2.4 CURB STOPS

A. Work Included: Furnish and install curb stops of the type(s) and size(s) and in the location(s) shown on the Drawings and as specified herein.

B. All curb stops shall be manufactured by one manufacturer.

C. Qualifications of Manufacturer: Products shall have proven reliable in similar installations over a reasonable number of years.

D. Acceptable Manufacturers per the Maine Water Company

E. Product Construction
   1. Constructed of brass.
   2. Inlet and outlet shall be CPPJxCPPJ.
   3. Working pressure shall be required.

F. Installation
   1. Install at locations shown on the Drawings and in accordance with manufacturer's instructions.

G. Adjustments
   1. Check and adjust all curb stops for smooth operation.

2.5 FIRE HYDRANTS

A. Work Included: Furnish and install hydrant assemblies of the type(s) and size (s) and in the locations (s) shown on the Drawings and as specified herein.
   1. Hydrant Assemblies consist of:
      a. Hydrant tee.
      b. Six (6) inch gate valve and curb box.
      c. Six (6) inch hydrant branch piping.
      d. Hydrant.
      e. Drainage material.
      f. Thrust blocking.

B. Hydrants shall conform to AWWA C502 and all hydrants shall be from one manufacturer.

C. Gate valves shall conform to AWWA C500.

D. Acceptable Manufacturers: As specified by the Maine Water Company.

E. Materials:
   1. Dry barrel type with a five (5) inch minimum valve opening.
   2. Two (2), 2-1/2 inch hose connections and one (1), 4-1/2 inch pumper connection.
      a. 2-1/2 inch outlets: 60o V threads, 7-1/2 threads to the inch, external threads 3-1/16 inches, O.D. National Standard threads.
      b. 4-1/2 inch outlet: four (4) threads to the inch, external threads 5-3/4 inches, O.D. National Standard threads.

c. Supply adapters if existing firefighting equipment does not match the threads specified above.
3. 150 pounds working pressure and 300 pounds hydrostatic test pressure.
4. Working parts shall be bronze and open counterclockwise unless otherwise specified.
5. Designed with standpipe breaking ring or breakable sections.
6. Caps shall be attached to hydrant body by chains.

F. Gate Valves: Waterworks type non-rising stem AWWA valve as specified in The Maine Water Company 'Water Main Extension Package'.

G. Valve Boxes:
1. Cast iron, minimum thickness 3/10 inch with the word "WATER" cast in covers.
2. Be of such length as required without full extensions.
3. As specified herein and as specified by the Maine Water Company

2.5 METERS

A. Water service meters to be provided and installed by the Maine Water Company.

2.6 ACCESSORIES

A. Tapping Sleeves:
1. Tapping sleeves are not allowed, unless approved by the Maine Water Company.

B. Insulating Joints
1. Provide a rubber-gasketed insulating joint or dielectric coupling between pipe of dissimilar metals which will effectively prevent metal-to-metal contact between adjacent sections of piping.

C. Bonded Joints
1. Contractor is to use bonded joints to maintain electrical continuity in metallic pipeline where cathodic protection is provided during construction or where it is anticipated that cathodic protection will be provided in the future.
a. For all ferrous pipe, provide a metallic bond at each joint, including joints made with flexible couplings, caulking, or rubber gaskets, of ferrous metallic piping to effect continuous conductivity. Provide Size 1/0 copper conductor thermal weld type bond wire designed for direct burial and shaped to stand clear of the joint.

D. Dielectric Fittings
1. Install dielectric fittings between threaded ferrous and nonferrous metallic pipe, fittings and valves, except where corporation stops join mains to prevent metal-to-metal contact of dissimilar metallic piping elements and compatible with the indicated working pressure.

E. Tracer Wire for Nonmetallic Piping
1. Provide bare copper or aluminum wire not less than 2.5 mm 0.10 inch in diameter in sufficient length to be continuous over each separate run of nonmetallic pipe.
2. Warning tape may be substituted for tracer wire with City of Rockland and Maine Water approval or as otherwise noted on the Drawings.

F. Water Service Line Appurtenances
1. Corporation Stops
a. Per Maine Water and City of Rockland standards and specifications; lead-free bronze, ASTM B61 or ASTM B62; compatible with the working pressure of the system and solder-joint, or flared tube compression type joint. Threaded ends for inlet and outlet of corporation stops, AWWA C800; coupling nut for connection to flared copper tubing, ASME B16.26.
2. Curb or Service Stops

a. Per the Maine Water Company and City of Rockland standards and specifications; made of lead-free bronze, ASTM B61 or ASTM B62; and compatible with the working pressure of the system.
b. Provide compatible ends for connection to the service piping.
c. Cast an arrow into body of the curb or service stop indicating direction of flow.

3. Service Clamps
   a. Provide service clamps used for repairing damaged cast-iron, steel or PVC pipe with a pressure rating not less than that of the pipe to be connected and either the single or double flattened strap type.
   b. Provide clamps with a galvanized malleable-iron body with cadmium plated straps and nuts and a rubber gasket cemented to the body.
4. Goosenecks
   a. Manufacture goosenecks from Type K copper tubing per the Maine Water Company and City of Rockland standards and specifications; provide joint ends for goosenecks compatible with connecting to corporation stop and service line.
   b. Where multiple gooseneck connections are required for an individual service, connect goosenecks to the service line, per Maine Water, through a compatible lead-free brass or bronze branch connection; the total clear area of the branches to be at least equal to the clear area of the service line.
5. Curb Boxes
   a. Provide a curb box, per the City of Rockland standards, for each curb or service stop of a size compatible for the stop on which it is to be used.
   b. The word "WATER" shall be cast on the lid.
6. Fire Department Connections (Siamese Connection)
   a. Provide freestanding, fire department connections with cast-bronze body, thread inlets according to NFPA 1963 and matching local fire department hose threads, threaded bottom outlet and match requirements of NFPA 24 and in accordance with the City of Rockland and applicable State standards and specifications.

2.7 BACKFLOW PREVENTERS

A. Reduced pressure principle type conforming to the applicable requirements AWWA C511.

B. Provide backflow preventers complete per City of Rockland and the Maine Water Company standards and Specifications.

C. The particular make, model/design, and size of backflow preventers to be installed must be included in the latest edition of the List of Approved Backflow Prevention Assemblies issued by the FCCCHR List and be accompanied by a Certificate of Full Approval from FCCCHR List.

D. Select materials for piping, strainers, and valves used in assembly installation that are galvanically compatible.
   1. Materials joined, connected, or otherwise in contact are to have no greater than 0.25 V difference on the Anodic Index, unless separated by a dielectric type union or fitting.

2.8 PROTECTIVE ENCLOSURES

A. Provide Freeze-Protection Enclosures that are insulated and designed to protect aboveground water piping, equipment, or specialties from freezing and damage.
   1. Consider the enclosure materials and ensure that the material is compatible with the environment.
   2. Aluminum enclosures are acceptable in most environments and are recommended for harsh environments and areas subject to vandalism.

B. Housing
   1. Reinforced and insulated aluminum or fiberglass construction (per City of Rockland and the

Maine Water Company standards and specifications); with anchoring devices for attaching housing to concrete base, access doors with locking devices, sized to allow access and service of the protected unit, drain openings, and an electric heating cable or heater with self-limiting temperature control.

2.9 DISINFECTION

A. Chlorinating materials are to conform to: Chlorine, Liquid: AWWA B301; Hypochlorite, Calcium and Sodium: AWWA B300.

B. Disinfect water distribution system per City of Rockland and the Maine Water Company standards and specifications.

PART 3 - EXECUTION

3.1 PRECAUTIONS

A. Connections to Existing System
   1. Perform all connections to the existing water system in the presence of the City of Rockland or the Maine Water Company representative.

B. Operation of Existing Valves
   1. Do not operate valves within or directly connected to the existing water system unless expressly directed to do so by the City of Rockland or the Maine Water Company representative.

3.2 INSTALLATION OF PIPELINES

A. General Requirements for Installation of Pipelines
   1. Submit manufacturer's instructions for pipeline installations.
   2. These manufacturer's instructions apply to all pipeline installation except as noted herein.

B. Location of Water Lines
   1. Terminate the work covered by this section at a point approximately five (5) feet from the building, unless otherwise directed by the Engineer.
   2. Where the location of the water line is not clearly defined by dimensions on the Drawings, do not lay water line closer horizontally than 10 feet from any sewer line.
   3. Where water lines cross under gravity sewer lines, construct sewer line of AWWA - compliant ductile iron water piping with rubber-gasketed joints and no joint located within 10 feet horizontally of the crossing.
   4. Lay water lines which cross sewer force mains and inverted siphons at least two (2) feet above these sewer lines; when joints in the sewer line are closer than three (3) feet horizontally from the water line relay the sewer line to ensue no joint closer than three (3) feet.
   5. Do not lay water lines in the same trench with gas lines, fuel lines, electric wiring, or any other utility.
   6. Do not install copper tubing in the same trench with ferrous piping materials.
      a. Where nonferrous metallic pipe, e.g. copper tubing, cross any ferrous piping, provide a minimum vertical separation of 12-inches between pipes.
   7. Where water piping is required to be installed within three (3) feet of existing structures, sleeve the water pipe as follows:
      a. Provide ductile-iron or Schedule 40 steel sleeves.
      b. Fill annular space between pipe and sleeves with mastic.
      c. Install the water pipe and sleeve ensuring that there will be no damage to the structures and no settlement or movement of foundations or footings.

C. Water Piping Installation Parallel with Sewer Piping

1. Normal Conditions:
   a. Lay water piping at least 10-feet horizontally from a sewer or sewer manhole.
   b. Measure the distance between pipes from inside edge of outer wall to the inside edge of outer wall.
   c. Provide at least 18-inches above the top (crown) of the sewer piping and the bottom (invert) of the water piping.
   d. The sewer piping is to be constructed of AWWA-compliant water pipe and pressure tested in place without leakage prior to backfilling where this vertical separation cannot be obtained.
   e. Shop drawings for the wastewater disposal method are required.
   f. Test the sewer manhole in place to ensure watertight construction.

D. Installation of Water Piping Crossing Sewer Piping
   1. Normal Conditions:
      a. Provide a separation of at least 18-inches between the bottom of the water piping and the top of the sewer piping in cases where water piping crosses above sewer piping.
   2. Unusual Conditions:
      a. When local conditions prevent the vertical separation described above, construct sewer piping passing over or under water piping of AWWA-compliant ductile iron water piping, pressure tested in-place without leakage prior to backfilling.
      b. Protect water piping passing under sewer piping by providing a vertical separation of at least 18-inches between the bottom of the sewer piping and the top of the water piping; provide adequate structural support for the sewer piping to prevent excessive deflection of the joints and the settling on and breaking of the water piping; and that the length, minimum 20-feet, of the water piping be centered at the point of the crossing so that joints are equidistant and as far as possible from the sewer piping.

E. Sewer Piping or Sewer Manholes
   1. No water piping is to pass through or come in contact with any part of a sewer manhole.

F. Earthwork
   1. Pipe Laying and Jointing:
      a. Remove fins and burrs from pipe and fittings.
      b. Before placing in position, clean pipe, fittings, valves, and accessories, and maintain in a clean condition.
      c. Provide proper facilities for lowering sections of pipe into trenches.
      d. Under no circumstances is it permissible to drop or dump pipe, fittings, valves, or other water line material into trenches.
      e. Cut pipe cleanly, squarely, and accurately to the length established at the site and work into place without springing or forcing.
      f. Replace a pipe or fitting that does not allow sufficient space for installation of jointing material.
      g. Blocking or wedging between bells and spigots is not permitted.
      h. Lay bell-and-spigot pipe with the bell end pointing in the direction of laying.
      i. Grade the pipeline in straight lines; avoid the formation of dips and low points.
      j. Support pipe at the design elevation and grade.
      k. Secure firm, uniform support.
      l. Wood support blocking is not permitted.
      m. Lay pipe so that the full length of each section of pipe and each fitting rests solidly on the pipe bedding; excavate recesses to accommodate bells, joints, and couplings.
      n. Provide anchors and supports for fastening work into place.
      o. Make provision for expansion and contraction of pipelines.
      p. Keep trenches free of water until joints have been assembled.
      q. At the end of each work day, close open ends of pipe temporarily with wood blocks or bulkheads.
      r. Do not lay pipe when conditions of trench or weather prevent installation.

s. Provide a minimum of five (5) feet depth of cover over top of pipe unless otherwise indicated or approved of by the Engineer or Maine Water representative.
t. Where cover depth is not attained, provide two (2) inches (minimum) of rigid insulation per City of Rockland and Maine Water standards and specifications.

G. Installation of Tracer Wire
1. Install a continuous length of tracer wire for the full length of each run of nonmetallic pipe.
2. Attach wire to top of pipe in such manner that it will not be displaced during construction operations.

H. Connections to Existing Water Lines
1. Make connections to existing water lines after coordination with the Maine Water Company and the City of Rockland and with a minimum interruption of service on the existing line.
2. Make connections to existing lines under pressure in accordance with the recommended procedures of the manufacturer of the pipe being tapped and as indicated, except as otherwise specified, tap concrete pipe in accordance with AWWA M9 for tapping concrete pressure pipe.

I. Penetrations
1. Provide ductile-iron or Schedule 40 steel wall sleeves for pipe passing through walls of valve pits and structures.
2. Fill annular space between walls and sleeves with rich cement mortar.
3. Fill annular space between pipe and sleeves with mastic.

J. Flanged Pipe
1. Only install flanged pipe aboveground or with the flanges in valve pits.

K. Special Requirements for Installation of Water Lines
1. Installation of Ductile-Iron Piping
a. Assembling Joints:
i. Push-on Joints:
(1) Insert the gasket into the groove of the bell.
(2) Uniformly apply a thin film of special lubricant over the inner surface of the gasket that will contact the spigot end of the pipe.
(3) Insert the chamfered end of the plain pipe into the gasket and push until it seats against the bottom of the socket.
ii. Bolted Joints:
(1) Remove rust preventive coatings from machined surfaces prior to assembly.
(2) Thoroughly clean and carefully smooth all burrs and other defects from pipe ends, sockets, sleeves, housings and gaskets.
iii. Flanged Joints:
(1) Insert the nuts and bolts (or studs), finger tighten, and progressively tighten diametrically opposite bolts uniformly around the flange to the proper tension.
(2) Execute care when tightening joints to prevent undue strain upon valves, pumps, and other equipment.
iv. Mechanical Joints:
(1) Thoroughly clean, with a wire brush, surfaces that will be in contact with the gaskets.
(2) Lubricate the gasket, bell, and spigot by washing with soapy water.
(3) Slip the gland and gasket, in that order, over the spigot and insert the spigot into the bell until properly seated.
(4) Evenly seat the gasket in the bell at all points, center the spigot, and firmly press the gland against the gasket.
(5) Insert the bolts, install the nuts finger tight, and progressively tighten diametrically opposite nuts uniformly around the joint to the proper tension with a torque wrench.
(6) The correct range of torque (as indicated by a torque wrench) and the length of wrench (if not a torque wrench) shall not exceed:

(a) Range or Torque: 60-90 ft.-lbs.
(b) Length of Wrench: 10 inches.
(7) If effective joint sealing is not attained at the maximum torque specified above, disassemble, thoroughly clean, and reassemble the joint. Do not overstress the bolts to tighten a leaking joint.

v. Bell and Spigot Joints:
(1) Thoroughly clean the bell and spigots and remove excess tar and other obstructions.
(2) Insert the spigot firmly into place and hold securely until the joint has been properly completed.

b. Fabrication:
i. Tapped Connections:
(1) Make all tapped connections as shown on the Drawings or as required by the Engineer.
(2) Make all connections watertight and of adequate strength to prevent pullout.
(3) Drill and tap normal to the longitudinal axis of the pipe.
(4) The maximum sizes of taps in pipes and fittings without busses shall not exceed the sizes listed in the appendix of ANS A2l.5l based on two (2) full threads for ductile iron.

ii. Cutting:
(1) Perform all cutting as set forth in AWWA C600.
(2) Carefully chamfer all cut ends to be used with push-on joints to prevent damage to gaskets when pipe is installed.

c. Pipe Deflection:
i. Push-on and Mechanical Joints:
(1) The maximum permissible deflection of alignment at joints shall be limited to that given in AWWA C600.

ii. Flexible Joints:
(2) The maximum deflection in any direction shall not exceed the manufacturer's instructions and recommendations.

L. Installation of Polyethylene (PE) Piping
1. Install PE pipes in accordance with AWWA M55 and ASTM D2774 and the Maine Water Company standards and specifications.

M. Fire Protection Service Lines for Sprinkler Supplies
1. Connect water service lines used to supply building sprinkler systems for fire protection to the water distribution main in accordance with NFPA 24.

N. Pipe Anchorage Installation
1. Provide thrust blocks where indicated.
2. Use concrete, ASTM C94/C94M, having a minimum compressive strength of 2,500 psi at 28 days; or use concrete of a mix not leaner than one (1) part cement, 2 ½ half parts sand, and five (5) parts gravel, having the same minimum compressive strength.
3. Provide restrained joints in accordance with NFPA 24, Chapter 10 and in accordance with ASTM F1674.
4. Provide metal harness fabricated by the pipe manufacturer and furnished with the pipe per NFPA 24.

O. Installation of Valves
1. Installation of Gate Valves
a. Install gate valves, AWWA C500 and UL 262, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C500.
b. Install gate valves, AWWA C509 or AWWA C515, in accordance with the requirements of AWWA C600 for valve-and-fitting installation and with the recommendations of the

Appendix ("Installation, Operation, and Maintenance of Gate Valves") to AWWA C509 or AWWA C515.

c. Install gate valves on PVC and PVCO water mains in accordance with the recommendations for appurtenance installation in AWWA M23, Chapter 7, "Installation."
d. Make and assemble joints to gate valves as specified for making and assembling the same type joints between pipe and fittings.

P. Installation of Check Valves
1. Install check valves in accordance with the applicable requirements of AWWA C600 for valve-and-fitting installation, except as otherwise indicated by Maine Water or the City of Rockland.
2. Make and assemble joints to check valves as specified for making and assembling the same type joints between pipe and fittings.

Q. Installation of Air Release, Air/Vacuum, and Combination Air Valves
1. Install pressure vacuum assemblies of type, size, and capacity indicated.
2. Include valves and test cocks.
3. Install according to the requirements of the City of Rockland and Maine Water.
4. Do not install pressure vacuum breaker assemblies in vault or other space subject to flooding.

R. Installation of Fire Hydrants
8. Installation
a. Install hydrants as shown in the details and using manufacturer's written instructions.
b. No hydrant assembly shall be backfilled until approved by the Engineer.
c. Provide drainage material and thrust blocks as shown.
d. Provide barrel extensions as required for hydrant to be installed at proper grade.
e. Provide finish paint on all exposed surfaces. Color shall meet City of Rockland requirements as approved by the Maine Water Company.
9. Cleaning
a. Clean all hydrants of concrete, etc. and repaint as necessary to the satisfaction of the City or Rockland.

S. Installation of Water Service Piping
1. Location:
a. Connect water service piping to the building service where the building service has been installed.
b. Where building service has not been installed, terminate water service lines approximately five (5) feet from the building line at the points indicated; close such water service lines with plugs or caps.
2. Service Line Connections to Water Mains
a. Connect service lines less than three (3) inches in diameter to the main by a rigid connection or a corporation stop and gooseneck and install a service stop below the frostline as indicated.
b. Connect service lines three (3) inches and bigger in size to the main with a rigid connection and install a gate valve on service line below the frostline as indicated.
c. Connect service lines to ductile-iron water mains in accordance with AWWA C600 for service taps.
d. Connect service lines to PVC plastic water mains in accordance with UBPPA UNI-PUB-08 and the recommendations of AWWA M23, Chapter 9, "Service Connections."
e. Connect service lines to concrete water mains in accordance with the recommendations of AWWA M9, "Tapping Concrete Pressure Pipe."
f. Connect service lines to steel water mains in accordance with the recommendations of the steel water main pipe manufacturer and with the recommendations for special and valve connections and other appurtenances in AWWA M11, Chapter 13, "Supplementary Design Data and Details."

T. Installation of Meters
   1. Meters are to be provided and installed by Maine Water.

U. Installation of Backflow Preventers
   1. Install backflow preventers of type, size, and capacity indicated in the Drawings or as directed by Maine Water.
   2. Include valves and test cocks as directed by Maine Water.
   3. Install according to requirements of the City of Rockland and Maine Water.
   4. Support NPS 2 1/2 inch and larger backflow preventers, valves, and piping near floor with 12-inch minimum air gap, and on concrete piers or steel pipe supports.
   5. Do not install backflow preventers that have a relief drain in vault or in other spaces subject to flooding.
   6. Do not install by-pass piping around backflow preventers.

V. Installation of Protective Enclosures
   1. Install protective enclosure over valve and equipment as indicated in the Drawings or as directed by Maine Water or the City of Rockland.
   2. Anchor protective enclosure to concrete base.

W. Final Testing, Disinfection, and Commissioning
   1. Final water main testing work includes the performance of testing and inspecting each and every length of water main pipe, fittings, accessories, and each item of appurtenant construction.
   2. Perform testing at a time acceptable to the Engineer, which may coincide with the completion of a substantial and convenient section of the work, or after the completion of all pipe laying operations.
   3. Provide all labor, pumps, pipe, connections, gages, measuring devices and all other necessary apparatus to conduct tests.
   4. All water main, fittings, valves, assemblies, and appurtenant work, in order to be eligible for acceptance by the City of Rockland representative, shall be subjected to tests that will certify conformance with published standards for pressure handling capacity, leakage, and operability and shall be adequately disinfected.
   5. To ensure readiness for service after testing, thoroughly clean and flush all lines to be tested prior to initiating test procedures.
   6. Contractor shall furnish a tap for pressure and leak testing and chlorination as part of this work, unless other means are used with the consent of The Maine Water Company. The chlorine tap (or the relief point in a counterflow arrangement) shall be installed within ten feet of the connection to the existing main if practical. Otherwise, install the tap immediately outside of existing pavement. The Contractor is responsible for all work associated with the tap, including proper trench protection, barricades, traffic control and proper backfilling and compaction upon successful completion of the test.
   7. Perform testing by methods determined by or acceptable to the City of Rockland representative. Provide notice and perform all tests and inspections in the presence of the Owners Representative and The Maine Water Company in accordance with the requirements specified herein. Do not operate existing valves. Request assistance or permission from The Maine Water Company.
   8. Remedial Work:
      a. Perform all work necessary to correct deficiencies discovered as a result of testing and/or inspections. Replace defective or damaged components at no additional cost to the owner.
      b. Completely retest all portions of the original construction on which remedial work has been performed.
      c. Perform all remedial work and retesting in a manner and at a time acceptable to by the Owner at no additional cost to the Owner.
   9. Filling:
      a. Fill previously prepared pipes after backfilling in complete with water from the municipal system. The method of connection to the supply shall be acceptable to The Maine Water

Company. In no case shall the connection cause harm to the existing system by cross contamination. Whenever possible, the water system adjacent to the work shall be flushed prior to the filling, flushing testing, and disinfection of the new lines.

b. Fill evenly and slowly to the satisfaction of The Maine Water Company, ensuring that all air has been expelled from the main, hydrants, air valves, and service leads.

10. Flushing:
    a. Flush the new main at a minimum velocity of 2.5 feet per second for a minimum of 4 hours to remove any particulate matter. The scour flow rate in GPM shall be computed and demonstrated to the satisfaction of The Maine Water Company. The contractor shall dechlorinate where indicated, dispose of all flushing water; this work includes protection of traffic and all steps to prevent any erosion, to include temporary erosion control measures.
11. Pressure Tests:
    a. Perform tests after filling and flushing to determine tightness in accordance with ASTM C600-82. Perform the test in the presence of the City of Rockland representative with notification at least 24 hours in advance of the proposed testing.
    b. Purge all air from the line to be tested.
    c. Decrease pressure in the line to be tested to register a gauge reading 20 psig less than the system pressure in the surrounding system. Observe the test gauge for at least 15 minutes to ensure pressure does not drop and system connections do not leak into the test line, permitting possible cross-connection contamination.
    d. Initiate test pumping with a fixed, known quantity of water in the test pump supply reservoir. Ensure that all makeup water for the test pump is taken from the reservoir. Build system pressure slowly, arriving at 150 psig and stabilizing (+/- 2 psig) for at least 15 minutes. Record reservoir level or gallonage so that consumption can be accurately computed.
    e. Maintain 150 psig pressure for at least one (1) hour, drawing water as required to maintain the test pressure from the supply reservoir only.
    f. After one (1) hour, carefully record the reservoir level or gallonage and calculated water drawn. Allowable leakage in gallons per hour shall be as specified by the Maine Water Company, but in no case shall allowable leakage be more than the product of the test segment length (in inches) multiplied by the nominal diameter (in inches) (or sum of the test segment lengths by their respective widths) divided by 10,900.
    g. If any test discloses leakage greater than that specified above, the Contractor shall, at his own expense, locate and make repairs as necessary until the leakage is within the specified allowance. No repair clamps of any kind will be allowed. Repair shall consist of no less than removing the leaking section and replacing with couplings and pipe.
12. Cleanliness and Disinfection:
    a. This specification outlines the minimum work required. Test results from samples indicating no contamination of the lines, a performance criteria, will determine satisfactory completion of these requirements.
    b. Pipes shall be handled at all times in accordance with the provisions of this section.
    c. Disinfection shall be disinfected in accordance with AWWA C-600. Residual chlorine levels shall be in accordance with the requirements of the Maine Water Company, but in no case shall be less than 50 mg/l or more than 100 mg/l. Disinfect with a liquid solution of sodium hypochlorite introduced by continuous feed method to achieve the specified concentration. The concentration shall be achieved throughout the system or line. The line shall remain charged with the heavily chlorinated water for a period of 24 hours. At the end of the 24-hour time period, the residual in any part of the line shall be no less than 10 mg/l.
13. Flushing and Analytical Testing:
    a. Flush heavily chlorinated water from the system, consistent with the provisions of this section for sufficient duration so that residual chlorine concentration is the same as the adjacent system. Control, capture, and/or dechlorinate flushwater as may be required.
    b. After flushing, wait a minimum of 24-hours, and provide analytical testing with one test per 500 feet of main installed. Each sample shall be properly handled and analyzed by a state certified laboratory. Testing shall be for total coliform. Any positive sample shall require retesting of the entire system.
14. Placing in service:

a. All inspection logs, tests, reports, lab results, and the approval of the Maine Water Company shall be secured before a line is placed in service. The Maine Water Company will be notified of the specific date and time the line is to be placed in service. The section of pipe to be placed in service will be flushed within four (4) hours prior to activation.

3.3 FIELD QUALITY CONTROL

A. Field Tests and Inspections
   1. Notify Maine Water and the City of Rockland a minimum of five (5) days in advance of hydrostatic testing.
   2. Coordinate the proposed method for disposal of wastewater from hydrostatic testing with the City of Rockland Pollution Control Facilities.
   3. Perform field tests, and provide labor, equipment, and incidentals required for testing.
   4. Provide documentation that all items of work have been constructed in accordance with the Contract documents.
   5. Do not begin testing on any section of a pipeline where concrete thrust blocks have been provided until at least five (5) days after placing of the concrete.
   6. After installation conduct Backflow Preventer Tests and provide test reports to Maine Water verifying that the installation meets the FCCCHR Manual Standards.

B. Special Testing Requirements for Fire Service
   1. NFPA 24 requires a minimum test pressure of 1400 kPa 200 psi or 375 kPa 50 psi in excess of the system working pressure.
   2. Where water mains or water service lines provide fire service or water and fire service, they must be tested in accordance with NFPA 24.
   3. Test water mains and water service lines providing fire service or water and fire service in accordance with NFPA 24.
   4. The additional water added to the system must not exceed the limits given in NFPA 24

C. Tracer Wire Continuity
   1. Test tracer wire for continuity after service connections have been completed and prior to final pavement or restoration.
   2. Verify that tracer wire is locatable with electronic utility locating equipment.
   3. Repair breaks or separations and re-test for continuity.

3.4 CLEANUP

A. Upon completion of the installation of water lines and appurtenances, remove all debris and surplus materials resulting from the work.

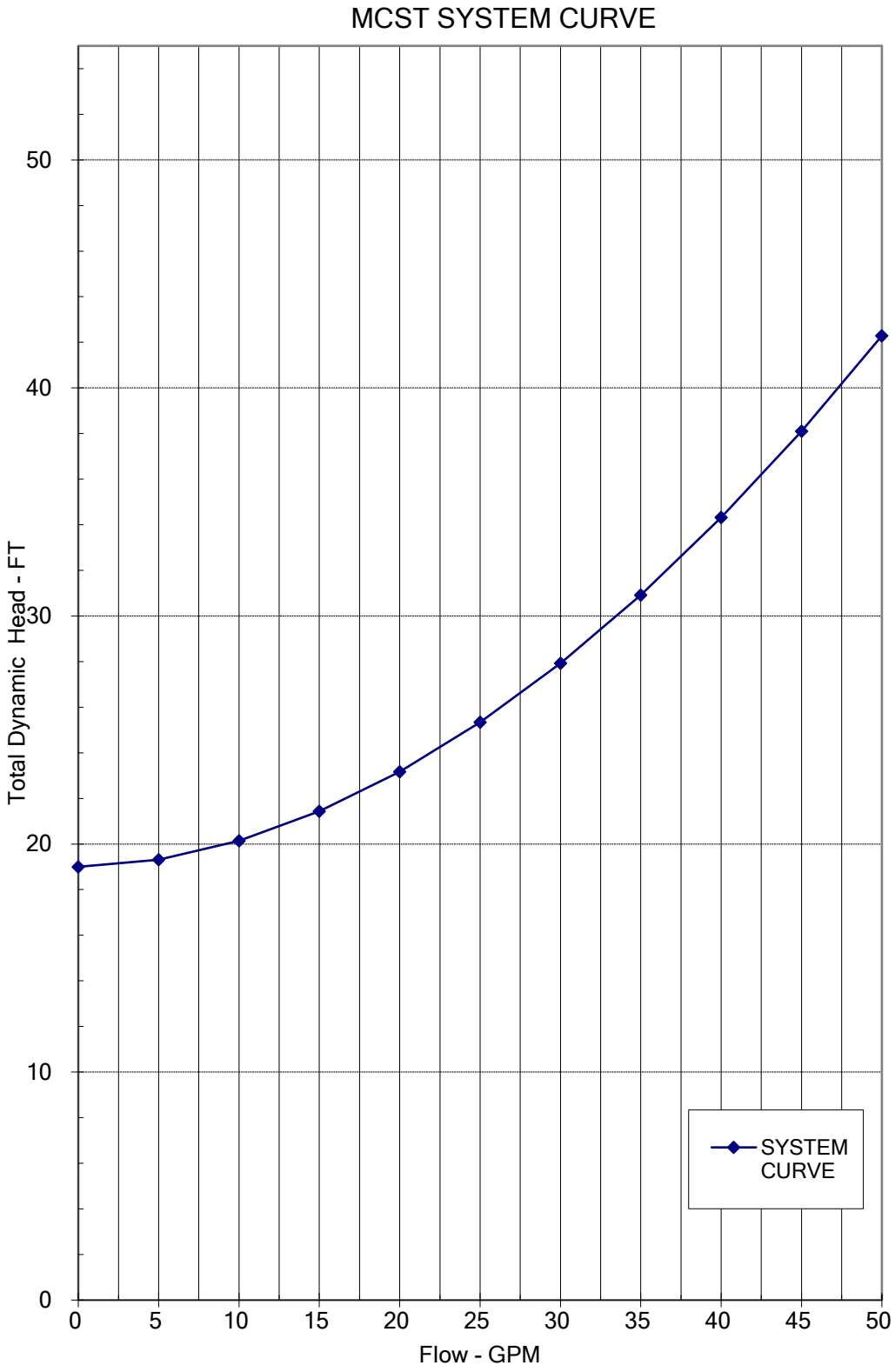
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SECTION 33 32 13.13
PACKAGED SEWAGE LIFT STATIONS

PART 1 - GENERAL

A. Product Type: Precast packaged duplex sewage pump station complete from one vendor to form a complete integrated pump and control system as shown on plan. System shall be a complete functional system, capable of providing the following performance:
   1. Discharge Flow Rate (single pump) 30 GPM or best efficiency at system TDH.
   2. Pump System: Duplex, alternating lead/lag. Programmable pumping operation; basic operation to be draw down. Control-control operation shall operate motor actuated normally open ball valves on pump discharge lines to closed position prior to pump operation and again after pump operation.
   3. Controls are to be remote mounted in a Nema IV stainless steel enclosure, with power, branch protection, W
   4. Wet well appurtenances as required to furnish a complete system, to include: level control, brackets, stilling wells with mount system, pump anchorage mounts, noncorrosive piping, fittings, junction boxes, and electrical devices. All appurtenances are to be stainless steel (ss) or non-corrosive (nc).
   5. Size of wet well 6’ nominal, to be based on acceptable cycling of wet well pump. Precast manufacturer or pump vendor shall certify suitability of wet well size or furnish required size.
   6. Anti-flotation design to resist empty wet well buoyancy given groundwater level condition equal to finished grade.
   7. Pump station system accessories to include vent with carbon canister, any necessary disconnects, hatches and confined space signage.
   8. Pumps shall be furnished in wet well with six (6) inch PVC screened stilling wells, stilling well support brackets, pipe supports, union connection, pump accessories including thrust restraints, spacers, lifting cable, power leads and nema 4x junction box, disconnects as may be required by code, and associated appurtenances.
   9. Pump shall be Goulds or equal, all stainless pump end and motor.

B. Performance, Pump Selection and System Curve: Vendor shall furnish effluent pumps in conformance with the performance criteria:
   1. 3 Phase, 460 V (per electrical spec, submersible pump motors, continuous duty)
   2. Pump motors shall be non-overloading throughout the entire range of the pump curve (from shut-off head to the end of the curve).
   3. Grinder pumps shall be provided, motors shall have minimum 2 HP motor rating.
   4. Pump performance: Best efficiency at or near 30 GPM @ 28’ TDH.


MCST SYSTEM CURVE
Total Dynamic Head - FT
0
10
20
30
40
50
0
5
10
15
20
25
30
35
40
45
50
Flow - GPM
SYSTEM CURVE

PART 2 - EXECUTION

2.1 EXAMINATION

A. Refer to and comply with rules and specifications as promulgated by State of Maine DHS.

B. Verify that actual pump selected by pump vendor will operate at sufficient flow to create a force main velocity in the range of two (2) to three (3) fps for the project as constructed.

C. Verify that all inverts as constructed coordinate with the Drawings and Contract Documents.

2.2 PREPARATION

A. Have all materials on hand to complete phased work operations without delay to avoid open trenches and exposed soils.

B. Hand trim excavations to required elevations. Correct over excavation with compacted crushed stone or coarse aggregate.

C. Remove large stones or other hard matter that could damage structures or piping or impede consistent backfilling or compaction.

2.3 BEDDING

A. Excavate in accordance with the appropriate section. Hand trim excavation for accurate placement of pump station base course elevations indicated.

B. Place bedding material at trench bottom, level materials in continuous layer not exceeding six (6) inches compacted depth. Bed with one (1) inch crushed stoned.

C. Maintain optimum moisture content of bedding material to attain required compaction density.

2.4 INSTALLATION - PUMP STATION

A. Install precast concrete pump station, pipe, fittings, appurtenances, control panel, and accessories in accordance with City of Rockland Specifications (Provided in the following Subsections), the referenced standards and manufacturer's instructions to the lines and grades indicated in the Contract Documents.

B. Seal joints watertight.

C. Set frame and hatch cover to grade and protect from damage or water infiltration.

D. Install aggregate at sides and over top of pipe. Provide top cover to minimum compacted thickness as specified sides and over top of pipe. Provide top cover to minimum compacted thickness as specified within construction drawings.

2.5 FIELD QUALITY CONTROL

A. Request inspection prior to backfilling.

B. Compaction testing will be performed in accordance with ANSI/ASTM D1557, ANSI/ASTM D698, AASHTO T180., and ASTM D2922.

C. Leak test to leakage standards for manholes.

D. If inspections indicate work does not meet specified requirements, remove work, and replace.

2.6 PROTECTION

A. Protect all completed work. Protect exposed pipe, conduit, appurtenances, and aggregate cover from damage or displacement until backfilling operation is in progress.

SUBSECTION 13440 INSTRUMENTATION AND PROCESS CONTROL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. Furnish, install and test the complete (factory built) Packaged Sewage Lift Station and all appurtenances necessary to make a complete and operable system as indicated in the Contract Documents and in accordance with the City of Rockland, Water Pollution Control Facility.

1.2 REFERENCES

A. City of Rockland – Standard Specifications Related to Construction of Sanitary Sewers, Pump Stations and Appurtenances

B. Maine Wastewater Disposal Rules

C. National Sanitary Foundation

D. ANSI/ASTM D1557, ANSI/ASTM D698, AASHTO T180 and ASTM D2922.

E. National Electric Code, current edition

1.3 QUALITY ASSURANCE

A. General:
   1. The Contract Documents do purport to cover all components of design. The Contractor shall furnish materials and equipment required to complete the Work described herein.
   2. Equipment design, construction and installation shall be in accordance with the standards of the Hydraulic Institute.
   3. All equipment and accessories shall be the approved manufacturer's latest and proven design.
   4. All equipment and accessories shall be designed for the intended use with uninterrupted service.
   5. Replacement parts shall be provided as indicated in the Contract Documents. Contractor shall furnish replacement part information sufficient for Owner to acquire parts without conflict.

B. Qualifications of the Manufacturer:
   1. Minimum of 5-years' experience in the design and manufacture of packaged sewage lift Stations.
   2. The packaged sewage lift station complete with all appurtenances and equipment shall be provided by one (1) manufacturer regardless of individual component supply chains.

1.4 SUBMITTALS TO THE ENGINEER

A. The Contractor shall submit the following for City's review:
   1. Complete construction details illustrating all dimensions and manufacturers' instructions.
   2. A Shop Drawings Submittal Package including all manufacturer's literature, maintenance data, operating instructions and list of maintenance materials.
   3. Pump manufacturer's performance curves showing total dynamic head, pump input horsepower and pump efficiency over the specified capacity range of each pump.
   4. Submit calculations demonstrating the pump station has a factor of safety of at least 1.15 against flotation assuming the groundwater level is at finish grade and the wet well is empty.
   5. Submit confirmation the environmental operating conditions of all components will be adequately met by the enclosure.
   6. Letters from the manufacturer stating they have reviewed the intended function and operational conditions, determined all conditions to be acceptable and found no conditions which would cause the warranty to be void, or the equipment to function improperly or not meet the performance requirements.

B. Prior to shipment, the completed pump and motor assemblies shall be shop tested for performance in accordance with all applicable standards of the Hydraulic Institute and certified copies of the pump and motor performance data furnished.

1.5 GUARANTEE

A. The Contractor shall obtain a warranty by the packaged sewage lift station manufacturer, in the name of the Owner.

B. The Contractor shall obtain a 5-year (10,000 Hour) prorated warranty from the pump manufacturer, in the name of the Owner, against defects in workmanship and materials, covering parts and labor. The terms of the warranty shall be from the date of substantial completion as determined by the City of Rockland and as follows:

0-18 Months (3000 hours)	100%
19-39 Months (6500 hours)	50%
40-60 Months (10,000 hours)	25%

C. The Contractor shall obtain a 5-year warranty from the access hatch manufacturer, in the name of the Owner, against defects in workmanship and materials, covering all parts and labor.

PART 2 - PRODUCTS

2.1 GENERAL

A. Pumping units shall draw raw, unscreened sewage from a wet well and discharge into a force main against a total dynamic head as specified by the Project Engineer.

B. The pumps shall be controlled automatically actuated by the change in wet well level. All equipment for the station shall perform automatically.

C. The pump station shall consist of a wet well and valve pit in which the following principal items of equipment shall be installed: sewage pumps, slide rail system, valves, gauges, portable davit crane, internal piping, piping connecting the wet well and valve pit, automatic level controllers,

and all internal wiring. The main control panel, circuit breakers, motor starters, and alarm system are specified

2.2 INSTRUMENTATION AND PROCESS CONTROL

A. Description
   1. A single instrumentation supplier shall furnish all services and equipment as specified herein.
   2. Instrumentation supplier shall provide all labor, materials, equipment, operations. methods and procedures as indicated in the Contract Documents to achieve a fully integrated and operational system, together with all items necessary for, or incidental to, the completion of the Work.
   3. All systems indicated in the Contract Documents, shall mean all necessary supervision, labor, equipment and materials required to provide complete, properly functioning systems.
   4. All systems shall be adjusted, tested, inspected and turned over to the Owner in perfect working order.
   5. The words *"provide," "supply," "supply and install," "install," "furnish,"* or *"furnish and install"* shall mean a complete and properly functioning installation performed by the Contractor.
   6. Refer to the Contract Documents for coordination of material and equipment locations.

B. Work Included:
   1. New Instrumentation:
      a. Furnish and install the instrumentation as shown on the Contract Documents and required by pump station manufacturers.
   2. Equipment Control:
      a. Provide equipment control or connection to control, status indication and alarm annunciation of equipment as shown in the Contract Documents, required by the pump station manufacturers.
   3. Control Panels:
      a. Furnish and install new Control Panels as described herein.
      b. Control panels shall be constructed in conformance with UL 508A and bear the UL 508A seal confirming the construction. UL inspection and seal application can be accomplished at the panel fabrication facility or by field inspection by UL inspectors.
      c. Control Panel(s) and all assembles components shall be UL approved as a complete package.
      d. Coordinate with the manufacturers of supplied equipment for specific instrumentation and control requirements. Any deviation in instrumentation or electrical required for supplied equipment will be provided at no additional cost to the Owner.
   4. Telemetry System:
      a. Furnish and install a new wireless I/0 Remote Telemetry Unit (RTU) at the Pump Station to transmit status, alarms, wet well level, and flow to the SCADA system as specified in Subsection 13445.
      b. This work will include required modifications to the City's existing telemetry system and SCADA system (including all required programming and hardware) to provide for a complete remote control and monitoring system
   5. Miscellaneous:

a. Furnish and install all transducers, converters, terminals, transformers, interposing or pilot relays (for both new and existing equipment), signal transmitters, signal splitters/boosters, power supplies, power supply connections and other miscellaneous instrumentation required to make a complete system.
b. Furnish and install all vendor or manufacturer wires and appurtenances between primary instruments and the transmitters, receiving instruments or destination terminals. All methods, materials and supplies will be in accordance with City of Rockland, standards.
c. Furnish mounting hardware for each instrument. The System Integrator will provide information on the proper installation for each instrument and shall supervise the installation. Furnish and install tubing from each process connection to the primary instrument. Process taps and an isolation valve will be provided in accordance with City of Rockland, Water Pollution Control Facility. Coordinate the size and type of connection required.

6. Acceptance Testing:
   a. A Factory Acceptance Test will be performed on each control panel prior to being delivered to the site. The Factory Acceptance Test requirements are described herein
   b. A Site Acceptance Test will be performed each control panel after the installation at each site. The Site Acceptance Test requirements are described herein.
7. O&M Documentation:
   a. Provide complete O&M documentation as identified in the Contract Documents including panel diagrams, point to point ISA S5.4 diagrams, O&M Manuals, PLC programs, and operator terminal files bound into Volumes.
8. Demolition:
   a. Remove and/or relocate existing equipment as indicated on the Drawings. Deliver items not reused to Owner.
9. Coordination:
   a. ~~Process Instrumentation and Process Control Systems will be provided by Division 11, where specified.~~ The systems integrator shall coordinate with the instrumentation and control systems ~~provided under these sections~~.
   b. The systems integrator shall provide protocols for communication between all control panels provided under this project and in accordance with the City of Rockland, Pollution Control Facility.~~, existing PLC- based control panels and any PLC-based control panels provided under Division 11~~.
   c. ~~Conduit and wiring (not including integral or vendor furnished cables) will be provided under Division 16 and shown on the Drawings.~~ Provide ISA S5.4 or equivalent loop diagrams to be used by the electrical subcontractor to properly terminate the wiring at each control panel, transmitter or other instrumentation device provided under this section.
   d. Provide manufacturer recommended installation and mounting requirements for each instrument to be connected to process equipment, piping or fittings requiring a process connection such as NPT taps, sample piping and process line insertion. The systems integrator will supervise and provide guidance on proper installation of instrumentation equipment.
10. Service calls and additional programming:
    a. The system integrator shall provide one (1) day of service call as described herein.
    b. The programmer shall provide three (3) days of additional programming as described in Subsection 13442.

C. Tests and Procedures Prior to Start-up:
1. The Contractor shall coordinate the work of the system manufacturer's service personnel as necessary. This shall include the installation, interconnection, testing, and calibration of the instruments, and the scheduling of the manufacturer's service personnel.
2. The supervisory services of a factory-trained service engineer/technician, who is specifically trained on the type of equipment specified herein, shall be provided during construction to assist the Contractor or Subcontractor in the location of sleeves; methods of installing conduit and special cable; mounting, piping, and wiring of one (1) of each type of device, and the methods of protecting all of the equipment prior to placing it into service. Upon completion of the installation, the services a trained service engineer/technician calibration and startup the equipment in the presence of the City of Rockland Department of Pollution Control personnel, and provide instruction and training for the operating personnel. A sufficient number of service days shall be provided to place the system in satisfactory operation. One (1) additional service call of one (1) eight (8) hour working day (not including travel time) shall be included for use upon demand of the Owner within the first year's operation.

D. Demonstration of Complete Instrumentation and Process Control System:
1. The Owner will assume no liability or responsibility for any portions of the installation until they are demonstrated and accepted in writing. Final demonstrations shall be made only after the City is satisfied that the work has been completed in accordance with the intent of the Contract Documents.
2. After the Instrumentation and Process Control System is completed, and at the City's convenience, demonstrate the total system operation and make final adjustments to the system. If any system or piece of equipment within a system fails to function properly, rectify such defects or inadequacies and make a final demonstration to the satisfaction of the City.
3. Provide the services of authorized manufacturers' representatives to instruct the Owner's representatives in the proper operation of each partial or complete system installed under this Contract.
4. Pay all charges or fees, including the cost of any special test equipment, factory engineers, etc., necessary for the proper performance of the specified tests, demonstrations and instructions.
5. All demonstrations and instructions referred to shall be scheduled at the convenience of the City of Rockland and the Owner and in no case, shall be scheduled without at least 72-hours written notice.

E. Removals, Relocations and Rearrangements:
1. ~~Examine the existing site for the work of all trades, which will influence the cost of the work under Division 13.~~ This work shall include removals, relocations and rearrangements relating to the work of all trades which may interfere with, disturb or complicate the performance of the W~~w~~ork ~~under Division 13~~; and relating to the work involving systems, equipment and related service lines which shall continue to be utilized as part of the finished project.

2.3 CONTROL SYSTEM TESTING

A. Tests Procedures Prior to Start-up:
1. Factory Acceptance Test (FAT): A Factory Acceptance Test and verification for all deliverable equipment, software, and associated documentation shall be performed prior to shipment of control systems. The factory tests shall be performed to verify that the

control systems are manufactured and assembled correctly, are operating as designed, and are in compliance with the contractual requirements for the deliverables.

2. The Factory Acceptance Test shall include verification and integrated testing of all components. These tests shall include the following:
   a. Visual Inspections: The following inspection checks shall be performed on all deliverable hardware items, as a minimum:
      1) I/0 Subsystem physical layout
      2) Power supply mounting
      3) Power cable routing
      4) Data cable routing
      5) Wiring runs properly installed
      6) Fans and blowers are unobstructed
      7) Power supply and power conditioning equipment correctly installed
      8) Wire numbering and color coding
      9) Device labeling
      10) Enclosure integrity
      11) Paint work

B. I/0 Point Checkout:

1) The instrumentation supplier shall perform a complete checkout for every I/0 point from the field wiring terminal strip to the operator interface terminal functions. The control system supplier shall test every input and output point including spares for proper operation. Test signals shall be generated to verify the operation of each Analog Input (AI) and Discrete Input (DI) including connected interposing relays, intrinsically safe circuits and relay circuits. Each Analog Output (AO) and Discrete Output (DO) shall be also tested for proper operation included control circuits, isolation relays, signal conditioner/isolators and other required control circuits.
2) The instrumentation supplier shall demonstrate that signals are alarmed when reporting under 4 mA and over 20 mA and do not report negative or out of range values.
3) The system supplier shall develop a point checkout form for each I/0 point. The point checkout form shall include the point ID, description, all checks performed for the point, date and time of the check, and a signoff block for the system supplier. For each item checked, the form shall include both the expected value/result and the actual value/result witnessed.
4) The following items shall be checked for each I/0 point:
   a) For each analog input point, the following values shall be checked:
      - Value at -2% of full scale (ramped in both directions)
      - Value at 0% of full scale (ramped in both directions)
      - Value at 25% of full scale (ramped in both directions)
      - Value at 50% of full scale (ramped in both directions)
      - Value at 75% of full scale (ramped in both directions)
      - Value at 100% of full scale (ramped in both directions)
      - Value at 102% of full scale (ramped in both directions)
      - Each High and Low Alarm condition
      - Alarm Delay
      - Alarm Enable/Disable
   b) For each analog output point, the following values shall be checked:
      - Milliamp reading at 0% of full scale (ramped in both directions)
      - Milliamp reading at 25% of full scale (ramped in both directions)
      - Milliamp reading at 50% of full scale (ramped in both directions)
      - Milliamp reading at 75% of full scale (ramped in both directions)
      - Milliamp reading at 100% of full scale (ramped in both directions)

c) For each discrete input point, the following items shall be checked:
- For status points, proper indication
- For alarm points, proper alarm notification

d) For each discrete output point, the following items shall be checked:
- Proper operation

C. PLC Programming and Operator Terminal Configuration Checkout:
1) Submit the proposed PLC program and operation terminal configuration (screen captures) to the City of Rockland's Director of the Pollution Control Department 30 days prior to the performance of the Factory Acceptance Testing for review and approval.
2) Verify to the extent possible that the PLC program and operator interface terminal configuration, as submitted, performs all control and monitoring requirements as described under this section and Subsection 13441 - Control Descriptions. A list of all modification to the submitted PLC program shall be maintained and submitted after factory acceptance testing.

D. 72-Hour Continuous Burn-in Test:
1) After the successful completion of the functional testing specified above, a 72-hour continuous run of each control panel provided shall be performed. The test shall be passed if no function is lost, no hardware or software failure occurs, and no module automatic failover occurs. Hardware failure is defined for this test as the loss of a major piece of hardware, such as a PLC processor, I/0 board, power supply, UPS, other panel equipment, or improper operation by the controller.
2) During this test, the PLC shall be occasionally (a minimum of three (3) times per 24-hour period) exercised with simulated inputs, events, and conditions in a manner that approximates an operational environment in order to verify proper operation.
3) No programming changes will be allowed to bypass failed modules during this test. Any major software and/or hardware correction made to the control panel shall result in the mandatory rerun of the entire 72-hour test for that control panel.

E. Procedures Prior to Start-up:
1. The Contractor shall coordinate the work of the system manufacturer's service personnel as necessary. This shall include the installation, interconnection, testing, and calibration of the instruments, and the scheduling of the manufacturer's service personnel.
2. The supervisory services of a factory-trained service engineer/technician who is specifically trained on the type of equipment herein specified, shall be provided during construction to assist the Contractor in the location of sleeves; methods of installing conduit and special cable; mounting, piping, and wiring of one (1) of each type of device, and the methods of protecting all of the equipment prior to placing it into service. Upon completion of the installation, the services a trained service engineer/technician calibration and startup the equipment in the presence of the engineer, and provide instruction and training for the operating personnel. A sufficient number of service days shall be provided to place the system in satisfactory operation. One additional service call of one (1) eight (8) hour working day (not including travel time) shall be included for use upon demand of the Owner within the first year's operation.
3. Final demonstrations shall be made only after the City and Engineer are satisfied that the work has been completed in accordance with the intent of the Contract Documents.
4. Instrument Calibration:
a. Calibrate each analyzing instrument in the presence of the Owner and Engineer using manufacture's recommended calibration procedure and standards.

b. Provide a copy of the factory calibration sheet for each instrument which required factory calibration.
c. Verify that each instrument is properly installed and that the control system is properly scaled for the output signal. Provide digital averaging where required in order to provide a smooth but responsive signal.
d. Each instrument will be provided with an adhesive sticker declaring the date of certified calibration and initialed by the factory authorized field personnel.
e. Onsite Control System Startup:
f. Site Acceptance Test (SAT): Perform a Site Acceptance Test to verify that each instrument and equipment drive is connected properly to the control panel and that all functions of the control panel are operating as specified.
g. The instrumentation supplier shall:
    1) Verify the facility installation.
    2) Demonstrate each functional requirement identified by the specification. This demonstration shall repeat the tests used during FAT, but using real rather than simulated conditions.
    3) Demonstrate all equipment control functions, including the operation of automatic control strategies. Actuation of field devices shall be closely coordinated with Engineer and Owner's staff.
    4) Demonstrate that the parameters for each PID operation in the PLC provide a smooth responsive transition without over oscillation with a sudden change in the process value or set point. PID parameters will be determined/verified using a PC based PID tuning software showing a graph of the process value, control valve and set point over time.
    5) Verify system performance parameters and system responses under field operational conditions.
    6) Verify accuracy of documentation, especially operator's manuals, software documentation, and site operating instructions.
h. The instrumentation supplier's test support personnel shall be qualified to resolve and correct problems encountered with the system during the tests. In addition to test support personnel, the instrumentation supplier shall provide all test instruments and equipment necessary to troubleshoot any of the problems encountered.
i. The SAT will be observed by the Engineer and/or Owner's representative.
j. Provide the services of authorized manufacturers' representatives to instruct the Owner's representatives in the proper operation of each control system installed under this Contract.

2.4 QUALITY ASSURANCE

A. All materials provided in this project shall be equal in quality, appearance and performance to that specified herein and shall be subject to the approval of the City of Rockland. The discontinuance of production of any material or product after approval has been granted shall not relieve the Contractor from furnishing a City approved alternate of comparable quality and design.

B. Materials and equipment furnished for this project shall be standard products of manufacturers regularly engaged in manufacture of such products and shall be manufacturer's latest standard design that complies with Specification requirements.

C. The Instrumentation Supplier shall have supplied comparable systems to those specified herein. Provide, for a period of 12 months from the date of final acceptance of the work, all

necessary supervision, labor, materials, and equipment, in order to correct any defects in any system due to faulty materials, equipment, installation methods, or workmanship and consequent damage resulting from such defects. This work shall be scheduled during normal working hours and at the convenience of the Operator.

D. Instrumentation Supplier:
   1. The Contractor's attention is directed to the fact that the instrumentation is an integrated system and as such, shall be furnished by one supplier, who shall provide all of the equipment and appurtenances regardless of manufacturer, and be responsible to the Contractor for satisfactory operation of the entire system. Substitutions on functions specified will not be acceptable.
   2. The exception shall be where instrumentation and control packages are furnished by respective equipment manufacturers ~~as required in Division 11~~. All necessary provisions will be made to ensure a proper interface between the main process instrumentation and control packages specified within this section ~~and those provided under Division 11~~.
   3. The Instrumentation Supplier shall hold a valid UL-508 certification for its panel fabrication facility or, if panel fabrication is subcontracted, shall utilize only panel contractors who hold the UL-508 certification.

E. Acceptable Instrumentation Suppliers:
   1. AEC, Freeport, ME
   2. Electrical Installation Inc., Moultonboro, NH
   3. Results Engineering, Inc., Saco, ME
   4. LCS, Rochester, VT
   5. Or equal, having a minimum of 5-years' experience in supplying comparable systems.

F. The Instrumentation Supplier may be provided with certain items by others for inclusion within his Control Panels. These items are shown as manufacturer's equipment on the Instrumentation Drawings.

2.5 SUBMITTALS TO THE ENGINEER

A. Shop Drawings and Samples:
   1. Submit Shop Drawings shall be in accordance with Subsection 01340 and as indicated herein.
   2. Shop Drawings shall be thoroughly checked by the Contractor for compliance with the Contract Documents. Verify that all equipment and materials proposed will fit into available space and maintain specified clearances, and that all equipment is compatible with system operation. The submittal of any Shop Drawing implies that the Contractor has reviewed this Shop Drawing and that the above requirements have been met
   3. Shop Drawings Shall Consist Of:
      a. Project name and location
      b. Contractor's name
      c. Index Sheet - Listing the equipment being submitted utilizing equipment designations. or symbols, indicated on the Contract Documents together with the proposed manufacturer, style/type and catalog number.
      d. Manufacturer's scale or dimensioned drawings along with standard catalog number.
      e. Equipment ratings, service clearances and configuration.
      f. Listing of accessories to be furnished
      g. Panel wiring diagrams showing the location of each mounted component, front panel elevation(s), internal wiring diagram of each component including terminal numbers.

h. Table showing a complete listing of the components in each control panel.
i. ISA S5.4 loop diagrams or equivalent showing point to point wiring for all instrumentation equipment including terminal numbers. Prior to final completion, update the above drawings with wire numbers and color provide by the Electrical Subcontractor.

4. All material shall be contained in one submission; partial submissions will not be accepted.
5. Submissions shall be in the form of individual binders, of the quantity indicated in the General Conditions. Each equipment type shall be separated by index tabs with typewritten titles.
6. Provide samples of instruments, devices, graphics, etc., within 10 days upon receipt of request.
7. Provide documentation of the ladder logic program and operator terminal graphic screens for each control panel for review and comment by the City of Rockland's Director of the Pollution Control Facility.

B. Maintain properly documented and witnessed test and checkout reports and submit these to the City. No form of energy shall be applied to any part of the instrumentation system prior to receipt by the City, from the contractor, of the supplier's certified statement of approval of the installation and containing his authorization to energize the system, except that the supplier's serviceman may do so for the purpose of check-out as described herein.

2.6 DELIVERY, STORAGE, AND HANDLING

A. Coordinate material and equipment delivery with the project schedule.

B. Coordinate delivery of equipment directly to other vendors where instrumentation supplied under this section has to be installed in panels supplied under other specification sections.

C. Exercise care during loading, transporting, unloading and handling of materials to prevent damage.

D. Check for defective or damaged materials, and for incomplete equipment shipments within seven (7) days after equipment delivery to the project site.

E. Store materials and equipment on the construction site in enclosures or under protective covering in order to assure that materials and equipment are kept undamaged, clean and dry.

F. Replace or repair, to the satisfaction of the City, all materials and equipment that are defective or that have been damaged during installation.

2.7 O&M REQUIREMENTS

A. In addition to requirements outlined in Subsection 01340, the following requirements apply.

B. Provide a list of local service departments of duly authorized distributors of materials and equipment of the type installed, which will stock the manufacturer's standard parts, etc.

C. At the completion of the installation, provide six copies of reproducible Record Drawings on sheets no less than 11"xl 7" (8.5" x 11" for ISA S5.4 Drawings), indicating the final configuration of all systems as they were installed. Symbols, equipment designations, etc.,

shall be consistent with the project Drawings. Provide exact locations of all work which has been concealed in concrete, masonry or underground. The following diagrams shall be included:

1. Panel diagrams on 11"x17" showing the front face and panel mounted equipment with full listing of components including names, descriptions and model numbers for each component. One copy of the panel diagrams will be laminated for insertion into the pocket inside each control panel.
2. Point to Point terminal wiring diagrams for all field instruments, motor starters, equipment drives, valve actuators and other field equipment connected to the control system. All diagrams will meet ISA S5.4 standards requirements for loop diagrams on 8Yz" x 11" or 11" x 17" papers, showing one loop per page.
3. All drawing will be provided as record drawings in either Autocad DWG format or Adobe PDF format.

D. O&M Manual Organization: The operations and maintenance manuals shall be organized in three (3) ring binders with a maximum size of four (4) inches. The following is a proposed outline for the O&M Manual(s):

Table of Contents

Section 1 - Reserved for description of system by Owner

Section 2 - Field Instruments (arranged alphabetically by Tag No.)
- 2.1 ISA data sheet or instrumentation listing
- 2.2 O&M literature for each type of instrument with labeled dividers

Section 3 - Panel Equipment (arranged alphabetically by manufacturer)
- 3.1 Device Listing
- 3.2 O&M and Manufacturer's literature

Section 4 - Miscellaneous devices (arranged alphabetically by manufacturer)
- 4.1 Device Listing
- 4.2 O&M and Manufacturer's literature

Section 5 - Drawings
- 5.1 Panel fabrication and assembly drawings
- 5.2 Panel wiring diagrams
- 5.3 ISA S5.4 loop diagrams

Section 6 - PLC
- 6. I Rack Layout
- 6.2 110 List
- 6.3 PLC communication parameters

Section 7 - Program
- 7.1 PLC Program (with register and cross reflist)
- 7.2 Operator Terminal Screen Color Printouts
- 7.3 SCADA Screen Color Printouts
- 7.4 Report Printouts
- 7.5 Alarm Configuration

Section 8 - Software programs and PDF Literature Section 9 -Miscellaneous Data

E. The cover and edge of each volume shall contain the following information:
Project Name
Owner's Name
Instrumentation and Control System Operations and Maintenance Manual
Specification Subsections 13440, 13441, 13442, 13443 and 13455 Volume X of Y
(where X is the volume number and Y is the number of volumes)
Subcontractor Name, Date

F. Electronic O&M Information:
1. In addition to the hard copy O&M data, provide whenever possible an electronic version of all equipment manuals. Electronic version shall be in Adobe™ reader (pdf) format. Graphic files should be in GIF or JPEG format.
2. Provide electronic files for all custom-developed manuals in Adobe TM reader (pdf) format.
3. Supply all electronic files on 4.8 GB DVD-R media.

PART 3 - PRODUCTS

3.1 MATERIALS

A. General:
1. All of the equipment shall be the manufacturer's latest proven design. Specifications and Drawings call attention to certain features, but do not purport to cover all details entering into the design of the instrumentation system. The completed system and the equipment furnished by the Contractor shall be compatible with the functions required.
2. Components shall be finished to the manufacturer's standard for the service intended unless otherwise indicated in the specifications or on the drawings.
3. All electrical components of the system shall operate on **120-volt, single- phase, 60-Hertz** current, except as otherwise noted in the specifications. Power shall be supplied from local electrical distribution panels with breakers for each circuit.
4. All controls for electrically operated or motor-driven equipment (including electrically actuated valves, small pumps and chemical feed equipment, etc.) shall be completed, including all necessary auxiliary relays, so as to require only wiring and connections to the equipment control circuit. All contacts for control of motor-operated or electrically operated equipment shall be rated not less than 10 amperes on 120-volts unless otherwise specified herein.
5. All motor-operated or electrically operated equipment shall have separate 120-volt control circuits.
6. Control wiring for externally operated motors shall be No. 12 AWO, minimum and in accordance with Subsection 16160.
7. All necessary fuses or switches required by the instrumentation manufacturer for his equipment requiring a 120-V power supply shall have a labeled ON-OFF breaker switch. Refer to Electrical Drawing for instruments requiring power from the control panel.
8. Control panels shall be furnished and installed in accordance with Subsection 16160, and as indicated on the Drawings and in the Specifications. All transducers, converters, terminals, transformers, relays, signal transmitters, power supply connections and other miscellaneous equipment required to make a complete system in accordance with the intent of this Section shall be furnished and installed in the control panels.
9. Panel components including switches, relays, instrumentation, etc. supplied by the various process equipment manufacturers, but indicated to be installed within panels

furnished by the Instrumentation Supplier, shall be furnished to the Instrumentation Supplier for incorporation into his panels. Instrumentation Supplier shall install these items within his panel and shall produce a complete, functional, pre-wired system for installation requiring only external power and instrumentation connections. The Contractor shall coordinate this requirement and shall ensure that equipment manufacturers provide all necessary installation instructions and requirements to the Instrumentation Supplier.

10. Provide all required piping, connections, hangers, supports, etc. required for the Instrumentation and Process Control Systems and equipment.
11. The Drawings and Specifications indicate the energy sources that will be provided. Any other devices necessary to obtain proper operation of the instrument system from these energy sources shall be furnished with the instrumentation.
12. Each alarm-actuating circuit shall contain a simple means for disconnecting the alarm function during normal maintenance or standby of the equipment, which actuates the alarm.
13. All equipment mounted outdoors that requires heating during winter conditions shall be provided with heaters, thermostats, enclosures and associated accessories as necessary in accordance with Subsection 16160.
14. All recorders shall be by a common manufacturer and shall be of the same manufacturer and type as specified herein.
15. Instrumentation supplier shall provide and install all "vendor furnished cable" between instrumentation system equipment components, unless otherwise indicated. Conduit shall be provided under Division 16 and is shown on the Drawings.
16. Transient voltage protection shall be provided for analog instrumentation, field sensor devices, field loop transmitter devices, PLC analog inputs, PLC discrete inputs, PLC to PLC communication interfaces, VFD/RVSS interfaces, and all other locations susceptible to lightning and transient over voltage. The surge arrestor shall be adequate for the intended function and shall be by a nationally recognized manufacturer with a minimum of three (3) years' experience in the manufacturer of such devices. The technology shall be silicon avalanche diode technology. MOY technology shall not be acceptable. Submit selected model and backup information for review and acceptance by the City of Rockland.
17. Provide sample conditioning equipment for all analyzers as required by the manufacturer for the intended service. This includes but is not limited to filters, basket strainers, pressure reducing valve, flow control valves, rotameter and pressure gauges.
18. Relays integral to instrumentation equipment shall be Form C with a minimum rating of IOA at 120 VAC.
19. Identification:
    a. All panels, and panel mounted instruments and control devices shall have identifying nameplates in accordance with Subsection 16160. Equal quality nameplates shall be attached to all field-installed units.
    b. Each field transmitter shall have an attached manufactures tag with the Manufactures name, model number, serial number, power requirements, and scaled range of the instrument
20. Provide suitable lamacoid labels for each process measurement element and transmitter. Label will be identifying each media being measured, range and units of measurement and indicating transmitter/element ID No., for example:

Influent Flow
0.00 to 5.00(MGD) FIT-142A

B. Instrumentation Equipment
   1. Level Indicator (LI):
      a. Display: 0.5 inch LED, four (4) digit numerical display.
      b. Digital Format: ###.#
      c. Units: feet
      d. Rating: NEMA 4X, IP65
      e. Power: 120 VAC
      f. Mounting: Indicator will be mounted inside a NEMA 4X enclosure viewable through a window.
      g. Input Signal: 4-20 ma
      h. Programming: Setup and programming of the indicator shall be by using keys on the front of the bezel. All settings shall be held in non-volatile memory.
      i. Indicator shall have two user configurable Form C (SPDT) relays.
      j. Equivalent to:
         1) Trident Model PD765 by Precision Digital.
         2) Or Equal
   2. Wet well Float Type Level Switches: (LSL, LSLL, LSH, LSHH)
      a. Polypropylene encapsulated non-mercury float switch with oil resistant, waterproof cable
      b. Normally open or normally closed contacts rated a minimum of I OA at 120/240 VAC.
      c. Float switches in Class I Div 1 (explosion proof) areas shall be protected with an intrinsically safe relay.
      d. An adjustable weight shall be attached to each float cable
      e. Provide a stainless-steel float rack for each series of switches with adjustable cable stops.
      f. Equal to:
         1) KARI KA Series by ST! Automation
         2) Series M by Warrick Controls
         3) LS Float Switch by US Filter
         4) or equal by US Filter
   3. Submersible Pressure Transducers: LE/LT
      a. Submersible level sensor shall be capable of measuring liquid pressure with temperature compensation from 32°F to 122°F, and converting the sensed pressure to a 4-20 mA signal corresponding to liquid depth in feet.
      b. Accuracy shall be ±0.25% for non-linearity, hysteresis and non-repeatability.
      c. Transducer shall be 24V DC loop powered.
      d. Case and wetted parts shall be constructed of 316 SS and viton.
      e. The sensor shall be fitted with an open nose cap suitable for water applications.
      f. The signal cable shall be a polyurethane-coated cable containing control and power wiring, shielding and a reference vent tube. Cable shall be provided with sufficient continuous length between the level elements and a NEMA 4X stainless steel junction box located outside the tank.
      g. Sensor shall be suitable to transmit signal up to a distance of 1000' without need for a signal booster.
      h. The pressure transducers shall be mounted in a 2-inch diameter schedule 80 PVC pipe (stilling well), installed adjacent to the tank/channel wall, extending to within 6-inches of the tank bottom and within 12-inches below tank cover (where enclosed). The pipe shall be rigidly supported along its length with stainless steel brackets and hardware. The installation must also be in complete compliance with the pressure

transducer manufacturer's installation requirements. and applicable sections of the specifications.

i. The level element air reference tube shall terminate with a desiccant canister or bellows in a NEMA 4X stainless steel junction box.
j. Submersible level sensor shall be equal to:
   1) KPSI Model No. 720 or 705
   2) or equal.

4. Control Panels:
   a. Control panels shall meet the requirements of the City of Rockland Pollution Control Facility, Subsection 16160.
   b. Provide control panels as listed in this section.
5. Alarm Horn:
   a. Weatherproof alarm horn. Hom shall meet NEMA 4X classifications. Horns shall come with a 3 " electrical conduit connection. Horn shall be 120 V AC powered with adjustable volume of 78 to 103 dBa. Equal to Adaptahorn by Edwards.
6. Miscellaneous Hand Switches and Indicator Lights: HS, YL, AL
   a. Size: 30 mm
   b. All indicator lights shall be 120V AC. LED with push to test option.
   c. Reference Subsection 16900 for specifications.
   d. Number of positions and nameplate legends shall be as indicated 111 Subsection 13441 and on the Drawings.
7. Programmable Logic Controller: PLC
   a. See Programmable Logic Controllers - Subsection 13442
8. Operator Terminal: OIT
   a. See Programmable Logic Controllers - Subsection 13442
9. UPS Power Supply Backup System:
   a. See Programmable Logic Controllers - Subsection 13442
10. Surge Suppresser: Transtector, Ditek Model # DTK -1201240CM or equal
11. Fuses and Fuse Blocks: refer to City of Rockland Pollution Control Facility, Subsection 16900
12. Terminals: refer to Subsection 16900
13. Power Monitoring: Refer to Division 16
14. Special Tools:
   a. The Contractor shall provide all required tools for instrumentation.
15. Spare Parts and Test Equipment:
   a. The Contractor shall furnish the following spare parts, in addition to the manufacturer's standard spare parts kit, with each part packed m a container and labeled:
      1) 10 of each type lamp, unless otherwise specified herein
      2) 1 of each color indicator light lens.
      3) 1 relay of each type
      4) 1 complete selector switch of each type.
      5) 1 complete push-button of each type.
      6) 1 of each different contact block for control units.
      7) 2 of every type of fuse.
      8) 1 N.O. and 1 N.C. contact for each type of switch.

3.2 CONTROL DESCRIPTION

A. General:
   1. The control of each new control system will be similar in operation.

2. Run time totalizers (KQI) for each piece of equipment will be located on the front of the motor starter cubicle, variable speed drive, or control panel for each piece of equipment, as specified in Division 16. The PLCs will also totalize the run times for each piece of equipment in hours. Each totalizer will allow an operator to reset it.

B. E-Stop Stations:
1. E-STOP stations will be provided per the City of Rockland Pollution Control Facility ~~under Division 16~~ and as shown on the Drawings.
2. The E-STOP will immediately shut down the associated equipment when activated. The E-STOP will be directly interlocked with the motor starter or variable speed drives and will not allowed the equipment to be run from any control location when the E-Stop is in the STOP position.

C. Control Panels (CP):
1. Local Control Stations (LCS) will be provided per the City of Rockland Pollution Control Facility ~~under Division 16~~
2. All Local and PLC Control Panels and Communication Panels will be located as shown on the Drawings. Each PLC control panel includes a PLC and/or an operator terminal, which will monitor and control the instrumentation and equipment as shown on the Drawings and described in 13441 and in this section.
3. The SCADA system will also display the status of each piece of equipment. The operator will be capable of adjusting process parameters and setpoints. See Subsection 1344L
4. All alarms shall activate an alarm light(s) at the associated control panel and SCADA stations as specified in Subsection 13441. Each alarm will be latching unless otherwise indicated. Each Control ·Panel will include a RESET pushbutton, mounted to the front of the panel, which will reset all latched alarms circuits and programmed alarms. A soft reset will also be provided through the Operator Interface Terminal (OIT) for programmed alarms only.
5. All motor drives, including motor starters, soft starts and variable speed drives, will be activated based on a START command from the PLC or HOA switch. The START command will be developed by the control panel circuitry driving an auxiliary control relay in the Control Panel. The PLC will not be capable of activating the equipment if the equipment is in the HAND or OFF pos1t10ns. The control circuitry will include all permissive conditions, interlocks and run commands (PLC and HOR switches).
6. A return RUN contact from the drive will activate a RUN light mounted to the front of the motor control center (MCC), variable speed drive (VFD) or control panel for each piece of equipment. The PLC will activate a FAIL alarm at the operator terminal, if the equipment is in AUTO and the PLC attempts to activate the equipment but the RUN contact does not indicate that the equipment is running after a 15 second delay time.
7. Drive equipment and instrumentation, which contain self-diagnostics, overload relay (0/L) or faults relay (FAULT) contacts. will be connected to the PLC to produce an 0/L or FAULT alarm at the OJT and SCADA.
8. The PLC will be connected via a radio telemetry system to the City's Water Pollution Control Facilities SCADA system. The Operator Terminal (OIT) will also be connected to the PLC.
9. Each PLC Control Panel will be powered from a 120V power source. An uninterruptible power supply (UPS) will be provided for each PLC control panel. Each PLC control panel will include indicator lights on the front of the panel indicating POWER (green) and UPS POWER (amber). A POWER FAIL alarm will be activated through SCADA if the normal 120V power fails. A UPS FAIL alarm (red) will be activated by the UPS, if the UPS battery should run low or the UPS should fail.

10. A relay will be provided off each PLC, which will be energized by the PLC under normal operating conditions. The relay will activate a cumulative alarm signal or a PLC Fail, which will activate a general ALARM (red) light on the front of the Control Panel.
11. Each PLC will be programmed to perform the functions as described in Subsection 13441 or as required by the manufacturer of the equipment.
12. All analog control signals will be 4-20 mA and powered from power supplies within the process control panel, unless otherwise indicated or required.
13. All inputs to the PLC shall be dry isolated contacts. All outputs from the PLC shall have interposing relays. All outgoing power (120V and 24V) to field devices shall be fused.
14. All wiring in and out of the panels will be connected to terminal strips for ease of installation and maintenance. All connections will be made in such a way as to preserve the NEMA rating of the panel. The supplier will label the terminal strips and provide a complete wiring diagram for each system control panel.
15. All control panels will use the following light color convention:
    a. Alarm/Run: Red
    b. Power/Stop Lights: Green
    c. Warning Lights: Amber
    d. Enable Lights: White
    e. Position Lights Blue
21. The Control Panels shall be furnished and installed in the locations as shown on the Electrical Drawings.
22. All transducers, converters, terminals, transformers, relays, signal transmitters, signal boosters, power supply connections, remote instrumentation/equipment surge protection devices, and other miscellaneous equipment required to make a complete system in accordance with the intent of this section of the Specifications shall be furnished and installed in each panel.
23. The Instrumentation supplier shall review the control section of the submittal for each Division 16 specification where equipment drive controls are to be provided and interfaced with the new Process Control System and SCADA System.

PART 4 - EXECUTION

4.1 INSTALLATION

A. General:
1. The Specifications and Drawings do not attempt to fully indicate the degree of assembly, subassembly, shipped condition, extent of field work, or degree of accuracy required to install the equipment or materials. The Contractor shall be required to rely on his prior experience or to otherwise inform himself of the amount of field work required to assembly, erect, and install the equipment or material, as received, to produce a finished installation ready for use or operation.
2. All equipment installed as part of the work shall be positioned, assembled, aligned, doweled, and otherwise set to the tolerances required by the equipment manufacturer. Where tolerances and methods are not specifically indicated, they shall be in accordance with best millwright practice.
3. All materials incorporated in the work shall be installed in accordance with the Contract Documents. Where detailed drawings or technical specifications are not provided, the materials shall be installed in accordance with the manufacturer's preferred recommendations and conforming to the best practice of the trade involved. Installation shall include all accessories required to produce a completed installation ready for use.

B. Electrical Work:
   1. All electrical work shall conform to IEEE standards and the City of Rockland Pollution Control Facility. ~~requirements indicated in Division 16~~.

C. Field Calibration:
   1. All instrumentation shall be calibrated.
   2. All flow and level transmitters shall be factory calibrated and set up to the extent possible at the factory. Span, range, and operating parameter adjustment shall be made at the factory or in the field by a factory trained personnel. Each system shall meet the manufacturer's standard accuracy.
   3. Analyzing instruments shall be field calibrated by a factory-trained engineer or technician using procedures recommended by the manufacturer. Provide all materials required for proper calibration. Calibration shall be done in the presence of the City if they so wish.
   4. Secondary functions such as alarm actuations and pacing shall be adjusted during initial calibration and demonstrated after the system is placed in service. Range adjustments shall be sealed by colored lacquer in the presence of the City immediately following calibration.
   5. Process calibration. such as volumetric drawdown tests on flows and level measurements, shall be conducted on all measuring systems as requested by the City.

END OF SUBSECTION

SUBSECTION 13441 CONTROL LOOP DESCRIPTIONS

PART I - GENERAL

1.1 SUMMARY

A. Section includes control loop descriptions for the following:
   1. Loop - Pump Station

B. Each loop description includes a description of a proposed automatic control sequence to be programmed into the PLC along with a listing of the control functions to be displayed and adjusted from the Operator interface Terminal (OIT) and on the Pollution Control Facilities SCADA system.

1.2 QUALITY ASSURANCE

A. See Subsection 13440.

1.3 SYSTEM DESCRIPTION

A. Provide instrumentation hardware, software and programming as necessary to perform control functions specified herein and as shown on drawings. Ensure coordination with other work to ensure that necessary wiring, conduits, contacts, relays, converters, and incidentals are provided in order to transmit, receive, and control necessary signals to other control elements, to control panels, and to receiving stations.

1.4 SUBMITTALS

A. See Subsection 13440.

B. Operation and Maintenance Manuals:
   1. See Subsection 01340.

PART 2 - PRODUCTS - (NOT APPLICABLE TO THIS SECTION)

PART 3 - EXECUTION

3.1 CONTROL DESCRIPTIONS

A. General
   1. All process setpoints will be adjustable though the operator terminals and at the SCADA computer.
   2. The deadband, gain, derivative, integral and delay functions of each PID algorithm will be adjustable though the operator terminal or SCADA system on a secure screen.
   3. All process alarms from analog process values (i.e. High Wet well Level Alarm from a pressure transducer) will have a means through the operator terminal to adjust the activate/deactivate the alarm, adjust the setpoint and set a delay period from O to 60 seconds.

4. References to control function in the PLC Control Description shall pertain to virtual controls to be accessible from both the Operator terminal and in the Pollution Control Facilities SCADA.

B. Loop - Pump Station
1. General: The Pump Station, regardless of type, shall convey sewerage from a wet well to the gravity sewer system. For the Submersible Non- Clog Station and the Above Ground Vacuum Primed Pump Stations a micro-programmable logic controller (PLC) will control the pumps at a Control Panel. The PLC will control the activation of the pumps based on liquid level in the wet well, as measured by a submersible pressure transducer. In addition, backup float switches will be provided for alarm annunciation if the submersible pressure transducer should fail. For the Simplex Grinder Pump Station, control will be as per the manufacturer's recommendations. For the Submersible Grinder Pump Station, control will be by float switches as described in Subsection 11305, however, the general operating concept, alarms, and OIT/SCADA functions shall be as per this specification.
2. Local Control: None
3. Interlocks: Interlocks shall be as per pump station manufacturer's recommendations, and:
   a) (If Applicable) Each pump will be provided with a pump seal fail detection by the Manufacturer which shall be interlocked to shut down the respective pump and activate an alarm at the control panel. This interlock shall be latching and shall require a reset at the Control Panel.
   b) (If Applicable) Each pump will be provided with a Pump motor over-temperature detection which shall be interlocked to shut down the respective pump. This interlock shall be released when the condition changes to normal status.
   c) The Low-Low Level Float switch (LSLL) shall be interlocked to shut down all the pumps. This interlock shall be latching and shall require a reset at the Control Panel.
4. Field Instruments:
   a) Wet well Level
   b) High-High Level Float Switch
   c) Low-Low Level Float Switch
5. Equipment Control:
   a) Elapsed Time Meters (each pump)
   b) HAND-OFF-AUTO switches (each pump)
   c) (Back-up System) Normal-Test switch
   d) (Back-up System) P1-P2-OFF switch (as applicable)
   e) Back-up System Operating Light
   f) Pump Run Lights
   g) Pump Fail Lights
   h) Pump High Temperature Lights (each pump, as applicable)
   i) Motor 0/L Alarm Light (each pump - as applicable)
6. Control Description:
   a) Wetwell Level Measurement:
      1) The level in the Wet well will be monitored by a submersible level transducer and indicating transmitter. The wet well level will be displayed on the operator terminal in feet and graphically as % full.
   b) Pump Activation/Deactivation:
      1) There will be a HAND-OFF-AUTO selector switch at the Control Panel for each pump. In the HAND position, the associated pump shall run continuously. In the OFF position, the pump will not be allowed to run. In the AUTO position, The PLC will automatically start and stop the pumps based on adjustable LEAD/LAG PUMP ON and LEAD/LAG PUMP OFF elevations.

2) The operator will select the LEAD and LAG pump through the operator terminal.
3) As the level in the wet well rises, the PLC shall start the lead pump at the LEAD PUMP ON elevation. The lead pump will pump down to the LEAD PUMP OFF elevation. If the Level rises to the LAG PUMP ON elevation, the LAG pump will be activated and shut off when the water level reached the LAG PUMP OFF elevation. These elevations shall be adjustable through the operator terminal. Refer to the Drawings for initial elevations.
4) During emergency power operation only one pump shall be allowed to operate. The control system shall stagger that start of the pump on the restoration of normal power.

c) Backup Float Switches
1) A High-High Level and a Low-Low Level float switch will be installed in the wet well. The High-High Level Float Switch will activate a Wet well High-High Level alarm light at the control panel and an alarm at the operator terminal and activate a selected backup pump. The Low-Low Level Float Switch will activate a Wet well Low-Low Level alarm light at the control panel and an alarm at the operator terminal and shut down the backup pump.
2) A Pl-P2-0FF selector switch will allow the operator to select the backup pump or disable the function by selecting OFF.
3) A BACKUP ENABLE light will indicate when the control system is operating under backup float control.
4) A Normal-Test selector switch on the front of the panel shall be provided to test the backup float switch system by preventing the PLC from activating the pump when the switch is in the TEST position.

d) Pump Alternation:
1) The operator will be capable of enabling AUTOmatic ALTernation. In the AUTO ALT position, the pumps will be alternated each time the active pump is cycled and shut down.
2) A pump cycle will be defined as the start and stop of the pump. Once the pump cycle is completed, (i.e., when the pumps shut off), the pumps shall alternate lead and lag position.

e) Pump Control Elevations:
1) As shown on the Drawings. Each of the elevations, except for the level switches, shall be indicated and adjustable from the operator terminal.

f) Alarms:
1) PUMP FAIL alarms
2) Wet well HIGH-HIGH AND LOW-LOW alarms based on float switches.
3) The PLC will activate an adjustable HIGH and LOW-LEVEL alarm at the operator terminal if the level in the wet well should rise above or drop below a HIGH and LOW LEVEL SETPOINT. The setpoint, enable/disable functions and delays shall be adjustable through the operator terminal.
4) Where applicable, a high temperature switch in the pump will activate a Pump # High Temp alarm light at the control panel and alarm at the operator terminal.
5) Where applicable, a seal fail switch in the pump will activate a Pump # Seal Fail alarm light at the control panel and alarm at the operator terminal.

7. OIT/SCADA Functions
a) P-1 and P-2 RUN status
b) P-1 and P-2 In AUTO position [PLC Controlled Stations Only]
c) P-1 and P-2 0/L and Fail Alarms
d) P-1 and P-2 Elapsed Time (Hours)
e) P-1 and P-2 High Temp alarm

f) P-1 and P-2 Seal Fail alarm
e) Lead-Lag Pump Selector
f) WETWELL LEVEL (ft and % full) [PLC Controlled Stations Only]
g) WETWELL Pump Control Elevations [PLC Controlled Stations Only]
h) HIGH and LOW-LEVEL alarms, setpoints, delays, enable/disable [PLC Controlled Stations Only]
i) High-High and Low-Low Level Alarms
j) AUTO ALTERNATION selection

END OF SECTION

SUBSECTION 13442

PROGRAMMABLE LOGIC CONTROLLERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install, program and test the programmable logic controllers (PLCs) as shown in the Drawings and described in Specification Subsection 13440 and the pump station's specific specifications (Division 11). Operator terminals (OPT) will be provided to monitor and control operating parameters within the PLCs.

B. Related Work Specified Elsewhere.
1. Pump Stations - Division 11
2. Controls and Instrumentation - Subsection 13440.
3. Control Descriptions - Subsection 13441.
4. SCADA System - Subsection 13443
4. Radio Telemetry System - Subsection 13455.
5. Electrical work is specified in Division 16.
6. Instrumentation Drawings.

1.2 QUALITY ASSURANCE

A. The PLC's and operator terminals form an integral part of the overall control system for the facilities and as such all PLC's shall be the product of one manufacturer. The Contractor shall provide all coordination as necessary to ensure that all PLC's, whether provided by the Instrumentation Supplier, individual equipment manufacture's or others, are by the same manufacturer.

B. The manufacturer or its authorized representative shall provide complete technical support for all of their products.

1.3 SUBMITTALS

A. Submit shop drawings in accordance Subsection 01340 (Submittals) and Subsection 13440.

B. Ladder logic will be fully documented including a listing of each task/function.

1.4 DELIVERY, STORAGE AND HANDLING

A. In accordance with Subsection 13440.

PART 2 - PRODUCTS

2.1 GENERAL

A. The PLC shall consist of rugged components designed specifically for industrial environments. The PLC shall consist of a power supply and one or more racks containing a central processing

unit (CPU) module, I/0 modules and PLC network interface module(s). All components shall be housed in structurally secure en-closures.

B. The central processing unit CPU shall be modular and fully enclosed within a durable plastic shroud. When mounted on the system base, the modular CPU shall not occupy more than one available slot.

C. The I/0 system shall be modular. Each module shall be fully enclosed within a durable plastic shroud. When mounted on the system base, each I/0 module shall not occupy more than one available slot.

D. All components within the controller family shall be manufactured with a high degree of durability. All switches and other operator-controlled devices shall be of the size and durability for their intended use as is normally offered for industrial applications. All signal cables furnished by the manufacturer shall be constructed so as to withstand, without damage, all normal use and handling.

E. In order to minimize spare parts stocking requirements, the controller family shall have a high degree of interchangeability. The system shall incorporate a modular design using plug-in assemblies with pin and socket connectors. Wherever possible, all assemblies and sub-assemblies performing similar functions shall be interchangeable. The system design shall accommodate the replacement of assemblies without having to disconnect field wiring. Wherever possible, removable connectors shall be used to connect field wiring to the individual circuit board assemblies. All major assemblies and sub-assemblies, circuit boards, and devices shall be identified using permanent labels or markings each of which indicates the manufacturer's catalog number and a product manufacturing date code.

F. Refer to the control panel descriptions in Subsection 13440.

2.2 PROGRAMMABLE LOGIC CONTROLLER (PLC)

A. Micro-programmable logic controller (micro-PLC) shall be capable of performing the functions described Specification Subsection 13440 and 13441, with the following minimum specifications:
   1. Min. Memory: 12 Kilobytes with EEPROM memory backup and real-time clock.
   2. Min. Number of I/0 points (discrete or analog): 30
   3. Power: 110/220 VAC power supply. Each PLC shall be connected to an uninterruptible power supply (UPS)
   4. Required agency approvals:
      UL Listed (UL 508)
      CSA Certified (CSA 142)
   5. External communications: Two RS-232/485 ports.
   6. Programming and diagnostic software shall be Windows based via Relay Ladder Logic (RLL) custom programming tools for the PLCs. Provide a licensed copy in the name of the Owner of all programming software used to configure the PLCs. Provide all necessary programming time required to configure each PLC to provide complete control and monitoring functions as described in Subsection 13440 and 13455. All software shall be provided on CD ROM.
   7. The supplied software shall include the software and hardware required for direct PLC-to-PC communications for PLC programming.
   8. Future Connections: Wire all spare embedded PLC I/0 to terminals for future connection.
   9. Spare Parts
      a. one (1) each discrete input and output module

b. one (1) each analog input and output module
c. one (1) spare CPU module
d. one (1) spare power supply

10. Acceptable Programmable Logic Controller (PLC):
    a. Allen Bradley Micrologix Series 1500
    b. Multitrode Multismart
    c. Or equal

2.3 OPERATOR TERMINALS

A. Operators Terminal (OIT):
1. General: Provide an operator terminal at each control panel to continuously indicate status of equipment, change operational parameters and indicate alarm status as described in Subsection 13440 and 13441.
2. The operator terminal shall be fully compatible with the PLCs provided.
3. Screen Size: 6-inch color matrix screen with a min. resolution of 320 x 200 pixels with field replaceable backlight.
4. Interface: Touchscreen rated at 1 million cycles (min.)
5. Memory: 1 MB minimum application and graphic memory.
6. Clock: Provide integral real-time clock with battery backup.
7. Communication: Operator terminal shall be provided with interface and cable, to connect to the PLC using serial communication.
8. Power: 120V or 24V DC
9. Operating Temperature: 32-130°F
10. Enclosure: NEMA 4X with NEMA 4X touchscreen
11. Provide programming time required to configure operator terminal interface as described in Subsection 13440, 13441 and finalized in the instrumentation meetings.
12. Provide all cables required to connect the operator terminal to the communication port on the PLC.
13. Provide a licensed copy of all programming software, drivers, hardware interface and cable used to configure the operator terminal.
14. Acceptable Operator Terminal (OIT):
    a. Allen Bradley Panelview plus 600 color touchscreen
    b. Or equivalent

2.4 UNINTERRUPTIBLE POWER SUPPLIES {UPS)

A. UPS Power Supply Backup System:
1. Provide an uninterruptible 120-volt backup power supply for each PLC to maintain continuous operation of PLC, operator terminals, monitoring instrumentation and control circuits during a power outage.
2. The UPS shall be provided with surge arresting capabilities to prevent sudden surges to the attached electrical control systems.
3. The UPS will be either rack mounted inside the control panel, located in the bottom section of floor stand type control panels, or provided an independent wall mounted enclosure.
4. Provide appropriate electrical disconnect or provision to easily remove and bypass the UPS.
5. The UPS shall be type rated for industrial use and capable of supplying standby power to all connected control panel equipment and circuits for a minimum of sixty (60) minutes at full load. UPS minimum rating shall be 1000 VA for control and RTU panels.
6. Equivalent to APC Backup Pro, Ferrups or equal.

PART 3 · EXECUTION In accordance with Subsection 13440

END OF SUBSECTION

SUBSECTION 13443 SCADA SYSTEM

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Includes:
   1. Furnish, install and test hardware necessary to integrate the new pump station's radio telemetry system into the existing Supervisory Control and Data Acquisition (SCADA) system. The existing SCADA system includes the following key components:
      a. SCADA Server running a development version of SCADA software
      b. SCADA Workstations running a view node version ofSCADA software.
      c. PLC network including Ethernet network interface modules, Ethernet- based hub, Ethernet-based media converters and RJ-45 patch panels.
      d. Existing pump station SCADA software is Citect Version 5.4.2
   2. Perform software customization and PLC programming required to integrate the new pump station's radio telemetry system into the existing SCADA system. Software modifications shall provide for remote monitoring of the facilities through a laptop workstation computer via existing PCAnywhere software.
      a. Programming shall be performed at an off-site location and shall be shop tested in the presence of a representative of the City of Rockland, if so requested.
   3. The Instrumentation System supplier shall review Drawings and Specifications and meet with the City of Rockland's Director of the Pollution Control Department at the beginning of system design to clarify all conditions and requirements, and provide them an overview of the proposed system design and capabilities.

B. Control System Description (also refer to Subsection 13441): The control system shall be a Distributed Control type System (DCS). Each process or group of processes is monitored and controlled by a PLC as described in Subsection 13440 and 13441.

C. Related Work Specified Elsewhere:
   1. Pump Station equipment is specified herein.
   2. Controls and Instrumentation are specified in Subsection 13440.
   3. Control Descriptions are described in Subsection 13441
   3. Programmable Logic Controllers are specified in Subsection 13442.
   4. Radio Telemetry System is specified in Subsection 13455.
   5. Electrical work as specified by Electrical Engineer.
   6. Instrumentation and Electrical Drawings.

1.2 QUALITY ASSURANCE

A. The specifications direct attention to certain required features of the equipment but do not purport to cover all details entering into its design and construction. Nevertheless, the Contractor shall furnish the SCADA system complete in all details and ready for operation.

B. The SCADA system forms an integrated system with all plant controls and as such shall be supplied by the Instrumentation Supplier as described under Subsection 13440.

1.3 SUBMITTALS

A. Submit shop drawings in accordance with the General Conditions of the Construction Contract, Subsection 01340, Submittals, and Subsection 13440.

B. SCADA Software:
   1. A preliminary printout of the SCADA screens and tags will be provided to the City for review and changes. Once those changes have been implemented there will follow a SCADA screen review meeting where the City of Rockland's Director of the Pollution Control Facility shall witness the screens on the computer. At that time, the screen contents shall be reviewed and the method of moving from screen to screen shall be finalized.
   2. A drawing showing the complete DCS topology shall be generated.

1.4 DELIVERY STORAGE AND HANDLING

A. In accordance with Subsection 13440.

PART 2 - PRODUCTS

2.1 SCADA SOFTWARE

A. General Requirements
   1. The Contractor shall supply all programming necessary to provide a fully debugged and operating SCADA system. The software required shall consist of those programs necessary for the system to efficiently perform the functions specified herein and in Subsections 13440 and 13441, plus enable convenient and efficient preparation of new programs. The Contractor shall assume complete responsibility for the successful operation of all software and application programs provided as part of the system.
   2. Process parameters such as: date, time, set points, alarm limits, loop tuning constants, etc., shall be entered or modified via the SCADA Stations as Described in Subsection 13440 and 13441. Any input which modifies the process shall be printed on the dot matrix printer with date, and previous value.

B. Software Licensing: Existing SCADA software is licensed.

C. System Security
   1. The system shall be provided with a mechanism to create and maintain a safe, secure operating environment. This security shall be accomplished through software provisions offered by the software supplier. The system will be provided with three levels of security. One level (Supervisory) will allow full control and monitoring of facility equipment and operating parameters. Level two (Operation) will allow monitoring and limited control of facility functions. The third level (Monitoring) will allow only monitoring of facility status and alarm functions. Each user shall be assigned a password, which is associated with the user's name which shall permit access to the system at one of the above levels or not at all.
   2. An interactive menu display shall be provided to allow a System Manager to define and change the security access for each individual user on the system. The system shall also allow new users to be added as well as users to be removed (no longer allowed access) from the system. Upon logging into the system, menu displays shall only display to the operator those functions which he is allowed to perform based upon this specific group security level.

D. Process Control

1. The application software shall provide standard process control algorithms for both supervisory and regulatory direct digital control schemes. The algorithms provided shall consist of modular, function block type of control elements which are familiar to control engineers. The algorithms shall include input blocks for acquiring, converting and characterizing signals representing process variables; computational blocks for performing arithmetic, scaling, and compensating operations; control blocks for performing control functions; and special algorithm blocks for switching, fan-out, display, and user-specified operations, including interacting with supervisory programs.
2. Plant personnel shall be able to develop new control schemes, and modify existing schemes on-line in the background mode without effecting normal plant operation.
3. The system supplier shall provide completely debugged and operational control schemes for all of the control schemes shown on the Loop Diagrams and described in Subsection 13440 and 13441.
4. It shall be possible to program PLC's from the SCADA Server Station.

2.7 SCADA SOFTWARE SETUP AND PROGRAMMING

A. The SCADA setup and programming shall include:
   1. Graphic screens to monitor equipment status (on/off: enable, speed, etc.) and process instrumentation (i.e. wet well levels, etc.); elements to allow easy review and adjustment of process parameters; trending screens for measured process values such as flows, level, etc.; alarm adjustment screen with ability to adjust (if required), set delay time and activate/deactivate each alarm condition and alarm summary screen with acknowledge.
   2. Provide all screens needed for process and equipment monitoring, equipment control, operating parameter adjustment, and alarms as specified. A minimum list of SCADA screens for this project is as follows (note some of these screens may exist and only require the new information to be integrated into them):
      a. Radio Telemetry System Overview Screen showing each node of the radio telemetry system, as shown on the Instrumentation Drawings, including status of connectivity. Operators shall be able to access more detailed process system screens, identifying equipment, process levels, etc., upon clicking on a location displayed on overview screen.
      b. Location Overview: Screens shall be provided for each node of the radio telemetry system for process and equipment monitoring, equipment control, operating parameters adjustment, and alarms as described in Subsection 13440 and 1344 L Operators shall be able to access specific function screens, as applicable, showing process control variables and alarm set-ups, tank levels, etc. upon clicking the piece of equipment or tag setting displayed on process system overview screen.
      c. Alarm Summary and Alarm Set-up Screens.
      d. Equipment Run Time Screen
      e. System 1/0 Screen
      f Trending Screens
   3. The alarm screens will show all current and past alarm conditions along with the date/time of activation and date/time of acknowledgment. Each alarm condition will be maintained in a database which shall include the ability to track alarm frequency. The operator will be capable of printing out an alarm report for a selected period of time and removing old data from the system.

B. The SCADA system shall automatically track and accumulate the operating hours of all major equipment provided under this contract. The totalized time and a reset for each time meter shall

be displayed on equipment run time screen. Six (6) fields for each piece of equipment shall be provided to allow the inclusion of maintenance related data.

PART 3 - EXECUTION

3.1 GENERAL INSTALLATION

A. Install in accordance with Subsection 13440.

3.2 TESTS AND ACCEPTANCE

A. Some of the tests to be performed shall include, but not be limited to, the following:
   1. Building and loading the System Data Base.
   2. Conduct on-line modifications to the data base.
   3. Demonstrate operability of the data communication network.
   4. Demonstrate all system software functions specified.
   5. Verify the displays and interactive capabilities of the Main Control Station.
   6. Simulate selected operating conditions to verify the performance of the monitoring and control functions.
   7. Generate reports using test data.
   8. During the test, the City of Rockland shall have unrestricted access to the system, and all faults identified during this period shall be corrected and retested prior to completion of factory test. All test data and procedures followed during testing shall be logged, and certified copies of logs shall be provided to the City.

END OF SUBSECTION 13455-I

SUBSECTION 13455 RADIO NETWORK SYSTEM

PART I - GENERAL

1.1 DESCRIPTION OF WORK

A. Work Includes:
   1. Completely integrating the new pump station into an existing Radio Telemetry system to provide communication between the pump station and the Pollution Control Facility
   2. A new remote telemetry/control panel (RTU) will be installed at each location which will contain a programmable logic controller (PLC) and radio modem.
   3. The radio telemetry system will also include the following:
      a. Cabling, conduit, surge arrestors, grounding rod, and connectors from the PLC to the radio modem.
      b. The intelligent or "smart" radio modems include the protocol converters (software drivers) allowing direct communication to the PLCs. Radio modem shall be specifically designed for data transmission, connection to PLCs and shall be compatible with the PLCs supplied.
      c. Power supply and wiring connection to the radio modem.
      d. Antenna tower with base.
      d. Antenna coax cabling and all connectors from the radio to the antenna including lightning arrestor surge protection for the coaxial cabling.
      e. The antenna and all antenna mounting hardware (stainless steel) to mount to 1-1/2" to 2" size support pipe.
   4. Provide programming, software and drivers required for transmission of data between all the sites and the SCADA system.

B. Location of Work:
   1. The master telemetry unit (MRTU) is located at the existing Pollution Control Facility.
   2. The pump station
   3. Where repeaters are required

C. Data to be transmitted:
   1. The Radio Telemetry System will transmit data to/from the pump station to the master station and SCADA system. The information to be transmitted for each remote station is listed in the control descriptions in 13441.

D. Work required for the Radio Telemetry System but Specified Elsewhere:
   1. Instrumentation - Subsection 13440
   2. Control Descriptions - Subsection 13441
   3. Programmable Logic Controllers (PLCs) - Subsections 13442
   4. Electrical – Per Electrical Engineer

1.2 PATH STUDY

A. Perform a radio path study consisting of, but not limited to, a computer path loss simulation followed by an on-site radio transmission measurement using the proposed frequencies with antenna heights close to the design height. The proposed frequencies will include UHF, VHF and spread spectrum (900MHz) at no more than 4-watt radio powerless cable,

connector and antenna losses. Perform on-site radio testing during summer conditions. This study will also document the need for a repeater or store and forward requirements, if required, and its location. The path study report will be submitted to the Director, of the Pollution Control Facility for review and approval.

B. The Path study will analyze radio paths from the Pollution Control Facility to the proposed pump station's sites, or as directed by the Director, of the Pollution Control Facility.

1.3 FCC APPLICATION

A. If a new radio frequency is required to accommodate the new pump station, apply for and obtain a FCC licensed frequency in the name of the City prior to startup of the radio telemetry system.

1.4 RADIO SYSTEM DESIGN

A. Perform an engineering design of the radio communication system based on the frequency selected in the path study. This shall include the design of the antenna and telemetry stations.
   1. Antenna Design.
      a. The type, size and height of the antenna at each remote station and at the treatment facility shall be designed to provide adequate communication performance and reliability.
      b. Omni directional whip antenna systems are preferred to allow all the remotes to communicate with each other and the master station or to allow repeating by remotes to other remotes in 360-degree direction. Yagi directional antennas shall be used if a station will not be used for a store and forward repeater and the additional signal gain that the antenna provides improves system performance and reliability.
      c. Determine the antenna mounting height above grade which will provide adequate performance and reliability.
      d. The antenna tower shall be designed for a 100-mph wind with 1/2' radial ice loadings. Antenna support poles, antenna masts, and mast attachment details, as indicated on the Drawings, are schematic and indicate minimum requirements. Radio Network Supplier is responsible for the installed design and material specifications. Documentation shall be submitted with the shop drawings. Contractor will supply and install the antenna support system consisting of either a mast or pole and supports in accordance with the final design by the Radio Network Supplier.

1.5 QUALITY ASSURANCE

A. All materials provided under this Contract shall he equal in quality, appearance and performance to that specified herein and shall be subject to the approval of the City of Rockland's Director of the Pollution Control Facility. Verify the availability of all materials proposed to be used in the execution of the work prior to submitting same for approval.

B. The Radio Network System will be provided by one system supplier or subcontractor, hereafter called the Radio Network Supplier who will be responsibility for providing and coordinating with the other suppliers (if applicable) under 13440. The Contractor, Instrumentation Supplier (if applicable) and Radio Network Supplier shall provide a complete operating system which shall be turned over to the City in perfect working order.

C. Materials and equipment furnished shall be standard products of manufacturers regularly engaged in manufacture of such products and shall be manufacturer's latest standard design that

complies with Specification requirements. Products shall essentially duplicate material and equipment that have been in satisfactory use at least five years.

D. The Radio Network (radio modem) Supplier shall have a minimum of 5 - years experience in the design, manufacture and installation of radio network and modem systems.

E. The Radio Network Supplier and his suppliers shall have provided comparable systems to those specified herein and shall maintain engineering and service departments capable of designing and maintaining these systems. The system supplier shall have engineering services capable of completing RF path studies and trouble shooting and solving radio transmission and reception problems.

F. All equipment and devices furnished under this Section shall be designed for continuous operation, 24 hours per day, 7 days per week in areas where ambient temperatures may vary between -30°F and 110°F, and the relative humidity may vary between O and 95%.

1.6 SUBMITTALS

A. Shop Drawings
1. Submit Shop Drawings and Operations and Maintenance Manuals shall be in accordance with General Condition's Subsection O1340 and as indicated herein.
2. The manufacturer shall provide wiring diagrams, schematic diagrams, layouts, bills of materials, operating instructions, and software documentation along with a detailed functional description of the entire telemetry system for submittal to the City of Rockland's Director of the Pollution Control Facility for approval prior to the manufacture of the system.
3. Provide to the City any modifications to structures, or existing systems, required to install selected equipment.
4. All material shall be contained in one submission; partial submissions will not be accepted.
5. Submissions shall be in the form of individual binders, with each equipment type separated by index tabs with typewritten titles.

B. Start-up Testing: Maintain properly documented and witnessed test and checkout reports of the operation of each function in the whole system and submit these to the Engineer.

C. Local Repair Service: Provide the City with a list of local authorized service organizations and authorized distributors of materials and equipment of the type installed, who will repair and stock the manufacturer's standard parts, etc.

D. Record Drawings: At the completion of the installation, provide Record Drawings indicating the final configuration of all systems as they were installed. Symbols, equipment designations, etc., shall be consistent with the Contract Documents.

1.7 GUARANTEE

A. The Contractor and Radio Network Supplier shall guarantee in writing in the name of the Owner (if the pump station is a private pump station provide a copy to the City) the system to be free from defective material and workmanship for a period of one year dating from the date of Completion of the system. The supplier of the Radio Network System shall replace any defective materials, components, or software during this period of time. Provide all necessary supervision, labor, materials, and equipment necessary to correct any defects in any system due

to faulty materials, equipment, installation methods, or workmanship and consequent damage resulting from such defects. This work shall be scheduled during normal working hours and at the convenience of the Owner/City.

1.8 DELIVERY STORAGE AND HANDLING

A. Coordinate material and equipment delivery with the project schedule.

B. Exercise care during loading, transporting, unloading and handling of materials to prevent damage.

C. Check for defective or damaged materials, and for incomplete equipment shipments immediately after equipment delivery to the project sites.

D. Store materials and equipment on the construction sites in accordance with the manufacturer's written instructions in enclosures to assure that materials and equipment are kept undamaged, clean and dry.

E. Replace or repair, to the satisfaction of the City, all materials and equipment that are defective or that have been damaged during installation.

PART 2 - PRODUCTS

2.1 RADIO NETWORK

A General

1. The Radio Network System will be a fully compatible part of the programmable logic controllers and Supervisory Control and Data Acquisition (SCADA) system.
2. The radio network shall be capable of communication between remote telemetry sites and the master station using radio modems by the following schemes:
   a. Point to point.
   b. Point to multi-point.
   c. Polled with report by exception
   d. Continuous polling.
   e. Store and forward
3. All the radio modems shall be programmable. Initial programming, field setup, warranty and one year service call programming shall be done by the Radio Network Supplier. Any reprogramming of the units shall be able to be done by field service personnel without having to take the unit out of service for an extended time.
4. The software for the radio modems shall be compatible with the software used for master polling stations. A copy of the software used to program the radio modem will be supplied to the Owner with documentation and operational instructions.
5. The radio modems shall be able to communicate with other radio modems without having to go through the master and shall be programmable to act as repeaters for other remotes.
6. The communication system between the remote radio modems and the master radio modems, including the security coding of the signal, the radio transmission of the signal and the decoding, shall be such that false alarms do not occur. The system shall report an alarm condition when it is not able to successfully communicate. The number of failed attempts to communicate shall be stored, and when the number reaches a preset operator adjustable

limit, the alarm shall be initiated, or after a preset continuous time period that communication is not successful, the alarm shall be initiated.

B. Radio Modem
   1. The radio modem will be specifically designed for the transmission of data via radio communication. The radio modem shall be a single module containing both modem hardware and FM radio transceiver designed for data transmission and shall contain the following features:
      a. Internal protocol software converter drivers for all major brands of Programmable Logic Controllers (PLC) including brand and model specified in Subsection 13442. Integral drivers shall be provided for more efficient data transfer, ease of system integration and start-up.
      b. The radio modem shall function as an integral digi-repeater with store and forward capability. The radio modems shall be able to route data through up to three other radio modems to the final end receiving destination.
      c. The radio modems shall be capable of storing up to four alternate repeating routes and transmitting through those alternate routes if the primary routes cannot communicate successfully.
   2. The radio modem shall accept blocks of data from a standard RS-232C asynchronous port connected to the PLC and re-code the data into a “packet" for transmission. These "packets" are sent in one or more "bursts” of radio communication to another radio modem.
   3. The radio modem shall use "polite" or "listen before transmit” type procedures called "carrier sensed multiple access with collision detection" (CSMA-CD) to monitor the transmission frequency for clear radio waves before transmitting any packets.
   4. Each radio modem shall have a unique address code.
   5. Radio modems shall use Cyclic Redundancy Check (CRC) error checking procedure to ensure that the data received has not been corrupted.
   6. The radio modem shall use transmit and acknowledge protocol. After decoding, and error checking, and if the packet is found acceptable the receiving modem shall transmit an acknowledgment (ACK) back to the sending radio modem. Once the originating sending radio modem receives, checks and accepts the acknowledgment, the normal operation of the system continues. The system software shall be able to track and record the number of times transmissions are not completed successfully.
   7. Radio modems shall include an integral telephone modem and standard phone line port for connection to phone system for remote programming and diagnostics.
   8. The radio modem shall include up to a minimum of 2020 byte receive and transmit memory buffers and support both software and hardware flow control. The modems shall be capable of communication between different devices on the network at baud rates up to 38,400 baud.
   10. Radio modem set-up and operating programs shall be stored in non-volatile memory without the need of constant battery power.
   11. Radio modems shall be equipped with monitoring hardware and software to provide readout on the radio received signal strength without additional equipment.
   12. Radio modem shall include the most current version of software with disks used for modem configuration set-up, site specific setup, interference testing and diagnostics. This software shall remain with the Owner.
   13. Radio modems shall be programmable to function as a Master, Remote or Repeater without additional hardware.
   14. Radio modems shall be powered from a 12 VDC power supply with battery backup.
   16. Transmit power shall be a maximum of 4 watt for remote sites and shall be configurable.
   17. Approvals: FCC, CSA

18. Radio modems shall be rated for operation in an environment of -30 to +50 degrees C at 95% non-condensing.
19. Equivalent to equipment manufactured by:
    a. Microwave Data Systems, Rochester, NY
    b. ESTEEM Radio Systems, Kennewich, WA
    c. TS4000 by Teledesign Systems, San Jose, CA.
    d. Or equal.

C. 12 VDC Universal Power Supply:
1. Input voltage: 90 to 264 VAC
2. Output voltage: 12 VDC +/-0.2 Volts
3. Ripple: < 70 rnV ptp
4. Output Current: 3A continuous
5. Operating temp -20 to +50 degrees C.
6. Output Power Connector: Molex (2 pin) for ESTeern
7. Approval and certifications: UL 1950, ISO 9000 factory certified
8. Safety: Over current and short circuit protection

D. Cables:
1. ½" weatherproof coax cable with an attenuation of less than 2.5 dB/100 feet of length. Cable shall be flexible with a copper clad aluminum or braided core, foam dielectric and outer RF shielding in a weatherproof and UV resistant polyethylene jacket. Cable shall be LMR-600 by Times Microwave System of Wallingford, MA or equal.
2. Connections:
    a. Provide N-Male, UHF and TNC connectors, as required, between the radio modern, surge arrestor and antenna. All connection shall be watertight and V.Tapped.
3. Radio modem to PLC: RS232 or PLC network cable with interface connectors. Coordinate connector and pin arrangements with supplied PLC.
4. All coax cable connectors to be soldered with all external connections wrapped with a vinyl wrap and coated with moisture barrier Scotchkote Electrical coating or equal.

E. Lightning arrestor:
1. Four pole filter
2. DC grounded on equipment port
3. Wide frequency bandwidth
4. Multi-strike capability
5. Bulkhead mounting and grounding
6. N silver shell and gold center for low intermodulation generation
7. Frequency range: 50 to 500 MHz
8. Throughput energy: 150 pj
9 Insertion low: 0.1 dB over frequency range.
10. Connectors: N-Type female.

F. Antenna:
1. Directional Yaggi antennas
    a) Impedance: 50 ohms
    b) Minimum Gain: 9 dB min.
    c) Minimum Power Rating: 150 watts
    d) Minimum Number of elements: 5
    e) Antenna materials: Elements-coated solid aluminum rod, boom - coated aluminum tube, mounting hardware- stainless steel.

f) Rated Wind Speed: 100 mph
g) Mounting: Provide with stainless steel mounting brackets for mounting to a 1 1/2" or 2" galvanized pole or wall mounting
h) Equivalent to Celwave, Clearwave, Antennex or equal

2. Omni-directional antenna.
   a) Radiating elements: copper
   b) Materials: Fiberglass antenna with copper/brass radiating elements
   c) Rated Wind Speed: 100 mpb
   d) Impedance: 50 Ohms
   e) Minimum Gain: 7.0 dB with ground plane
   f) Minimum Power Rating: 150 watts
   g) Mounting: Provide Stainless Steel hardware to mount the antenna to the side of tbe existing building.
   h) Equivalent to Celwave, Clearwave Antennex or equal
3. Antenna heights shall be a minimum of 15 feet above grade for security.
4. Cabling to the antenna shall be run in conduit, in accordance with Division 16 requirements, from the antenna to the remote telemetry panel enclosure to provide for physical protection from damage.
5. Antennas and cabling systems shall be provided with surge and lightning arrestor protection. A separate 8 ft long copper grounding rod shall be installed at each station and attached to the antenna systems.
6. Antennae and conduit shall be properly grounded to new grounding rod.

G. Antenna Tower:
   1. Minimum Height: 20-foot tower section with 5 ft top 2-inch diameter mast section.
   2. Materials: Anodized 6061 T6 Aluminum with cross bracing. Framing shall be bolted together using stainless steel bolts and locking nuts.
   3. Base: Tilt type base with galvanized steel base for mounting to a buried concrete pedestal. Minimum base dimensions shall be 12" triangular frame. Provide either a precast or cast-in-place concrete pedestal meeting the tower manufactures requirements.
   4. The tower shall be designed to withstand a 100-mph wind with 1/2," radial ice loading.
   5. When tipped down for maintenance, the tower shall clear all obstructions, such as trees, fences, buildings, power lines, etc.
   6. Equal to M-13 tower by Glen Martin Engineering.

H. PLC-Subsection 13442

I. Uninterruptible Power Supplies (UPS) - Subsection 13442

PART 3 - EXECUTION

3.1 PERMITS

A. The Contractor is responsible for obtaining the required permits from the local municipalities where the work will be done.

3.2 INSTALLATION

A. Install all equipment in accordance with manufacturer's written instructions.

B. The installing contractor shall obtain the services of a technical representative of the radio network system manufacturer to inspect the installation and make any adjustments prior to start-up. The Contractor shall be responsible for complying with any and all manufacturer's requirements for mounting all the associated telemetry equipment. This includes any modifications or additions to building structure, concrete pads and footings and associated site work.

C. The Radio Network Supplier shall be responsible for providing any wire and cable not specifically called out but required by the radio network system to furnish a complete functioning system. Contractor is responsible for installing and coordinating the requirements of Radio Network Supplier.

D. All materials incorporated in the work shall be installed in accordance with the Drawings and Specifications. Where detailed drawings or technical specifications are not provided, the materials shall be installed in accordance with the manufacturer's preferred recommendations and conforming to the best practice of the trade involved. Installation shall include all accessories and finishing required to produce a completed installation ready for use.

3.3 START-UP

A. Tests and Procedures Prior to Start-up: On site start-up, testing, verification and documentation are to be provided such that the radio communication system is determined to be accurately and reliably reporting all the alarms and status conditions as specified.
   1. The Contractor and Radio Network Supplier shall coordinate the work of the radio network system manufacturer's service personnel as necessary, including installation, interconnection, testing, calibration, and scheduling of the manufacturer's service personnel.
   2. The supervisory services of a factory-trained service engineer who is specifically trained on the type of equipment herein specified shall be provided on the site during construction to assist the Contractor or Telemetry System Supplier in equipment installation, if required. Upon completion of the installation, the services of the above service engineer will be provided for a period of not less than one(!) 8-hour day for calibration and start-up of the equipment, and instructing the operating personnel. The minimum days specified above does not relieve the manufacturer of providing sufficient service to place the system in satisfactory operation.
   3. No form of energy shall be turned on to any part of the radio network system prior to receipt by the City of a certified statement of approval of the installation from the Contractor containing his supplier's authorization for turning on energy to the system, except that the supplier's serviceman may do so for the purpose of check-out as described herein.
   4. Supplier shall test radio network system prior to connection of inputs.
   5. Refer to Subsection 11000 - Equipment for Additional Start-up and Training Information.

B. System Demonstration
   1. The City will assume no liability or responsibility for any portions of the installation under this Contract until they are demonstrated and accepted in writing. Final demonstrations shall be made only after the City is satisfied that the work has been completed in accordance with the intent of the Contract Documents.
   2. After the system is completed demonstrate the total system operation and make final adjustments to the system. If any system or piece of equipment within a system fails to function properly, rectify such defects or inadequacies and make a final demonstration as directed by the City. Once connected, all alarm inputs will be exercised and documented.

3. All demonstrations and instructions referred to shall be scheduled at the convenience of the City, and shall be scheduled with at least 72-hours written notice.
4. Testing of the radio network shall include determining the performance of the radio system by checking antenna losses, SIN ratios and final receive signal strength.

3.4 SERVICE CONTRACT

A. A service contract for periodic maintenance, tune-up and systems check shall be made available to the Owner to commence after the warranty expires.

B. Local in-state service shall be available to correct problems within 24 hours of notification.

C. Provide dial-up telephone modem communication with the radio modems to provide on-line testing and troubleshooting and diagnostics of the radio modems performance. (The master station will have phone service. Remote stations may not have phone service but shall have the capability, all hardware connections and software to be connected by phone). The Radio Network Supplier shall provide one line trouble shooting service without additional charge for one year after the Radio Telemetry System is completely functional and accepted as complete by the Owner. The service shall be available at a nominal fee after the warranty period.

END OF SUBSECTION

SUBSECTION 15050

PIPE & PIPE FITTINGS - GENERAL

PART I - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install, support, and test pipe and pipe fittings of the type(s) and size(s) and in the location(s) shown on the Drawings and as specified herein.

B. Related Work Specified Elsewhere (When Applicable):
1. Excavation and backfill are specified in Division 2.
2. Concrete cradles, arches, and encasements are specified in Division 3.
3. Painting and Pipe Identification are specified in Subsection 09900.
4. Surface Preparation and Shop Coatings are specified in Subsection 09905.
5. Valves, gates, pipe hangers, pipe supports, pipe and equipment insulation, heating, and plumbing are specified in the appropriate Sections in Division 15.
6. Pipe materials are specified in the appropriate Subsections of Division 2 and/or Division 15.

1.2 REFERENCES

A. American National Standards Institute (ANSI)
1. ANSI B3 I. I - Power Piping
2. ANSI B3l.3 - Process Piping
3. ANSI B31.4- Liquid Transportation Systems for Hydrocarbons, Liquid Petroleum Gas, Anhydrous Ammonia, and Alcohol.
4. ANSI B3l.5 - Refrigeration Piping
5. ANSI B31.9 - Building Services Piping
6. ANSI B31.8 - Gas Transmission and Distribution Piping Systems

1.3 SUBMITTALS

A. Submit shop drawings in accordance with Subsection 01340

B. Submit manufacturer's "Certification of Conformance" that pipe and fittings and other piping appurtenances meet or exceed the requirements of these Specifications.

C. Submit other documents as specified in the appropriate Sections of this Division.

D. Submit complete pipe support system design. The support system shall be designed for dead weight and dynamic analysis, including system thermal effects, pressure thrusts, and seismic forces.

E. Submit complete layouts, schedules, and location plans for all piping systems.

1.4 DELIVERY, STORAGE AND HANDLING

A. Exercise care during loading, transporting, unloading, and handling to prevent damage of any nature to interior and exterior surfaces of pipe and fittings.

B. Do not drop pipe and fittings.

C. Store materials on the project site in enclosures or under protective coverings in accordance with manufacturer's recommendations and as required by the City.

D. Assure that materials are kept clean and dry.

E. Do not store materials directly on the ground.

F. Follow manufacturer's specific instructions, recommendations and requirements.

G. Store in a manner to protect items with epoxy shop coatings from exposure to UV light which can cause chalking of the epoxy. Length of acceptable exposure prior to providing UV protective measures shall be in accordance with coating manufacturer's recommendations. This includes protection from UV light after installation while awaiting covering or filling of tanks, or prior to field painting for items scheduled to be top coated as specified in Subsection 09900.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials are specified in the following Sections in this Division, and Division 2.

2.2 SURFACE PREPARATION AND SHOP COATINGS

A. Provide surface preparation and shop coatings in accordance with Specification Subsection 09905.

PART 3 - EXECUTION

3.1 INSPECTION

A. Provide all labor necessary to assist the City in the inspecting pipe, fittings, gaskets, and other materials.

B. Carefully inspect all materials at the time of delivery and just prior to installation.

C. Carefully inspect all pipe and fittings for:
1. Defects and damage.
2. Deviations beyond allowable tolerances for joint dimensions.
3. Removal of debris and foreign matter.

D. Examine areas and structures to receive piping for:
1. Defects, such as weak structural components that adversely affect the execution and quality of work.
2. Deviations beyond allowable tolerances for pipe clearances.

E. All materials and methods not meeting the requirements of this Contract will be rejected.

F. Immediately remove all rejected materials from the project site.

3.2 INSTALLATION

A. General:
1. Install all pipe and fittings in strict accordance with the manufacturer's instructions and recommendations and as specified herein.
2. Install all pipes and fittings in accordance with the lines and grades shown on the Drawings and as required for a complete installation.
3. Install adapters, acceptable to the City of Rockland's Director of the Pollution Control Department, when connecting pipes constructed from different materials.
4. Support all piping not being installed in trenches in accordance with the "Pipe Hangers & Supports" Section in Division 15.

B. Installation in Trenches:
1. Firmly support the pipe and fittings on bedding material as shown on the Drawings and as specified in the appropriate Sections of these Specifications.
2. Do not permanently support the pipe or fittings on saddles, blocking stones, or any material which does not provide firm and uniform bearing along the outside length of the pipe.
3. Thoroughly compact the material under the pipe to obtain a substantial unyielding bed shaped to fully support the pipe.
4. Excavate suitable holes for the joints so that only the barrel of the pipe receives bearing pressure from the supporting material after placement.
5. Lay each pipe length so it forms a close joint with the adjoining length and bring the inverts to the required grade.
6. Set the pipe true to line and grade.
7. Do not drive the pipe down to grade by striking it with a shovel handle, timber, rammer, or any other unyielding object.
8. Immediately after making a joint, fill the holes for the joints with bedding material, and compact.
9. When each pipe length has been properly set, place and compact enough of the bedding material between the pipe and the sides of the trench to hold the pipe in correct alignment.
10. After filling the sides of the trench, place and lightly tamp bedding material to complete the bedding as shown on the Drawings.
11. Take all necessary precautions to prevent floatation of the pipe in the trench.
12. Bedding and backfill for all pipe materials shall be as specified in Subsection 02200, Earthwork, and as shown on the Drawings.

C. Temporary Plugs:
1. When pipe installation work in trenches is not in progress, close the open ends of the pipe with temporary watertight plugs.
2. If water is in the trench when work is resumed, do not remove plugs until all danger of water entering the pipe is eliminated.
3. Do not use the pipelines as conductors for trench drainage during construction.

3.3 CLEANING AND TESTING

A. Cleaning & Testing Piping - General:

1. Thoroughly clean all piping prior to testing. Remove all dirt, dust, oil, grease and other foreign material. Exercise care while cleaning to avoid damage to linings and coatings.
2. When the installation is complete, test all pipelines in the presence of a Pollution Control Department representative (if required) and the plumbing or building inspector in accordance with the requirements of the local and state plumbing codes and the appropriate Sections of these Specifications. When requested by the City of Rockland or building gravity drains shall be tested prior to backfilling or concealing. All other piping must be tested after backfilling.
3. Equipment: Supply all labor, equipment, materials, taps, gauges, and pumps required to conduct the tests.
4. Retesting: Perform all retesting required by the City.

B. Outside Potable Water Piping:
   1. Pressure Test (CLASS I):
      a. CLASS I Pressure Testing shall be performed in accordance with Section 4 of AWWA Standard C600.
      b. Pressure and leakage tests are required and will be conducted concurrently.
      c. Hydrant branch gate valves shall remain open during this test.
      d. The hydrostatic pressure shall be at the test pressures noted on the Drawings based on the elevation of the lowest point in the Section under test. If no test pressure is indicated, perform pressure and leakage test at 1-1/2 times the maximum system pressure or 150 psi, whichever is greater (based on the elevation of the lowest point of the section under test and corrected to gauge location). Test duration shall be two (2) hours.
      e. Leakage, if any, shall be equal to or Jess than the amounts as determined by Section 4.2 of AWWA C 600.

$$L = \frac{SD\sqrt{P}}{133{,}200}$$

L = allowable leakage in gallons per hour
S = length of pipe tested, in feet
D = nominal diameter of pipe, in inches
P = average test pressure, in pounds per square inch

      f. The Contractor shall furnish and install corporation stops, taps and lengths of line as required to conduct the testing.
   2. Disinfection of Pipelines:
      a. Chlorinate all new potable water lines in accordance with the procedure outlined in AWWA C65 l. (Section 5.1 deleted)
      b. Review locations of chlorination and sampling points with the Engineer prior to beginning disinfection.
      c. Use a dosage which will produce an initial minimum concentration of 25 mg/I and not Jess than 1O mg/I chlorine residual after a contact period of 24 hours.
      d. During the chlorination period, exercise care to prevent the contamination of water in the existing water main.
      e. After chlorination, flush the piping with clean potable water until the residual is that prevailing in the existing system or Jess than 0.5 mg/I.
      f. The Contractor shall furnish and install corporation stops, taps, lengths of pipe as required to conduct testing.
      g. Dispose of chlorinated water as per AWWA C65l, Appendix B.
   3. Bacteriological Testing:

a. Test all new potable water lines for total coliform bacteria at no additional cost to the Owner.
b. The length of pipe to be tested and the time of the test itself shall be as approved in advance by the Engineer.
c. The Engineer will observe the taking of samples.
d. Have all samples tested by a laboratory certified by the State and submit test results to the Engineer.
e. Any segment of a potable water line shall be considered unsuitable for service if a coliform bacteria count is obtained from that sample or if results show a high non-specific bacteria level.
f. Re-disinfect all segments of piping considered unsuitable and retest. Continue to disinfect and test until satisfactory results are obtained.
g. Place piping into service when it has been successfully tested for pressure, leakage and total coliform bacteria and has been accepted by the Engineer.

C. Building Interior Water Lines, Piping Which Carries Water or Liquid Under Pressure: Fill pipes with water and subject them to 100 psig. or 1-1/2 times the normal working pressure, whichever is greater, for two (2) hours with no loss in test pressure. Should leaks be found, repair as required even to the extent of disassembling and remaking the joints, or replacing sections of pipe and repeat tests until the testing results are approved by the City of Rockland.

D. Building Interior Sewer System: Plug all outlets and fill pipes with water to the top of the highest vent stack above the roof, or with not less than IO feet of water at all points in section. The piping shall hold this water for a period of 30 minutes without showing a drop-in water level. Should leaks be found, repair as required even to the extent of disassembling and remaking the joints, or replacing sections of pipe and repeat tests until the testing results are approved by the City of Rockland.

E. Outside Sewer Lines (CLASS II): CLASS II pipe testing shall be performed in accordance with Subsection 02755.

F. All Other Piping Systems:
1. CLASS IV and CLASS V Hydrostatic Pressure Test:
a. The section of pipe to be tested shall be filled with water of approved quality, and all air shall be expelled from the pipe. If blow offs are not available at high points for releasing air the Contractor shall make the necessary excavations, backfilling and taps at such points and shall plug said holes after completion of the test.
b. The section under test shall be maintained full of water for a period of 24 hours prior to the combined pressure and leakage test being applied.
c. CLASS IV - Perform pressure and leakage test at the test pressure shown on the Pipe Schedule. If no test pressure is indicated, perform pressure and leakage test at 1-1/2 times the maximum system pressure or 100 psi whichever is greater (based on the elevation of the lowest point of the section under test and corrected to the gauge location).
d. CLASS V - Perform pressure and leakage test at the test pressure shown on the Pipe Schedule. If no test pressure is indicated, perform pressure and leakage test at 1-1/2 times the maximum system pressure or 20 psi whichever is greater (based on the elevation of the lowest point of the section under test and corrected to the gauge location).
e. While maintaining this pressure, the Contractor shall make a leakage test by metering the flow of water into the pipe. If the average leakage during a two-hour period on buried

pipelines exceeds a rate calculated by the equation in this Specification Section, the section shall be considered as having failed the test. All pipes within structures and chambers and all flanged joints shall have no visible leakage.

f. If the section fails to pass the pressure and leakage test, the Contractor shall do everything necessary to locate, uncover, and repair or replace the defective pipe, fitting, or joint, all at his own expense and without extension of time for completion of the work. Additional tests and repairs shall be made until the section passes the specified test.

2. Connection to Work by Others.
   a. If work involves connection of pipe lines to pipes or structures provided by others, pressure tests pipe line prior to making the connection.
   b. After successfully passing the pipe line pressure test, make the necessary connections to the work by others, and pressure test the connection.
   c. The connection shall be pressurized to the pipe line test pressure, for a minimum of 4 hours. The connection shall have no visible leakage.
   d. Correct any leakage at no cost to the Owner and retest until connection passes.
3. Cleaning: Perform all specialized cleaning as specified or required by system.

3.4 PIPE SCHEDULE

SYMBOL	DESCRIPTION	LOCATION[1]	SIZE RESTRICTIONS	MATERIAL	JOINT SYSTEM	PRESSURE TESTING CLASS (PRESSURE) [3]
FM	FORCE MAIN	INTERIOR	LESS THAN 3"	SCH 80 PVC OR	SOLVENT WELD	CLASS I
			LARGER THAN 3"	CLASS 53 D.I.	FLANGED	CLASS IV
		EXTERIOR	4" & LARGER	CLASS 51 D.I.	MJ OR PUSH-ON	CLASS IV
			LESS THAN 4"	SDR 17 PE (DIPS)	THERMAL WELD	
S	SEWER	EXTERIOR	20" & LARGER	CLASS 52 D.I.	PUSH-ON	CLASS II
				RCP CLASS III/IV	BELL & SPIGOT	
			LESS THAN 20"	SDR 35 PVC	PUSH-ON	
				RCP CLASS III/IV	BELL & SPIGOT	
		INTERIOR	4" & LARGER	CLASS 51 D.I.	PUSH-ON	
			LESS THAN 4"	SDR 40 PVC	SOLVENT WELD	
SPD	SUMP DRAIN	INTERIOR/ EXTERIOR		CLASS 51 D.I.	MJ OR PUSH-ON	CLASS V
V	VENT LINE	EXTERIOR		316 SS	WELDED	CLASS II

(1) PIPE CONTAINED WITHIN TANKAGE SHALL BE CONSIDERED "INTERIOR" PIPING FOR THE PURPOSES OF THE PIPE SCHEDULE (UNLESS OTHERWISE SPECIFICALLY DESIGNATED).
(2) TYPE L COPPER MAY BE USED IN LIEU OF D.I. FOR 3" DUCTILE IRON PIPE.
(3) IF A SPECIFIC PRESSURE IS NOT INDICATED IN PARENTHESES AFTER THE PRESSURE TESTING CLASS, USE THE TEST PRESSURE INDICATED IN THE SPECIFICATION WRITE UP FOR THAT GENERAL PIPE PRESSURE TESTING CLASS.

END OF SUBSECTION

SUBSECTION 15062

DUCTILE IRON PIPE & FITTINGS (INTERIOR APPLICATIONS)

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Provide and install ductile iron pipe and fittings of the type(s) and size(s) in the location(s) shown on the Drawings and as specified herein.

B. Related Work Specified Elsewhere:
   1. Pipe and Pipe Fittings - General is specified in Subsection I 5050.
   2. Surface Preparation and Shop Coatings are specified in Subsection 09905.
   3. Ductile Iron Pipe & Fittings for Buried Applications is specified in Subsection 02615.

1.2 QUALITY ASSURANCE

A. Standards (As Applicable):
   1. Cement-mortar lining for water: ANSI A21.4 (AWWA Cl04).
   2. Rubber gasket joints: ANSI A21.ll (AWWA Cl 11).
   3. Ductile iron pipe thickness: ANSI A21.50 (AWWA C150).
   4. Ductile iron pipe centrifugally cast in metal or sand lined molds: ANSI A21.5I (AWWA Cl51).
   5. Pipe flanges and fittings: ANSI BI6.I and ANSI A21.10 (AWWA ClIO).
   6. Threaded,flangedpipe: ANSIA21.15(AWWAC115).
   7. Cast and ductile iron fittings: ANSI A21.10 (AWWA Cl 10).

B. Acceptable Manufacturers:
   1. Tyler
   2. Griffin
   3. Union
   4. US Pipe
   5. Or equivalent.

1.3 DELIVERY, STORAGE & HANDLING

A. Exercise extra care when handling cement lined pipe because damage to the lining will render it unfit for use.

B. Protect the spherical spigot ends and the plain ends of all pipe during shipment by wood lagging securely fastened in place.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. General:
   1. Unless otherwise shown on the Drawings, the minimum thickness of ductile iron pipe shall be Class 53.

2. Pipe for use with sleeve type couplings shall have plain ends (without bells or beads) cast or machined at right angles to the axis.
3. Pipe shall be double thickness cement lined and seal coated unless noted otherwise on the Drawings and except for air piping lines which shall be completely unlined.
4. Pipe for use with split type couplings shall have ends with cast or machined shoulders or grooves that meet the requirements of the manufacturer of the couplings.
5. The outside of all interior pipe shall be coated in accordance with Subsection 15050.

B. Joints (as shown on Drawings or as specified):
1. Flanged:
   a. Provide specially drilled flanges when required for connection to existing piping or special equipment.
   b. Flanges shall be flat face, Jong-hub screwed tightly on pipe by machine at the foundry prior to facing and drilling.
   c. Gaskets:
      (1) Full face gaskets only.
      (2) Thickness of gaskets 12 inches in diameter and smaller: 1/16 inch.
      (3) Thickness of gaskets larger than 12 inches in diameter: 3/32 inch.
      (4) On high temperature applications such as air lines, the gaskets shall be suitable for service from 40°F to 250°F.
   d. Fasteners:
      (1) Make joints with bolt, studs with a nut on each end, or one tapped flanged with a stud and nut.
      (2) The number and size of bolts shall meet the requirements of the applicable ANSI standard.
      (3) Nuts, bolts, and studs shall be Grade B meeting the requirements of ASTM A307.
   e. When applicable, provide and install flange clamps as shown on the Drawings.
2. Grooved split ring couplings, sleeve couplings, flexible joints and couplings, shall be supplied as specified in "Couplings and Connectors" Section.
3. Joint Bracing:
   a. Provide joint bracing to prevent the piping from pulling apart under pressure as required and as shown on the Drawings.
   b. Types of bracing:
      (1) Pipe and fittings furnished with approved lugs or hooks cast integrally for use with socket pipe clamps, tie rods, or bridles. Bridles and tie rods shall be a minimum of 3/4-inch diameter except where they replace flange bolts of a smaller size, in which case they shall be fitted with a nut on each side of the pair of flanges. The clamps, tie rods, and bridles shall be coated with bituminous paint in buried installations and shall be coated with the same coatings as the piping system in interior installations after assembly or, if necessary, prior to assembly.
      (2) Other types of bracing as shown on the Drawings.

2.2 FITTINGS

A. Standard Fittings:
1. Either gray cast iron or ductile iron fittings may be furnished.
2. Pressure rating of 250 psi unless indicated otherwise on the Drawings or as specified.
3. Flange fittings shall be ANSI Bl6.l, Class 125 unless indicated otherwise. Flanges shall be flat faced, with full face gaskets.
4. Joints the same as the pipe with which they are used or as shown on the Drawings.

5. Provide fittings with standard bases where shown on the Drawings.
6. Cement lining and seal coat unless noted otherwise on the Drawings, and except for air piping applications where the fittings shall be unlined.
7. All interior fittings shall receive coating in accordance with Subsection 15050.
8. On high temperature applications such as air lines, the gaskets shall be suitable for service from 40°F. to 250° F.

B. Non-Standard Fittings:
1. Fittings having non-standard dimensions shall be subject to the Engineer's review and acceptance.
2. Non-standard fittings shall have the same diameter and thickness as standard fittings and shall meet the specification requirements for standard fittings.
3. The lengths and types of joints shall be determined by the particular piping to which they connect.
4. Flanged fittings not meeting the requirements of ANSI A2l .10 (i.e., laterals or reducing elbows) shall meet the requirements of ANSI B16.1 in Class 125.

C. Wall Castings:
1. Size, type and location as shown on the Drawings.
2. Dimensions shall conform to ANSI A2l.10 except where required. A flange substantially flush with the face of a concrete or masonry wall shall be drilled and tapped for studs.
3. Other dimensions shall be identical to the corresponding parts of standard bell and spigot fittings.
4. A central fin not less than 1/2-inch-thick and of the same diameter as a flange shall be cast on the barrel at a point that will locate it midway through the wall to form a waterstop.
5. Alternate wall sleeve system as manufactured by Omni Sleeve, Malden, MA. can be utilized as approved by Engineer, in place of above specified wall casting system.

PART 3 - EXECUTION

3.1 INSPECTION

A. Carefully inspect all materials at the time of delivery and just prior to installation.

B. Carefully inspect all pipe and fittings for:
1. Defects, such as weak structural components, that adversely affect the execution and quality of work.
2. Deviations beyond allowable tolerances for pipe clearances.

C. Immediately remove all rejected materials from the project site.

PART 4 - INSTALLATION

A. General:
1. Install in strict accordance with the pipe and fitting manufacturer's instructions and recommendations and as specified or as shown on the Drawings.
2. Acceptable thrust resistant system is required at all fittings on pressure pipe.

B. Assembling Joints:

1. Flanged Joints:
   a. Insert the nuts and bolts (or studs), finger tighten, and progressively tighten diametrically opposite bolts uniformly around the flange to the proper tension.
   b. Execute care when tightening joints to prevent undue strain upon valves, pumps, and other equipment.
2. Bolted Joints:
   a. Remove rust preventive coatings from machined surfaces prior to assembly.
   b. Thoroughly clean and carefully smooth all burrs and other defects from pipe ends, sockets, sleeves, housings and gaskets.

C. Fabrication:
1. Tapped Connections:
   a. Make all tapped connections as shown on the Drawings.
   b. Make all connections watertight and of adequate strength to prevent pullout.
   c. Drill and tap normal to the longitudinal axis of the pipe.
   d. The maximum sizes of taps in pipes and fittings without busses shall not exceed the sizes listed in the appendix of ANSI A2I.51 based on 3 full threads for ductile iron.
   e. Taps in fittings shall be located where indicated by the manufacturer for that particular type of fitting.

D. Castings in Masonry:
1. Accurately set and align castings to be encased in masonry.
2. Thoroughly clean castings immediately prior to being set in place. Remove all rust, scale and other foreign material.

END OF SUBSECTION

SUBSECTION 15088 COUPLINGS & CONNECTORS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish and install couplings and connectors of the type(s) and size(s) as specified herein.

1.2 QUALITY ASSURANCE

A. Minimum pressure rating equal to that of the pipeline in which they are to be installed.

B. Couplings and connectors, other than those specified herein, are subject to the City of Rockland's approval.

PART 2 - PRODUCTS

2.1 MATERIALS

A. All Couplings and Connectors:
   1. Gasket Materials: Composition suitable for exposure to the liquids to be contained within the pipes.
   2. Diameters to properly fit the specific types of pipes on which couplings and connectors are to be installed.

B. Sleeve Type Couplings (When Applicable):
   1. Exposed Couplings (When Applicable):
      a. Steel middle ring,
      b. Two steel follower rings,
      c. Two wedge-section gaskets,
      d. Sufficient steel bolts to properly compress the gaskets,
      e. Acceptable Manufacturers:
         (1) Dresser Manufacturing Co. - Style 38,
         (2) Rockwell - Style 431,
         (3) Or equivalent.
   2. Buried Couplings (When Applicable):
      a. Cast iron or epoxy coaled steel middle rings with pipe stops removed,
      b. Two malleable iron or epoxy coated steel follower rings with ribbed construction,
      c. Two wedge-section gaskets,
      d. Sufficient AWWA C-111 or galvanized steel nuts and bolts to properly compress the gaskets,
      e. Acceptable Manufacturers:
         (1) Dresser Manufacturing Co. - Style 38 and/or 153,
         (2) Rockwell - Style 431, and/or 441,
         (3) Or equivalent.

C. Split Type Couplings (When Applicable):
   1. Constructed from malleable or ductile iron.

2. For use with grooved or shouldered end pipe with minimum wall thickness as required so as not to weaken pipe.
3. Cast in two segments for 3/4 inch through 14-inch pipe sizes, four segments for 15 inches through 24-inch pipe sizes, and six segments for pipe sizes over 24 inches.
4. Coating: Enamel.
5. Bolts: Carbon steel.
6. All gaskets shall be Manufacturers Standard or as required for intended service with respect to fluid, temperature and pressure.
7. Acceptable Manufacturers:
   a. Victaulic Company of America, Style 77 for IPS Pipe, Style 31 for Ductile Iron Pipe.
   b. Gustin-Bacon Co.,
   c. Or equivalent.

D. Flanged Adapters (When Applicable):
1. For joining plain end or grooved end pipe to flanged pipes and fittings.
2. Adapters shall conform in size and bolt hole placement to ANSI standards for steel and/or cast-iron flanges 125 or 150-pound standard unless otherwise required for connections.
3. Exposed Sleeve Type:
   a. Constructed from steel.
   b. Coating: Enamel.
   c. Bolts: Carbon steel or ASTM A588 steel.
   d. Acceptable Manufacturers:
      (1) Dresser Manufacturing Co. - Style 128 for cast iron, ductile iron and steel pipes with diameters of 2 inches through 96 inches,
      (2) Or equivalent. Buried Sleeve Type:
   a. Constructed from cast iron.
   b. Bolts: ASTM A588 steel or galvanized steel.
   c. Acceptable Manufacturers:
      (1) Dresser Manufacturing Co. - Style 127 locking type for cast iron, ductile iron, asbestos cement and steel pipes with diameters of 3 inches through 12 inches,
      (2) Or equivalent. Split Type:
   a. Constructed from malleable or ductile iron.
   b. For use with grooved or shouldered end pipe.
   c. Coating: Enamel.
   d. Acceptable Manufacturers:
      (1) Victaulic Company of America - Style 741 for IPS pipe, or Style 341 for Ductile Iron Pipe, for pipe diameters of 2 inches through 12 inches,
      (2) Victaulic Company of America - Style 742 for IPS pipe, or Style 342 for Ductile Iron Pipe, for pipe diameters of 14 inches through 16 inches,
      (3) Or equivalent.

E. Flexible Joints:
1. Expansion Joints:
   a. Materials shall be capable of withstanding the temperature, pressure and type of material in the pipeline.
   b. Shall be the filled arch type that will prevent sediment build up for all sludge, sewage, and other lines with similar service.
   c. Supplied with control rods to restrict elongation and compression.
   d. Metal retaining rings shall be split and beveled galvanized steel for placement against the flange of the expansion joint.
2. Deflection Joints:

a. Joints designed to permit a nominal maximum deflection of 15 degrees in all directions from the axis of the adjacent pipe length, will prevent pulling apart, and will remain watertight at any angle of deflection under 15 degrees.
b. Material to be manufactured from a composition material suitable for exposure to the liquid, pressure and temperature to be contained within the pipe.
c. Supplied with control rods as required.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Sleeve Type Couplings (When Applicable):
1. Thoroughly clean pipe ends for a distance of 8 inches from the ends prior to installing couplings, and use soapy water as a gasket lubricant.
2. Slip a follower ring and gasket (in that order) over each pipe and place the middle ring centered over the joint.
3. Insert the other pipe length into the middle ring the proper distance.
4. Press the gaskets and followers evenly and firmly into the middle ring flares.
5. Insert the bolts, finger tighten and progressively tighten diametrically opposite nuts uniformly around the adapter with a torque wrench applying the torque recommended by the manufacturer.
6. Insert and tighten the tapered threaded lock pins.
7. Insert the nuts and bolts for the flange, finger tighten and progressively tighten diametrically opposite bolts uniformly around the flange to the torque recommended by the manufacturer.

B. Split Type Flange Adapters (When Applicable): Install in the same manner as Split Type Couplings.

C. Buried Cast Iron Couplings, Adapters and Connectors (When Applicable): Thoroughly coat all exterior surfaces, including nuts and bolts, after assembly and inspection by the City of Rockland with a heavy-bodied bituminous mastic as approved by the City of Rockland.

D. Buried Epoxy Coated Steel Couplings: Thoroughly coat all exterior surfaces, including nuts and bolts after assembly and inspection by the City of Rockland with a coal tar approved by the City of Rockland. Prior to coating, roughen the epoxy with emory paper and follow with a solvent cleaner (aeromatic similar to xylol). Dry film thickness of the coal tar is to be 12-16 mils.

E. Install thrust rods, supports, and other provisions to properly support pipe weight and axial equipment loads.

F. All interior sleeve interior couplings shall be restrained with tie rods when used on pressurized lines. All buried couplings on pressure lines shall be restrained (solid sleeve) type.

END OF SUBSECTION

PIPE SLEEVES & SEALS

SUBSECTION 15092

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish and install wall sleeves and seals of the type(s) and sizes(s) specified herein.

1.1 QUALITY ASSURANCE

A. Provide and install all sleeves of the types specified herein, as shown on the Drawings and as directed by the City of Rockland.

B. Provide sleeves that are airtight, gastight or watertight as required.

PART 2 - PRODUCTS

2.1 TYPES AND LOCATIONS

A. New Construction:
   1. Concrete Walls - Liquid Containing Structures to Air or Ground:
      a. For ductile iron and steel piping systems, utilize wall castings. Materials, schedule, class and size to match pipe.
         i. For galvanized steel piping systems, use sleeve with I inch x 1/2-inch welded sealing and anchoring collar in middle, hot-dip galvanized after fabrication.
         ii. For ductile or cast-iron piping systems, use casting with 1 inch x 1/2 inch integrally cast sealing and anchoring collar in middle.
         iii. Refer to details on Process Drawings.
      b. For plastic piping systems, sleeve and seals to be in accordance with Concrete Walls - Air to Ground requirements noted above. These type penetrations will be allowable only in those locations specifically depicted on the drawings.
   2. Other conditions shall be sleeved as shown on the Drawings or as reviewed and accepted by the City of Rockland.

B. Penetrations Through Existing Walls:
   1. Concrete Walls - Liquid Containing Structures to Air or Ground:
      a. Limited to only those locations shown on the Drawings.
      b. Core smooth-walled opening with coring machine. Grout smooth any irregularities in opening.
      c. Size of cored opening as required by seal manufacturer.
      d. Seal with rubber link compression seal.
   2. Other conditions shall be installed as reviewed and accepted by the City of Rockland.

C. Rubber Link Seals:
   1. Multi-rubber link type with pressure plates, bolts, nuts and sealing element providing a leakproof seal.

2. General Service:
   a. Glass Reinforced Nylon Pressure Plate.
   b. Carbon steel zinc-phosphated nut and bolt.
   c. Sealing element: EPDM rubber.
   d. -40°F. to 250°F. rating.
3. Corrosive Service: (Where Applicable):
   a. Use: Sludge tanks, scum tanks, digesters, wetwells, manholes, as shown on the Drawings.
   b. Glass Reinforced Nylon Pressure Plate.
   c. Bolt and nut, 18-8 stainless steel.
   d. Sealing element: EPDM rubber.
4. Acceptable Manufacturers:
   a. Link Seal by Thunderline Company
   b. Or equivalent.

PART 3 -EXECUTION

3.1 INSTALLATION

A. New construction:
   1. Concrete: Set sleeves in proper location prior to placing concrete.

B. Existing Construction:
   1. The location will be reviewed and accepted by the City of Rockland prior to cutting hole.
   2. For concrete, holes shall be located to avoid the reinforcing steel when possible.
   3. Patch all damaged work as required to maintain a neat and clean appearance.

C. Rubber Link Seals: Install as required and in strict accordance with the manufacturer's instructions and recommendations.

END OF SUBSECTION

SUBSECTION 15094

PIPE HANGERS & SUPPORTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish and install pipe hangers and supports to rigidly support pipes, maintain the necessary pitch, prevent vibration, prevent movement, and to allow expansion and contraction of the pipe.

1.2 RELATED WORK

A. Concrete is included in Division 3.

B. Pipe and fittings are included in respective sections in Divisions 2, 11 and 15.

1.3 SUBMITTALS

A. Submit to the City of Rockland complete sets of shop drawings of all items to be furnished under this Section. Submittals shall include complete layouts, schedules, location plans and complete total bill of materials for all pipe support systems.

B. Submittals shall include a representative catalog cut for each different type of pipe hanger or support indicating the materials of construction, important dimensions and range of pipe sizes for which that hanger is suitable. Where standard hangers and/or supports are not suitable, submit detailed drawings showing materials and details of construction for each type of special hanger and/or support. Provide detailed information on anti-seize compound.

PART 2-PRODUCTS

2.1 GENERAL

A. All of the products specified herein are intended to support the various types of piping systems shown on the Drawings. It shall be the responsibility of the Contractor to develop final details associated with special conditions (in particular system temperatures and pressures) associated with this project.

B. All pipe and appurtenances connected to the equipment shall be supported in a matter to prevent any strain from being imposed on the equipment or piping system.

C. Unless otherwise specified, all rods, clamps, hangers, inserts, anchor bolts, brackets and components for interior pipe supports shall be furnished with galvanized finish, hot dipped or electro-galvanized coated, except where field welding is required, where cold-applied galvanizing may be used. Interior clamps on plastic pipe shall be plastic coated. All rods, clamps, hangers, inserts, anchor bolts, brackets and components for exterior pipe, piping subject to moisture or

corrosive atmosphere, submerged pipe and pipe within outdoor structures shall be of Type 316 stainless steel.

D. All insulated pipe shall be furnished with a rigid form insulating saddle at each pipe support location as specified under respective pipe insulation. Provide protection shields as specified in each support location.

E. Unless otherwise specified herein, pipe hangers and supports shall be standard catalogued components, conforming to the requirements of MCC-SP-58 and -69; a shall be as manufactured by Anvil International Inc., Portsmouth, NH; Carpenter & Patterson Inc., Woburn, MA; F&S Central, Brooklyn, NY, or equal. Any reference to a specific figure number of a specific manufacturer is for the purpose of establishing a type and quality of product and shall not be considered as proprietary.

F. Expansion anchors shall be equal to Kwik-Bolt as manufactured by the McCullock Industries, Minneapolis, MI or Wej-it by Wej-it Expansion Products, Inc., Bloomfield, CO. The length of expansion bolts shall be sufficient to p lace the wedge portion of the bolt a minimum of I-inch behind the steel reinforcement.

2.2 MATERIALS

A. Overhead Hangers:
   1. For pipes 8 inches in diameter and smaller:
      a. Adjustable clevis.
      b. Acceptable manufacturers:
         (1) Anvil International, Inc.
         (2) Carpenter & Patterson Inc.
         (3) Or approved equal.
   2. For pipes larger than 8 inches in diameter:
      a. Single pipe rolls and sockets.
      b. Acceptable Manufacturers:
         (1) Anvil International, Inc.
         (2) Carpenter & Paterson Inc.
         (3) Or approved equal.
   3. For insulated pipe use insulation protection shield:
      a. Anvil International, Inc.
      b. Carpenter & Paterson Inc.
      c. Or approved equal.
   4. For copper piping:
      a. Copper plated malleable iron.
      b. Acceptable manufacturer:
         (1) Anvil International, Inc.
         (2) Carpenter & Paterson Inc.
         (3) Or approved equal.
   5. Threaded hanger rods:
      a. Right-hand and left-hand machine threads.
      b. Suspended from beam clamps or galvanized inserts in concrete.
      c. Acceptable manufacturers:
         (1) Anvil International, Inc.
         (2) Carpenter & Paterson Inc.
         (3) Or approved equal.

B. Pipe Saddle Supports:
   1. Adjustable type with pipe and floor flanges.
   2. When used under base fittings, substitute matching floor flanges for saddle sections.
   3. Acceptable manufacturers:
      a. Anvil International, Inc.
      b. Carpenter & Paterson Inc.
      c. Or approved equal.

C. Wall and column supports:
   1. Welded steel brackets with anchor chairs.
   2. Install additional wall bearing plates where required for wall brackets.
   3. Acceptable manufacturers:
      a. Anvil International, Inc.
      b. Carpenter & Paterson Inc.
      c. Or approved equal.

D. Brick and Concrete Piers:
   1. Locate where shown on the Drawings and/or where required for proper support.
   2. Construct piers to accurately conform to the bottom one-third to one-half of the pipe.

E. Plastic Pipe Hangers:
   1. Plastic coated hangers.
   2. Acceptable manufacturers:
      a. Anvil International, Inc.
      b. Carpenter & Paterson Inc., Fig. SOOPVC.
      c. Or approved equal.

F. Miscellaneous Hangers: Submit shop drawings for review and acceptance by City of Rockland prior to use.

G. All additional supports, braces, brackets, etc. which are not specifically described above, but which are required to provide a system in accordance with the applicable paragraphs of this section, shall be provided and installed. Submit all such devices for shop drawing review and acceptance by the City of Rockland prior to use.

PART 3 - EXECUTION

3.1 INSTALLATION

A. General:
   1. Install in at all changes in direction and at the end of piping runs. Provide additional devices as required to meet the intent of the specification with respect to support, pitch, vibration, movement, and expansion and contraction.
   2. Install all hangers, supports, rods, inserts, clamps, brackets, braces, bolts and other supporting devices of sizes and spacings to prevent loads from exceeding the manufacturer's maximum recommended loading with a safety factor of five (5).
   3. Provide lock washers or locknuts on hangers, supports, rods, inserts, clamps, brackets, braces, bolts and other supporting devices.

4. Secure hangers to beams or approved concrete inserts where possible.
5. When piping is installed on structural steel supports, provide blocking of pipe rolls to prevent lateral pipe movement.
6. Set all inserts before the concrete is placed.
7. Hangers secured to precast concrete plank construction shall be attached by means of steel plates placed on the upper side of the plank, with the hanger rod extending through the plate and secured by means of a nut and Jock washer. The hole in the plank shall be grouted to fill the void through which the hanger rod protrudes in order to distribute the load over the full area of the hanger plate. Plates shall conform to the following schedule.

Size of Pipe Supported (inches)	Plate Thickness (inches)	Minimum Plate Size (inches)
1 & smaller	3/16	4 x 4
1-1/4 to 2	3/16	5 x 5
2-1/2 to 4	1/4	6 x 6
5 to 6	1/4	10 x 10
Over 6	1/4	12 x 12

B. Expansion and Contraction:
   1. Rigidly support all piping with adequate provisions for expansion and contraction.
   2. Firmly anchor horizontal runs over 50 feet in length at the midpoint of the runs to force expansion equally toward the ends.

C. Spacing:
   1. Install hangers and supports at sufficiently close intervals to maintain alignment and prevent sagging.
   2. Maximum spacing of hangers and supports:

Pipe Size (inches)	Spacing (feet)
1 & smaller	6
1-1/4 to 2	9
2-1/2 to 3	11
4 and larger	14
C.I. Soil Pipe (all sizes)	5
P.V.C. (all sizes)	As recommended by manufacturer
Fiberglass	As recommended by manufacturer

D. Supporting Vertical Piping:
   1. Support at each floor level.
   2. Support at all points necessary to insure rigid installation with adequate provisions to allow expansion and contraction and prevent vibration.
   3. Support by approved pipe collars, clamps, brackets, or wall rests.

E. Supporting PVC and Fiberglass Piping (when applicable):
   1. Support in strict accordance with the manufacturer's instructions and recommendations for the conditions of operation temperature and size of pipe.
   2. Support in a manner which will prevent subsequent visible sagging of the pipe between supports due to plastic deformation.

F. Valves, Fittings & Specialties: Independently support pipe connected to pumps, equipment and piping systems.

G. Temporary pipe supports:

1. Lay out each section of pipeline and make connections while the pipe is held in temporary supports.
2. After the completion of connections in each section of pipeline, hold the section in place with temporary clamps.
3. Do not remove the temporary clamps until the piping is correctly installed on the permanent supports.

3.2 TESTING

A. Systems which do not meet the requirements of this section with respect to support, pitch, vibration, movement, and expansion and contraction will be supplemented with additional devices as required and re-demonstrated until compliance is achieved.

END OF SUBSECTION

SUBSECTION 15100

VALYES AND SPECIALTIES • GENERAL

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install, support, and test valves, gates, hydrants, cocks, stops, and faucets, when applicable, (hereinafter referred to as "valves") in the location(s) and of the size(s) as specified herein.

1.2 QUALITY ASSURANCE

A. Provide valves of proven reliability manufactured by reputable manufacturers.

B. Acceptable manufacturers are listed in each section of this Division. Substitute or "or-equal" valves will be allowed only when indicated.

1.3 SUBMITTALS

A. Provide shop drawings of proposed valves as specified herein. Shop drawings shall contain the following information at a minimum:
   1. Manufacturer's certification that the valves and accessories meet or exceed the requirements of these Specifications and that the valves are suitable for the intended service.
   2. Manufacturer's literature and illustrations for all valves.
   3. Operation & Maintenance Manuals for each valve type and size.

1.4 DELIVERY AND HANDLING

A. Shipping:
   1. Prepare valves and accessories for shipment as required for complete protection.
   2. Seal valve ends to prevent entry of foreign matter into valve body.
   3. Box, crate, completely enclose, and protect valves and accessories from accumulations of foreign matter.

B. Storage:
   1. Store valves and accessories in an area on the construction site protected from weather, moisture, or possible damage.
   2. Do not store valves or accessories directly on the ground.

C. Handling: Handle valves and accessories to prevent damage of any nature to the interior and the exterior surfaces.

1.5 INSPECTION

A. Carefully inspect all materials for:
   1. Defects in workmanship and materials.
   2. Removal of debris and foreign material in valve openings and seats.
   3. Proper functioning of all operating mechanisms.

4. Tightness of all nuts and bolts.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Materials are specified in appropriate Sections in this Division.

B. The specifications direct attention to certain required features of the valves and gates but do not purport to cover all details entering into their design and construction. Nevertheless, the Contractor shall furnish the valves and gates complete in all details and ready for operation for the intended purpose.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves and accessories in strict accordance with manufacturer's instructions and recommendations, as shown on the Drawings and/or as specified herein.

B. Carefully erect all valves and support them in their respective positions free from distortion and strain.

C. Independently support all valves connected to pumps and equipment, and in piping systems that cannot support valves.

D. Repair any scratches, marks and other types of surface damage etc. with original coating as supplied by the factory.

E. Install valves such that "open" and "close" position indicators are easily visible.

F. All valves (and actuators where specified) shall be installed in a manner that will provide for proper clearances and ease of operation. In addition, valve operators must be capable of being rotated in 90° increments to facilitate field installation.

G. Check and adjust all valves and accessories for smooth operation.

3.2 TESTING

A. The Contractor shall test all valves and gates in the presence of the City to demonstrate that each valve and gate complies with specified requirements and allowable leakage rates.

END OF SUBSECTION
SUBSECTION 15101 GATE VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install and test gate valves of the type(s) and size(s) as specified.

1.2 QUALITY ASSURANCE

A. All gate valves of same type and style shall be manufactured by one manufacturer.

B. Acceptable Manufacturers: as noted herein.

PART 2 - PRODUCTS

2.1 VALVE, LOCATION AND USE

A. As shown on the Drawings.

B. Water Supply Piping:
   1. Buried: AWWA Type, NRS.
   2. Exposed: AWWA OS&Y, or NRS as required.

C. General Service Piping (liquids containing solids):
   1. Includes plant water, and liquids containing solids.
   2. 2-1/2 inches and smaller: 125 bronze.
   3. 3 inches and larger: Non-rising stem; resilient wedge.

D. Accessories: As shown on the Drawings and required for proper operation.

2.2 MATERIALS

A. Waterworks type NRS valves (AWWA):
   1. Valve Body, bonnet and stuffing box - Cast iron (ASTM AJ26, CJB), coated inside and out with fusion bonded epoxy meeting AWWA C550. Face-to-face dimensions shall comply with ANSI B16.10 and flanges to comply with ANSI Bl6.l.
   2. Resilient Wedge - Ductile iron wedge with bonded Nitrite elastomer covering.
   3. Stem - Manganese bronze, ASTM B584
   4. Stuffing box 0-rings
      a. Two 0-rings, each nitrile rubber.
      b. Capable of changing under pressure.
   5. Wedgenut - Bronze, ASTM B62
   6. Bolting- stainless steel Type 18-8, ASTM F593, GPl
   7. End Connections
      a. Buried valves - mechanical joints
      b. Exposed valves - flanged
   8. Operation
      a. Buried valves - 2 inch square nut, cast iron, ASTM A126, CI B
      b. Exposed valves - Handwheel, cast iron or cast aluminum with direction arrow.
      c. Opening Direction - counterclockwise
   9. Water working pressure:
      a. 12 inches and smaller: 200 psi.
      b. 14 inches and larger: 150 psi.
   10. Manufacturer
      a. Waterous Company

b. Clow Corporation

11. Standards - valves shall meet or exceed AWWA C509, latest edition.

B. Waterworks type OS&Y valves (AWWA):
1. Equal in all respects to non-rising stem valve specified above, except as required for OS&Y operation.

C. General Service - 2-1/2 inch and smaller:
1. Bronze construction - 125-pound stem.
2. Union bonnet.
3. Inside screw, rising stem.
4. Solid disc, taper wedge.
5. End connections:
   a. Threaded.
   b. Or solder ends for copper pipe systems.
6. 200 psi non-shock WOO.
7. Malleable iron, or steel handwheel.
8. Acceptable Manufacturers:
   a. Stockham B-!05.
   b. Craine 428-UB.
   c. Powell 2700S.
   d. Jenkins 47U.
   e. Kennedy 525.
   f. Or approved equal.

D. General Service NRS – 3-inches and larger:
1. Wedge shall be constructed of ductile iron, fully encapsulated in synthetic rubber, except for guide and wedge nut areas.
2. Non-rising stem (NRS).
3. Bolted bonnet (stainless steel Type 18-8, ASTM F593, GP! bolts and nuts).
4. 125 class body.
5. Meet or exceed AWWA C-509.
6. All valves shall be fitted with a resilient wedge.
7. Flanged ends: 125-pound drilling, ANSI B16.1.
8. Face to Face dimensions: ANSI B16.1
9. Water working pressure:
   a. 12 inches and smaller: 200 psi.
   b. 14 inches and larger: 150 psi.
10. Operator:
   a. Handwheel standard.
   b. 2-inch square operating nut when shaft extension, floor box, valve box or floor stand is required or shown on the Drawings.
   c. Chain wheel:
      (1) Required for all valves shown.
      (2) When required for proper operation.
      (3) For all valves with centerline 7 feet above finished floor or equipment stand.
      (4) With chain guides.
      (5) Chain shall extend to 3 feet above floor.
      (6) Provide wall hooks for chain.
11. Buried Valves:
   a. Mechanical joint type with AWWA bituminous coating system

b. Gate box required.
c. Sufficient quantity of tee-handle valve wrenches for operating valves of various depths.
d. 2-inch square operating nut, securely fastened to shaft.

12. Acceptable Manufacturers:
    a. Waterous.
    b. Clow.
    c. Or equivalent.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install and test in accordance with Subsection 15100, AWWA C500 and AWWA C- 509, latest revision.

B. For horizontal piping, install valves with stem position between horizontal to vertical upward.

END OF SUBSECTION

SUBSECTION 15104 PLUG VALVES
PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install and test plug valves and actuators of the type(s) and size(s) and in the location(s) shown on the Drawings and as specified herein.

B. Related Work Specified Elsewhere: "Valves and Specialties - General" is specified in this Division.

1.2 QUALITY ASSURANCE

A. All plug valves of same type, style, and duty shall be of one manufacturer.

B. All actuators shall be supplied by the valve manufacturer who shall be responsible for proper operation of all valves with the actuators specified.

C. Acceptable Manufacturers:
1. DeZurik Corporation
2. Keystone Valve
3. Or equivalent.

1.3 JOB CONDITIONS

A. Piping as shown on the Drawings is detailed to accommodate standard design flanged plug valves having face-to-face dimensions of standard flanged gate valves.

B. Make all necessary adjustments to piping, subject to review of the City of Rockland, to accommodate plug valves furnished with face-to-face dimensions not of standard flanged gate valves.

C. Valves 2-inches and smaller may be of screwed type unless indicated otherwise.

D. Buried valves shall be mechanical joint type.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Two Way Valves:
1. Non-lubricated, eccentric type, cast iron body with end type as shown on the Drawings.
2. Shall have an unobstructed shaped waterway, when open, of not less than 80% of nominal pipe area.
3. Body shall be of gray cast iron, ASTM A126 Class B with resilient plug facings of neoprene or Buna-N.
4. Packing shall be BUNA (VEE) with a maximum temperature of 350°F. Packing shall be adjustable.
5. Bearings shall be stainless steel or bronze as required.
6. Suitable for particular service in piping in which installed.

7. Welded-in nickel or stainless-steel seat.
8. Shall have droptight shut-off.

B. Three Way and Four Way Valves:
1. Equal to that specified for two way valves.
2. Port location, style, and arrangement as shown on the Drawings and as required.
3. Shall have drip tight shut-off.

C. Actuators (type as shown on the Drawings and specified herein):
1. Lever Actuators:
a. Size and length as required with a 2-inch square socket end for use on 2-inch square actuating nut.
b. Attach handle to valve with a 4-foot length of chain.
c. Use for valves 6-inches and smaller.
2. Handwheel Actuators:
a. Totally enclosed gear type.
b. Sized for the operating conditions encountered.
c. Use on all valves 8 inches in size and larger, and on smaller valves when valve location does not allow lever actuator.
d. Plug position indicator required.
3. Chain Wheel Actuators:
a. Totally enclosed type.
b. Chain shall extend to 3 feet above floor unless otherwise shown.
c. Supplied with chain guides and chain wheel, chain guides shall be galvanized.
d. Use for all valves that are located with centerline 7-feet or more above floor.

D. Accessories (When Applicable):
1. Extension (for lever actuated valves):
a. Shall include extension pipe, bearing plate and couplings of the sizes as required.
2. Floor Stand (for handwheel actuated valves):
a. Shall include stand, coupling, handwheel mounted on stand and extension rod.
b. Stand shall have a dial valve position indicator.
3. Extended Actuator Mounting: Supplied when actuators are extended above ground.
4. Floor Boxes:
a. Iron body, size as required for valve.
b. Cast iron or bronze screwed cover plate.
c. Suitable for cast concrete floors of thickness as shown.

E. Buried Valves
1. AWWA bituminous coating system.
2. Worm gear operator with 2-inch square operating nut.
3. Gate box.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with Subsection 15100.

B. For horizontal piping, install valves with stems horizontal such that the plug in upper part of the body when in the open position and such that the plug is in the downstream end of the body when in the closed position. Coordinate valve orientation with the City.

END OF SUBSECTION

SUBSECTION 15110 CHECK VALVES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish and install check valves of the type(s) and size(s) and in the location(s) shown on the Drawings and as specified herein.

B. Related Work Specified Elsewhere: "Valves & Specialties - General" is specified in this Division.

1.2 QUALITY ASSURANCE

A. All check valves of same type and duty shall be by one manufacturer.

B. Acceptable Manufacturers:
1. Clow
2. Mueller
3. Or acceptable equivalent.

PART 2 – PRODUCTS

2.1 VALVES – 3-INCHES AND LARGER

A. Meet the materials requirement of AWWA C508.

B. Iron body, bronze mounted, single disc. Dimensions to comply with ANSI B16.1.

C. Flanged ends faced and drilled to the 125 lb. Standard.

D. The working water pressure shall be 175 psig up through 12-inch, inclusive and 150 psig for 16-24 inch, inclusive.

E. So constructed that disc and body seat may easily be removed and replaced without removing the valve from the line.

F. Fitted with extended hinge arm with outside lever and weight.

2.2 VALVES - SMALLER THAN 3 INCHES

A. Standard, all brass or bronze, swing check with screwed ends.

B. Suitable for 150 psi working steam pressure.

PART 3 - EXECUTION

3.1 INSTALLATION

A. In accordance with Subsection 15100.

B. Install check valves in horizontal sections of pipeline unless otherwise indicated on the Drawings.

END OF SUBSECTION

SUBSECTION 15127 AIR RELEASE VALYES

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Furnish, install and test air release valves of the size(s), types(s) and locations(s) specified herein. Related work specified elsewhere: "Valves and Specialties - General" is specified in this Division.

1.2 QUALITY ASSURANCE

A. All air release valves, for the same service, shall be manufactured by one manufacturer.

B. Acceptable Manufacturers:
   1. Valve & Primer Corporation (APCO Valves).
   2. Or equivalent.

1.3 SUBMITTALS

A. Submit shop drawing information on the proposed valves. Refer to requirements in Subsection 15100.

PART 2 - PRODUCTS

2.1 MATERIALS

A. General:
   1. All valves shall be suitable for the intended services.
   2. Valve sizing shall be as recommended by the manufacturer to suit the pressure and flow condition of each application.
   3. The valve manufacturer shall furnish installation and maintenance manuals with each valve.

B. Sewage and Sludge Service:
   1. Air Release Valves.
      a. Shall be designed to operate (open) while pressurized, allowing entrained air to escape through the air release orifice. After entrained air escapes through the air release orifice, the valve orifice shall be closed by a needle mounted on float energized compound lever mechanism and prevent sewage media from escaping
      b. Shall be specially adapted for use with sewage and sludge.
      c. The venting orifice and mechanism and the valve body shall be capable of being back-flushed with water.
      d. Cast iron body and covers, stainless steel float and lever pins, bronze seat with the mechanism cast bronze and Buna-N needle.
      e. Furnished with 2-inch inlet shutoff valve; I-inch blow off valve; Yz-inch valve, quick disconnect coupling and 6-feet of hose to permit backflushing without dismantling valve.
      f. Valve shall be capable of with standing 500 psi line pressure.
      g. Equal to Model 400 APCO sewage air release valve.
   2. Air and Vacuum Release Valves:

a. Shall allow unrestricted venting or re-entry of air, through it, during filling or draining of the force main, to prevent water column separation or pipeline collapse due to vacuum.
b. Valve shall incorporate one upper and one lower stainless steel float, connected by a common stainless steel float guide, thereby maintaining an air gap between the bottom float and top shut-off float. The air gap shall retard waste solids from fouling or clogging the top shut-off float.
c. The internal baffle shall be fitted with a guide bushing and act to protect the shut-off float from direct air flow. The baffle shall retain the 45 Durometer Buna-N seat in place without distortion, for tight shut-off.
d. Cast iron body, cover and baffle; brass internal parts.
e. All internals shall be easily removed through the top covers without removing the main valve from the lines.
f. Both floats shall withstand 1,000 psi or more.
g. Valve shall be fitted with blow off valves, shutoff valves, quick disconnect couplings and minimum 6-feet of hose, to permit backflushing after installation without dismantling valve.
h. The valve inlet shall have 2-inch N.P.T. and the outlet I-inch N.P.T.
i. Equal to Model 400 APCO sewage air and vacuum valves.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install valves in accordance with manufacturer's instructions and recommendations and as shown on the Drawings.

B. Install all valves in the vertical position and allow sufficient clearance around valve for proper maintenance and removal.

C. Provide gate valve between air release valve and pipeline.

D. Inlet piping to the air valves shall be brass.

E. The exhaust lines from the air valves shall terminate in down turned position 18 inches above the floor. For water applications, the end of the line shall be covered with a 24 mesh stainless steel screen attached with a stainless steel clamp.

END OF SUBSECTION

END OF SECTION 33 32 13.13

SECTION 33 34 00
SANITARY FORCE MAINS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. Provide and install pressure pipe and fittings of the size and type and in the locations indicated on the Drawings and as specified herein.

B. Related Work Specified Elsewhere: (When Applicable)
   1. Excavation and backfill, dewatering, pavement, borrow and bedding material, and cleaning and testing requirements are specified in the appropriate sections.
   2. Pipe & Pipe Fittings

1.2 REFERENCE STANDARDS

A. Plastic Pipe Institute (PPI) Handbook of Polyethylene Pipe (Second Edition)

B. PPI MS-3

C. American Society of Testing Materials (ASTM) D3350 Polyethylene Plastics Pip and Fittings Materials

D ASTM D3035-10 Standard Specification for Polyethylene (PE) Plastic Pipe (DR_PR) Based on Controlled Outside Diameter.

E. ASTM F2620-06 Standard Practice for Heat Fusion Joining of Polyethylene Pipe and Fittings

F. ASTM F1055 Standard Specification for Electrofusion Type Polyethylene Fittings for Outside Diameter Controlled Polyethylene Pipe and Tubing

1.3 QUALITY ASSURANCE

A. Manufacturers:
   1. Certain-Teed.
   2. J-M Manufacturing.
   3. Ford Meter Box Company, Inc.
   4. Or equivalent.

1.4 SUBMITTALS TO THE ENGINEER

A. Submit Shop Drawings in accordance with the General Conditions of the Contract Documents.
B. Submit manufacturer's "Certification of Conformance" that pipe and fittings meet or exceed the requirements of these Specifications.

C. Submit other documents as specified in the appropriate Sections.

1.5 DELIVERY STORAGE AND HANDLING

A. Provide all labor necessary to assist the Engineer in inspecting pipe, fittings, gaskets and other materials.

B. Carefully inspect all materials at the time of delivery and just prior to installation.

C. Carefully inspect all pipe and fittings for:
1. Defects and damage
2. Deviations beyond allowable tolerances for joint dimensions
3. Debris and foreign matter

D. Examine area and structures to receive piping for:
1. Defects, such as weak structural components that adversely affect the execution and quality of work.
2. Deviations beyond allowable tolerance for pipe clearances.

E. All materials and methods not meeting the requirements of the Contract Documents will be rejected.

F. Immediately remove all rejected materials from the project site.

PART 2 - MATERIALS

2.1 MATERIALS

A. Pipe and Fittings:
1. The force main pressure pipe shall be smooth wall HDPE sized according to the Contract Documents. Polyethylene pipe shall be made from a HDPE material having a minimum material designation code of PE 4710 or PE 3608. The material shall meet the requirements of ASTM D 3350 and shall have a minimum cell classification of PE445474C for PE 4710 and PE345464C for PE 3608. Pipe shall be DR 9 (or DR 11 where specified) conforming to ASTM D3035. Fittings shall be non-corrosive mechanical.
2. Longest possible lengths of continuous coil material shall be provided.
3. Saddles will not be allowed.

B. Joints:
1. Joints shall be avoided except for connection in the lift station wet well, valve pit or within designated structures. Joints within structures shall be made using manufacturers' approved mechanical fittings and recommendations.
2. Other joints, when needed by coil limitations, shall be butt fused or electrofused, and shall not employ mechanical fittings.

C. Marker Wire:
1. Shall be coated 16 gage stranded copper
2. Attach marker wire securely, minimum two (2) feet on center with tape, bands, or ties.
3. Furnish wire with the minimum number of splices in the field.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Inspection:
1. All pipe shall be inspected prior to installation. Ensure marker wire is firmly attached.
2. Any pipe unit or fitting discovered to be defective either before or after installation shall be removed and replaced in kind.

B. Placement:
   1. All pipe and fittings shall be cleared of all debris, dirt, etc., before being installed and shall be kept clean until accepted in the completed work.
   2. Pipe shall be installed to the lines and grades indicated on the Drawings or as required by the Owner's Representative. Care shall be taken to insure true alignments and gradients.
   3. Fuse pipe in accordance with manufacturer's recommendations.
   4. Splice marker wire with watertight connectors. Identify at terminus points with tags.

C. Pipe Deflection:
   1. Pipe provided under this specification shall be installed so there is no more than a maximum deflection of five percent (5.0%). Such deflection shall be computed by multiplying the amount of deflection (normal diameter less minimum diameter when measured) by 100 and dividing by the nominal diameter of the pipe.
   2. The Contractor shall wait a minimum of 30 days after completion of the force main, including placement and compaction of backfill, before measuring the amount of deflection by pulling a specially designed gage assembly through the completed section. The gage assembly shall be in accordance with the recommendations of the pipe manufacturer.
   3. Should the installed pipe fail to meet this requirement, the Contractor shall do all work to correct the problem as the Owner's Representative may require without additional compensation.

D. Testing:
   1. Clean and test pipe in accordance with appropriate sections of referenced standards and manufacturers' recommendations. Pressure testing shall be to the rated capacity of the pipe.

END OF SECTION 33 34 00

SECTION 33 42 13 - PIPE CULVERTS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included:
   1. Provide and install culvert, surface drain, and storm drain pipe and sections of the type(s), size(s) and in the location(s) shown on the Drawings and as specified herein.

B. Related Sections:
   1. Section 31 23 16 - Excavation
   2. Section 31 23 16.13 - Trenching
   3. Section 31 32 19.23 - Geotextile Layer Separation
   4. Section 33 46 00 - Subdrainage
   5. Section 33 49 13 - Storm Drainage Manholes, Frames and Covers

1.2 SUBMITTALS

A. Submit, in duplicate, sworn certificates of inspections and tests performed at the location of manufacturers.

B. Submit Shop Drawings in accordance with the General Conditions of the Construction Contract.

1.3 DELIVERY, STORAGE AND HANDLING

A. Exercise care when handling pipe to prevent damage of any nature to pipe and finish.

B. Immediately remove damaged materials and replace in kind at no additional cost to the Owner.

C. Store materials above ground on platforms, skids or other adequate supports.

1.4 FIELD QUALITY CONTROL

A. Acceptance will be based on material tests and inspection of the complete product.

B. Inspection may be made at the place of manufacture, local distributor or on the construction site after delivery. All Pipe Culvert materials are subject to rejection at any time throughout the project due to failure to meet specifications.

C. No damaged or rejected pipes are to be installed permanently for the Work. Contractor must immediately remove all rejected or damaged pipe culvert materials from the project site if not needed to complete the Work. Contractor is responsible for replacing damaged or rejected pipe materials at no additional cost to the Owner.

PART 2 - PRODUCTS

2.1 MATERIALS

A. Pipe shall be one of the following as specified on the Drawings; substitutions are only allowed with the approval of the Engineer.
   1. Corrugated Aluminum Alloy Pipe
   2. Aluminum Coated (Type 2) Corrugated Steel Pipe
   3. Zinc-Coated (Galvanized) Corrugated Steel Pipe
   4. Steel Structural Plate Pipe
   5. Aluminum Alloy Structural Plate Pipe
   6. Polymer Precoated, Galvanized Corrugated Steel Pipe
   7. Polyvinyl Chloride (PVC) Pipe
   8. Corrugated Polyethylene (PE) and High Density Polyethylene (HDPE) Pipe
   9. Reinforced Concrete Pipe

B. Materials for pipes shall conform to AASHTO Standards.
   1. Corrugated Aluminum Alloy Pipe. This pipe and special fittings such as elbows, tees and wyes shall conform to the requirements of AASHTO M196, Type I or II. Special sections, such as elbows and metal end sections shall be of the gage called for in the Contract Documents and shall conform to the applicable requirements of AASHTO M196. Aluminum sheet shall conform to the requirements of AASHTO M197.
   2. Aluminum Coated (Type 2) Corrugated Steel Pipe. This pipe shall conform to the requirements of AASHTO M36 using steel sheet conforming to AASHTO M274.
   3. Zinc - Coated (Galvanized) Corrugated Steel Pipe. This pipe shall conform to the requirements of AASHTO M36 using steel sheet conforming to AASHTO M218.
   4. Steel Structural Plate Pipe. Plates, bolts, nuts and other accessories shall conform to the requirements of AASHTO specification M167 and the following additional requirements:
      a. All shop welding shall meet the requirements of the latest edition of AWS D1.1, Structural Welding Code - Steel.
      b. Annually the fabricator shall have quality control tests performed on uncoated random samples of the lightest and heaviest gage plates produced by welding. The sampling and testing shall be done by a recognized independent testing agency and copies of the test reports, including all welding parameters, shall be submitted to the Engineer as requested.
      c. No field welding will be allowed.
   5. Aluminum Alloy Structural Plate Pipe. Plates, bolts and nuts for this pipe shall conform to the requirements of AASHTO M219.
   6. Polymer Precoated, Galvanized Corrugated Steel Pipe. This pipe and special fittings such as elbows, tees and wyes shall conform to the requirements of AASHTO M245, Type I, with Type B coating for the pipe as specified in AASHTO M246 with the thinner coating on the outside.
   7. Polyvinyl chloride (PVC) Pipe. This pipe and fittings shall conform to the requirements of AASHTO M278. All pipe shall be supplied with gasket type joints meeting the requirements of ASTM D3212.
   8. Corrugated polyethylene (PE & HDPE) pipe. This pipe and fittings shall conform to the requirements of AASHTO M252 and AASHTO M294.
   9. Reinforced Concrete Pipe. This pipe shall conform to the requirements of AASHTO M170, (ASTM C76) except paragraph 6.2. Elliptical pipe shall conform to the requirement of AASHTO M207, except paragraph 6.2. Unless otherwise specified, pipe wall design and use of elliptical reinforcement in circular pipe are optional. Pipe arch shall conform to the requirements of AASHTO M206, except paragraph 6.2. Aggregates shall meet the requirements of MDOT Standard Specifications Subsections 703.01 and 703.02 for fine aggregates and coarse aggregates respectively, except that grading requirements are hereby waived. Precast reinforced concrete special sections shall conform to the requirements of the cited specifications to the extent to which they apply.

C. Area Drain Assemblies. Unless otherwise noted, provide Nyloplast Inline Drain with 8” Bronze Insert Grate. Drain Basin not required.

PART 3 - EXECUTION

3.1 INSPECTION

A. Examine areas to receive piping for the following
   1. Obstructions that adversely affect the installation and quality of the work.
   2. Deviations beyond allowable tolerances for clearances.

B. Examine pipe and fittings before installation to assure no defective materials are incorporated into the Work.

C. Start the work only when conditions are satisfactory.

D. Remove and replace all defective materials at no additional cost to the Owner.

3.2 INSTALLATION

A. Do not install pipe, nor backfill, between December 15th and April 1st without the written permission of the Engineer.

B. Begin laying the pipe at the downstream end. Install bells upstream per manufacture's recommendations.

C. Place metal pipe with the longitudinal laps of seams at the sides and the outside laps of circumferential joints pointing up grade.

D. Lay paved or partially lined pipe with the lining on the bottom.

E. Join flexible pipe sections and metal end sections by coupling bands as recommended by the manufacturer.

F. Assemble the plates for structural plate arches according to the manufacturer's assembly instructions and as shown on the Drawings.

G. Place geotextile and armor stones at inlets and outlets as indicated in the Drawings.

END OF SECTION 33 42 13

SECTION 33 46 00
SUBDRAINAGE

PART 1 - GENERAL

1.1 SECTION INCLUDES

A. Underdrain system for paved sections and building perimeter.

1.2 RELATED SECTIONS

A. Section 31 05 16 - Aggregates for Earthwork

B. Section 31 23 16.13 - Trenching

C. Section 31 32 19.23 - Geotextile Layer Separation

1.3 REFERENCES

A. ASTM D2729 – Poly(vinyl chloride) (PVC) Sewer Pipe and Fittings.

1.4 DEFINITIONS

A. Bedding: Fill placed under, beside and directly over pipe, prior to subsequent backfill operations.

1.5 PROJECT RECORD DOCUMENTS

A. Record location of pipe runs, connections, cleanouts and principle invert elevations.

1.6 FIELD MEASUREMENTS

A. Verify that field measurements and elevations are as indicated on the construction Drawings.

PART 2 - PRODUCTS

2.1 PIPE MATERIALS

A. Poly(vinyl chloride) Pipe (Perforated): ASTM D2729; plain end, provide inside diameter as indicated on the Drawings; with required fittings.

2.2 AGGREGATE AND BEDDING

A. As indicated in the Drawings or as approved by the Engineer.

2.3 ACCESSORIES

A. Pipe Coupling: Integral to pipe or solid plastic solvent weld.

PART 3 - EXECUTION

3.1 EXAMINATION

A. Verify that trench cut and excavated base is ready to receive work and excavations, dimensions, and elevations are as indicated on Drawings.

3.2 PREPARATION

A. Hand trim excavations to required elevations. Correct over excavation with aggregate.

B. Remove large stones or other hard matter which could damage drainage piping or impede consistent backfilling or compaction.

3.3 INSTALLATION

A. Install and join pipe and pipe fittings in accordance with pipe manufacturer's instructions.

B. Lay pipe to slope gradients of 1/4 inch per foot or as noted on Drawings with maximum variation from true slope of 1/8 inch in 10 feet.

C. Place pipe with perforations facing down, or as indicated in the Drawings. Mechanically join pipe ends.

3.4 FIELD QUALITY CONTROL

A. Request inspection prior to and immediately after placing aggregate cover over pipe.

3.5 PROTECTION

A. Protect pipe and aggregate cover from damage or displacement until backfilling operation begins.

END OF SECTION 33 46 00

SECTION 33 49 13
STORM DRAINAGE MANHOLES, FRAMES, AND COVERS

PART 1 - GENERAL

1.1 DESCRIPTION

A. Work Included: Construct catch basins, grates, frames and brick masonry in conformance with the dimensions and locations shown on the Drawings.

B. Related Work Specified Elsewhere: (Where applicable)
   1. Pipe Culverts, Trenching, Excavation, Fill are specified in the appropriate Sections.

1.2 QUALITY ASSURANCE

A. Precast Catch Basin Base, Barrel and Top Sections:
   1. Conform to ASTM C478-72 (AASHTO M199-795) except as modified herein, on the Drawings, or as directed by the Engineer.
   2. Average strength of 4,000 psi at 28 days
   3. Testing:
      a. Determine concrete strength by tests on six (6) inch by 12 inch vibrated test cylinders cured in the same manner as the bases, barrels and tops.
      b. Have tests conducted at manufacturer's plant or at an approved testing laboratory.
      c. Have not less than two (2) tests made for each 100 vertical feet of precast catch basin sections.

B. Frames and Covers:
   1. Acceptable Manufacturers:
      a. Etheridge Foundry Company
      b. Neenah Foundry Company
      c. E. L. LeBaron Foundry Company
      d. Or equivalent.

C. Masonry:
   1. Brick: Shall comply with the ASTM Standard Specifications for Sewer Brick (made from clay or shale), Designation C32, for Grade SS, hard brick. (AASHTO M91-78).
   2. Cement: ASTM C-150.(AASHTO M85-79I)
   3. Hydrated Lime: ASTM C-207.
   4. Sand: ASTM C33. (AASHTO M6-65 C197A)).

1.3 SUBMITTALS TO THE ENGINEER

A. Submit shop Drawings and manufacturer's literature in conformance with the General Conditions of the Construction Documents.

B. Bases, Barrel Sections and Tops: Submit test results and receive approval from the Engineer prior to delivery to the site.

PART 2 - PRODUCTS

2.1 PRECAST CATCH BASIN SECTIONS

A. Dimensions, as shown on the Drawings.

B. Use flat tops or eccentric cones as appropriate. Exterior face of cone sections shall not flare out beyond the vertical.

C. Joints: Bell-and-spigot or tongue-and-groove formed on machine rings to insure accurate joint surfaces.

D. Constructed to support an HS-20 wheel loading.

E. Openings:
1. Provide openings in the risers to receive pipes entering the catch basin of the types and materials approved by the Engineer.
2. Make openings at the manufacturing plant or cut openings in the field.
3. Size: To provide a uniform annular space between the outside wall of pipe and the riser.
4. Location: To permit setting of the entering pipes at the correct elevations.

F. Joints:
1. Joint gaskets to be flexible self-seating butyl rubber joint sealant installed according to manufacturer's recommendations. For cold weather applications, use adhesive with joint sealant as recommended by manufacturer. Acceptable Materials:
   a. Kent-Seal No. 2
   b. Ram-Nek
   c. Or equivalent.
2. Joints between precast sections shall conform to related standards and manufacturer's instructions.

2.2 FRAMES AND GRATES

A. All essential details of design shall conform to the Drawings. Standard castings differing in non-essential details may be approved by the Engineer.

B. All frames and grates shall be made of cast iron and shall have machined bearing surfaces to prevent rocking under traffic.

C. Grate castings will be smooth with no sharp edges.

D. Constructed to support an HS-20 wheel loading.

2.3 MASONRY

A. Brick:
1. Sound, hard, uniformly burned, regular and uniform in shape and size, compact texture, and satisfactory to the Engineer.
2. Immediately remove rejected brick from the work.

B. Mortar:
1. Composition (by volume):
   a. 1 part portland cement.
   b. 1/2 part hydrated lime.
   c. 4-1/2 parts sand.

2. The proportion of cement to lime may vary from 1:1/4 for hard brick to 1:3/4 for softer brick, but in no case shall the volume of sand exceed three (3) times the sum of the volume of cement and lime.

C. Cement:
1. Shall be Type II Portland cement.

D. Hydrated Lime:
1. Shall be Type S.

E. Sand:
1. Shall consist of inert natural sand.
2. Grading:

Sieve	Percent Passing
3/8	100
4	95-100
8	80-100
16	50-85
50	10-30
100	2-10
Fineness Modulus	2.3 - 3.1

PART 3 - EXECUTION

3.1 PERFORMANCE

A. Precast Catch Basin Sections:
1. Perform jointing in accordance with manufacturer's recommendations and as approved by the Engineer.
2. Install barrels and tops level and plumb.
3. Make all joints water tight.
4. Solidly fill annular spaces around pipes entering the catch basin with non-shrink grout or other material approved by the Engineer.
5. Cut openings (as required) carefully to prevent damage to barrel sections and tops. Damaged barrel sections and tops shall be replaced by the Contractor at no additional expense to the Owner.

B. Pipe Connections to Catch Basins: Connect pipes to catch basins with joint design and materials approved by the Engineer.

C. Masonry:
1. Laying Brick:
   a. Use only clean bricks in brickwork for catch basins.
   b. Moisten the brick by suitable means until they are neither too dry to absorb water from the mortar or so wet as to be slippery when laid.
   c. Lay each brick in a full bed and joint of mortar without requiring subsequent grouting, flushing, or filling, and thoroughly bond as directed.
   d. Construct all joints in a neat workmanlike manner; construct the brick surfaces inside the manholes so they are smooth with no mortar extending beyond the bricks and no voids in the joints. Maximum mortar joints shall be 1/2 inch.
2. Curing:
   a. Protect brick masonry from drying too rapidly by using burlaps which are kept moist, or by other approved means.
   b. Protect brick masonry from the weather and frost as required.

D. Frames and Grates:
1. Set all frames in a full bed of mortar, true to grade and concentric with the catch basin opening.

2. Completely fill all voids beneath the bottom flange to make a watertight fit.
3. Place a ring of mortar at least 1 inch thick around the outside of the bottom flange, extending to the outer edge of the catch basin all around its circumference.
4. Clean the frame seats before setting the covers in place.

E. Bedding and Backfilling:
1. Bedding material of each catch basin shall be six (6) inches of compacted 3/4 inch crushed stone as indicated in the Drawings, or as approved by the Engineer.
2. Backfill all around each catch basin with a minimum 18 inches of granular borrow as indicated in the Drawings.

END OF SECTION 33 49 13

SECTION 33 56 10
FACTORY-FABRICATED FUEL STORAGE TANKS

PART 1- GENERAL

1.1 DESCRIPTION

A. This specification is intended for systems using factory-fabricated storage tanks with capacities less than or equal to 200,000 L 50,000 gal. Additional equipment/devices necessary to meet state and local regulations will be added by the manufacturer.

B. For underground tank installations, the designer developing the earthwork specifications will evaluate the need for a filter fabric to be installed between the native soil and the new backfill material. The intent of a filter fabric would be to prevent the displacement of new backfill material with native soil due to a high water table. If the new backfill material is displaced, it could affect the structural integrity of the tank specifically if the new tank(s) is the FRP type. If a filter fabric is determined to be necessary, include the requirements for the new fabric in the excavation and backfilling specifications.

C. Require backfill for Fiberglass Reinforced Plastic (FRP) tanks to be pea gravel or crushed stone.
   1. Pea gravel shall be between 1/8 and 3/4 inch in diameter,
   2. Crushed stone shall be between 1/8 and 1/2 inch in diameter.

3. Require backfill for steel tanks to be pea gravel, crushed stone, or sand.
   1. Pea gravel shall be between 1/8 and 3/4 inch in diameter,
   2. Crushed stone shall be between 1/8 and 1/2 inch in diameter.
   3. Sand shall be a fine aggregate that is washed and thoroughly dried, containing no more than 500 ppm chlorides or sulfates, and has a pH greater than seven (7).

1.2 Related Sections

A. Section 31 05 16 - Aggregates for Earthwork

B. Section 31 23 16 - Excavation

C. Section 31 23 16.13 - Trenching

D. Section 33 58 00 - Leak Detection for Fueling Systems (provided by Manufacturer)

E. Section 26 42 14.00 10 - Cathodic Protection System - Sacrificial Anode (provided by Manufacturer)

F. Section 26 42 13.00 20 - Cathodic Protection by Galvanic Anodes (provided by Manufacturer)

G. Section 26 42 17.00 10 - Cathodic Protection System - Impressed Current (provided by Manufacturer)

H. Section 26 42 19.00 20 - Cathodic Protection by Impressed Current (provided by Manufacturer)

1.3 REFERENCES

A. AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)
   1. AASHTO HB-17 (2002; Errata 2003; Errata 2005, 17th Edition) Standard Specifications for Highway Bridges

B. AMERICAN PETROLEUM INSTITUTE (API)
1. API MPMS 2.2A (1995; R 2012) Measurement and Calibration of Upright Cylindrical Tanks by the Manual Strapping Method
2. API MPMS 2.2E (2004; Errata 2009; R 2009) Petroleum and Liquid Petroleum Products - Calibration of Horizontal Cylindrical Tanks - Part 1: Manual Methods
3. API RP 1615 (2011) Installation of Underground Petroleum Storage Systems
4. API RP 2003 (2015; 8th Ed) Protection Against Ignitions Arising out of Static, Lightning, and Stray Currents
5. API RP 540 (1999; R 2004) Electrical Installations in Petroleum Processing Plants
6. API Std 1631 (2001; R 2010) Interior Lining and Periodic Inspection of Underground Storage Tanks

C. ASME INTERNATIONAL (ASME)
1. ASME B16.5 (2013) Pipe Flanges and Flanged Fittings: NPS 1/2 Through NPS 24 Metric/Inch Standard
2. ASME BPVC SEC VIII D1 (2015) BPVC Section VIII-Rules for Construction of Pressure Vessels Division 1

D. ASTM INTERNATIONAL (ASTM)
1. ASTM A193/A193M (2016) Standard Specification for Alloy-Steel and Stainless Steel Bolting Materials for High-Temperature Service and Other Special Purpose Applications
2. ASTM A194/A194M (2016a) Standard Specification for Carbon and Alloy Steel Nuts for Bolts for High-Pressure or High-Temperature Service, or Both
3. ASTM A27/A27M (2013; R 2016) Standard Specification for Steel Castings, Carbon, for General Application
4. ASTM A307(2014) Standard Specification for Carbon Steel Bolts and Studs, 60 000 PSI Tensile Strength
5. ASTM A48/A48M (2003; R 2012) Standard Specification for Gray Iron Castings
6. ASTM A563(2015) Standard Specification for Carbon and Alloy Steel Nuts
7. ASTM B117(2016) Standard Practice for Operating Salt Spray (Fog) Apparatus
8. ASTM B26/B26M (2014; E 2015) Standard Specification for Aluminum-Alloy Sand Castings
9. ASTM D3308 (2012) PTFE Resin Skived Tape
10. ASTM F844(2007a; R 2013) Washers, Steel, Plain (Flat), Unhardened for General Use

E. INSTITUTE OF ELECTRICAL AND ELECTRONICS ENGINEERS (IEEE)
1. IEEE 1100 (2005) Emerald Book IEEE Recommended Practice for Powering and Grounding Electronic Equipment
2. IEEE 142 (2007; Errata 2014) Recommended Practice for Grounding of Industrial and Commercial Power Systems - IEEE Green Book

F. NATIONAL ELECTRICAL MANUFACTURERS ASSOCIATION (NEMA)
1. NEMA 250 (2014) Enclosures for Electrical Equipment (1000 Volts Maximum)

G. NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)
1. NFPA 30 (2015) Flammable and Combustible Liquids Code
2. NFPA 30A (2015) Code for Motor Fuel Dispensing Facilities and Repair Garages
3. NFPA 407 (2017) Standard for Aircraft Fuel Servicing
4. NFPA 70 (2017) National Electrical Code
5. NFPA 77 (2014) Recommended Practice on Static Electricity
6. NFPA 780 (2017) Standard for the Installation of Lightning Protection Systems

H. STEEL TANK INSTITUTE (STI)
1. STI 010-50-1000 (2011) Specification and Manual for External Corrosion Protection of Underground Steel Storage Tanks

2. STI 020-50-1000 (2010) ACT-100 Specification for External Corrosion Protection of FRP Composite Steel USTs
3. STI 700-50-5007 (2010) Installation Instructions for Shop Fabricated Aboveground Tanks for Flammable, Combustible Liquids
4. STI F911 (1998; Reissued 2009) Standard for Diked Aboveground Storage Tanks

I. UNDERWRITERS LABORATORIES (UL)
1. UL 1316 (1994; Reprint May 2006) Glass-Fiber-Reinforced Plastic Underground Storage Tanks for Petroleum Products, Alcohols, and Alcohol-Gasoline Mixtures
2. UL 142 (2006; Reprint Jul 2013) Steel Aboveground Tanks for Flammable and Combustible Liquids
3. UL 1746 (2007; Reprint Dec 2014) External Corrosion Protection Systems for Steel Underground Storage Tanks
4. UL 2085 (1997; Reprint Sep 2010) Protected Aboveground Tanks for Flammable and Combustible Liquids
5. UL 58 (1996; Reprint Jul 1998) Steel Underground Tanks for Flammable and Combustible Liquids

1.3 SUBMITTALS (Submit per Contract Documents)

A. Shop Drawings:
1. Grounding and Bonding
2. Product Data
   a. Aboveground Storage Tank; G[, [ ]]
   b. Underground Storage Tank; G[, [ ]]
   c. Tank Protective Coatings
   d. Automatic Level Alarm System Tank Gauges
   e. Manway Containment Sump
   f. Tank Mounted Fuel Dispensing Unit Fuel Heaters
   g.

B. Test Reports
1. Aboveground Storage Tank Tightness Tests; G[, [ ]]
2. Underground Storage Tank Tightness Tests; G[, [ ]]
3. Tank Manufacturer's Tests
4. Tank Fill Tests

C. Certificates
1. Contractor Qualifications; G[, [ ]]
2. Permitting
3. Registration
4. Licensed Personnel
5. Demonstrations

D. Manufacturer's Instructions
1. Aboveground Storage Tank
2. Underground Storage Tank
3. Automatic Level Alarm System
4. Tank Gauges
5. Fuel Heaters

E. Operation and Maintenance Data
1. Aboveground Storage Tank; G[, [ ]]
2. Underground Storage Tank; G[, [ ]]
3. Automatic Level Alarm System; G[, [ ]]
4. Tank Gauges; G[, [ ]]
5. Fuel Heaters; G[, [ ]]

1.4 QUALITY ASSURANCE

A. Contractor Qualifications
   1. Each installation Contractor shall have successfully completed at least three (3) projects of the same scope, and the same size or larger within the last six (6) years, and demonstrated specific installation experience in regard to the specific system installation to be performed. Each installation Contractor shall have taken, if applicable, manufacturer's training courses on the installation of storage tanks and shall meet all applicable licensing requirements in the state of Maine. Submit a letter listing prior projects, the date of construction, a point of contact for each prior project, the scope of work of each prior project, and a detailed list of work performed. The letter shall also provide evidence of prior manufacturer's training, state licensing, and other related information.

B. Regulatory Requirements
   1. Permitting
      a. Obtain necessary permits in conjunction with the installation of underground storage tanks as required by federal, state, or local authority.
   2. Registration
      a. Obtain and complete all required tank registration forms required by federal, state, and local authorities.
      b. Submit all tank registration forms within 30 days after contract award to the proper regulatory agencies.

C. Licensed Personnel
   1. Tank installers shall be licensed/certified by the state when the state requires licensed installers.

1.5 DELIVERY, STORAGE, AND HANDLING

A. Handle, store, and protect equipment and materials to prevent damage before and during installation in accordance with the manufacturer's recommendations, and as approved by the Contracting Officer. Replace damaged or defective items.

1.6 PROJECT/SITE CONDITIONS

A. Exposed moving parts, parts that produce high operating temperatures and pressures, parts that may be electrically energized, and parts that may be a hazard to operating personnel shall be insulated, fully enclosed, guarded, or fitted with other types of safety devices. Install safety devices so that proper operation of equipment is not impaired.

PART 2 - PRODUCTS

2.1 MATERIALS AND EQUIPMENT

A. General
   1. Provide materials and equipment that are standard products of a manufacturer regularly engaged in the manufacturing of such products, that are of a similar material, design and workmanship.
   2. Provide materials and equipment that have been in satisfactory commercial or industrial use for a minimum two (2) years prior to bid opening. The two (2) year period shall include applications of the equipment and materials under similar circumstances and of similar size.
   3. Provide materials and equipment that have been for sale on the commercial market through advertisements, manufacturers' catalogs, or brochures during the two (2) year period. Products

having less than a two (2) year field service record will be acceptable if a certified record of satisfactory field operation, for not less than 6000 hours, exclusive of the manufacturer's factory tests, can be shown.

B. Nameplates
1. Attach nameplates to all specified equipment defined herein.
2. List on each nameplate the manufacturer's name, address, [contract number,] [acceptance date,] component type or style, model or serial number, catalog number, capacity or size, and the system that is controlled.
3. Construct plates of anodized aluminum, stainless steel, or melamine plastic, 0.125 inch thick, UV resistance, black with white center core, matte finish surface and square corners
4. Install nameplates in prominent locations with nonferrous screws, nonferrous bolts, or permanent adhesive.
5. Minimum size of nameplates shall be one (1) by 2.5 inches.
6. Lettering shall be the normal block style with a minimum 0.25 inch height
   a. Accurately align all lettering on nameplates.
   b. For plastic nameplates, engrave lettering into the white core.
   c. Key the nameplates to a chart and schedule for each system.
   d. Frame charts and schedule under glass, and locate where directed near each system.
7. Furnish two (2) copies of each chart and schedule.
8. Each nameplate description shall identify its function.

2.2 MATERIALS

A. Internal parts and components of equipment, piping, piping components and valves that could be exposed to fuel during system operation shall not be constructed of zinc coated (galvanized) metal, brass, bronze, or other copper bearing alloys.

B. Do not install cast iron bodied valves in piping systems that could be exposed to fuel during system operation.

2.3 ELECTRICAL WORK

A. Provide controllers, integral disconnects, contactors, controls, and control wiring with their respective pieces of equipment per manufacturer and IEEE standards.

B. Provide switches and devices necessary for controlling and protecting electrical equipment.

C. Controllers and contactors shall have a maximum of 120-volt control circuits and shall have auxiliary contacts for use with the controls provided.

D. Underground Wiring:
1. Enclose underground electrical wiring in PVC coated conduit. Dielectrically isolate conduit at any steel storage tank connection.

E. Grounding and Bonding:
1. Grounding and bonding shall be in accordance with NFPA 70, NFPA 77, NFPA 407, NFPA 780, API RP 540, API RP 2003, IEEE 142, and IEEE 1100.
2. Provide jumpers to overcome the insulating effects of gaskets, paints, or nonmetallic components.

2.4 UNDERGROUND STORAGE TANK

A. Provide a factory-fabricated, double-walled type storage tank that conforms to NFPA 30 and NFPA 30A.
   1. Tank shall be designed and manufactured for an underground, horizontal installation.
   2. The exterior tank walls shall be separated from the interior tank walls by standoffs; thus creating an open or interstitial space (Type II).
   3. The entire interstitial space shall be monitorable for leaks.
   4. For tanks requiring concrete anchor pads or concrete deadmen, provide holddown straps and accessories as recommended by the tank manufacturer.
   5. Use filler strips between the tank shell and any metal holddown straps that conform to the tank manufacturer's requirements.

B. Double-Walled Steel Tank
   1. Tank shall be constructed of steel and shall conform to UL 58, Type II.
   2. Tanks constructed with lap welded shell or head joints shall be continuous fillet welded; on both the interior and exterior surfaces.
   3. The UL 58 label shall be affixed to the exterior surface of the tank.

C. Double-Walled FRP Tank
   1. Tank shall be constructed of fiberglass reinforced plastic (FRP) and shall conform to UL 1316.

   2. The UL 1316 label shall be affixed to the exterior surface of the tank.

2.6 TANK PROTECTIVE COATINGS

A. Interior Surfaces
   1. Coat 100 percent of a metal tank's interior surfaces including all metal piping and metal appurtenances as specified in Section 09 97 13.15 LOW VOC POLYSULFIDE INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS, Section 09 97 13.17 THREE COAT EPOXY INTERIOR COATING OF WELDED STEEL PETROLEUM FUEL TANKS, and API Std 1631 (supplied by manufacturer).

B. Exterior Surfaces, Aboveground Tanks
   1. Protect the exterior surfaces of each aboveground tank as specified in Section 09 97 13.27 EXTERIOR COATING OF STEEL STRUCTURES with the manufacturer's standard coating system, as specified in Section 09 90 00 PAINTS AND COATINGS (provided by manufacturer).

C. Exterior Surfaces, Underground Tanks
   1. Provide steel tanks with one of the following corrosion protection systems.

D. FRP Coating System
   1. Coating system shall be in accordance with UL 1746 or STI 020-50-1000.
   2. The integrity of the coating shall be certified by the manufacturer as meeting the thickness requirements and having no flaws prior to shipment.
   3. The UL and/or STI label(s) shall be affixed and visible on the exterior surface of each coated tank.

E. STI 010-50-1000 System
   1. Coating system shall be in accordance with STI 010-50-1000.
   2. Tank manufacturer shall be licensed by the Steel Tank Institute as an applicator of the STI 010-50-1000 system.
   3. The STI label shall be affixed and visible on the exterior surface of each coated tank.

2.7 TANK COMPONENTS

A. Tank Manway
   1. Tank manway shall have an internal diameter of 36 inches.
   2. Provide each manway with a matching flanged watertight manway cover.
   3. Manway covers shall be UL listed, be constructed of pressed or mild steel, and include a UL listed gasket.
   4. Frame and cover assembly shall be rated to withstand H-20 highway loading as defined by AASHTO HB-17.

B. Tank Piping Penetrations
   1. Provide a welded-in-place double tapered National Pipe Thread (NPT) coupling for each tank piping connection.

C. Tank Striker/Impact Plates
   1. Provide an interior striker/impact plate under each tank manway and pipe connection.
   2. Each plate shall be a minimum of 1/4 inch in thickness, be larger in diameter than the tank penetration, fit the curvature of the tank bottom, and be completely coated in the same fashion as the interior tank bottom coating.
   3. Each plate shall be welded to the tank bottom at the factory (full circumference connection).

D. Tank Cleanout and Gauge Assembly
   1. Provide a combination cleanout and gauge assembly.
   2. The assembly shall include a bronze top-seal type adapter with a corresponding locking type cap (adapter and cap both externally-mounted to the top of the tank) and a steel or aluminum pipe mounted internal to the tank.
   3. The pipe shall be a minimum two (2) inches in size and extend downward through the top of the tank to within three (3) inches of the tank bottom.
   4. Provide the entire length of pipe inside the tank with 1/2 inch wide by 12 inches long slots at alternate locations.
   5. Coat the pipe in the same fashion as the interior tank bottom coating.

E. Tank Ladder
   1. Provide interior tank ladders constructed of either fiberglass or steel.
      a. If steel, coat the ladder in the same fashion as the tank interior.
   2. The two (2) stringers shall be a minimum 3/8 inch thick and a minimum two (2) inches wide.
   3. The rungs shall be a minimum 3/4 inch rod on 12 inches centers. Members of the ladder shall be securely affixed.
   4. Ladder shall be of sufficient length to extend from the bottom of the tank to the top surface of the tank.
   5. Ladder shall be rigidly connected to the tank bottom in accordance with the tank manufacturer's standard.
   6. Ladder shall be connected to the top of the tank with pipe guides or slip bars to accommodate expansion of the two stringers.

F. Aboveground Tank Emergency Vent
   1. Vent shall be the normally-closed, UL listed type that vents outward and upward.
   2. Vent shall conform with NFPA 30 and UL 142.
   3. Provide vent with the Liters per second (L/s) cubic feet per minute (cfm) rating permanently labeled on the vent's exterior.

2.8 AUTOMATIC LEVEL ALARM SYSTEM

A. Provide a system that will monitor three (3) programmable liquid level setpoints.

B. The system shall delineate between each individual setpoint as well as each individual tank.

C. The system shall produce an audible and visible alarm in the event of monitoring an alarm condition.

D. Mechanically-actuated float assemblies shall be field adjustable.

E. The system shall be totally independent of the tank gauging system.

F. Setpoints
   1. Configure the alarm system's three (3) setpoints in accordance with the following.
      a. High Level Setpoint.
         i. Produce an alarm condition when a tank's liquid level rises above [90] [95] [ ] percent capacity.
      b. High-High Level Setpoint.
         i. Produce an alarm condition when a tank's liquid level rises above [95] [98] [ ] percent capacity.
      c. Low Level Setpoint.
         i. Produce an alarm condition when a tank's liquid level drops below [15] [ ] percent capacity.

G. Control Panel
   1. Install the control panel for the alarm system in a NEMA 4 rated enclosure in accordance with NEMA 250 standard industrial enclosure.
   2. Panel doors shall swing left or right.

H. Audible Alarm
   1. Panel shall have [internal] [external] speakers that produce a buzzer sound of [70] [ ] decibels or greater in the event of a detected alarm condition.

I. Visual Alarm
   1. Panel shall have a visual alarm that illuminates in the event of a detected alarm condition.
   2. The visual alarm shall include either individual lights for each alarm condition or shall include a single light and a liquid crystal display (LCD) panel that displaces information regarding each alarm condition.

J. Acknowledge Switch
   1. Panel shall have a manual acknowledge switch that will deactivate the audible alarm.
   2. The acknowledge switch shall not deactivate subsequent audible alarms unless depressed manually again for each occurrence.
   3. Under no circumstance shall this acknowledgement switch extinguish the visual alarms until the alarm condition has been corrected.
   4. The acknowledge switch shall be an integral component located on the front of the control panel.
   5. The switch shall be either a key switch or push button.

2.9 TANK GAUGES

A. Stick Gauge
   1. For each tank, provide two (2) wooden stick gauges.
   2. Gauge length shall allow the measurement of the entire level of fuel in the corresponding tank.
   3. Gauges shall be compatible with the fuel to be measured (no swelling or damage from fuel contact).
   4. Provide gauge with non-sparking caps on each end.
   5. Mark gauges in m and mm feet and inches.
   6. The smallest unit of measure on the gauge shall be 1/16 inch.

B. Tank Strapping Table

1. Furnish [2] [ ] [API MPMS 2.2E] [API MPMS 2.2A] certified strapping tables (calibration charts) for each tank.
2. Tables shall indicate the liquid contents in gallons for each 1/16 inch of tank depth.
3. For each tank, provide an electronic media file of each strapping table.

C. Analog Tank Gauge
1. Gauge shall be the level sensing, mechanically actuated type that provides the tank level readout in a sealed glass cap contained in a gauge box.
2. Gauge shall be accurate to plus or minus 1/4 inch and shall measure the liquid level over the full range of a tank's height.
3. Gauge shall have vapor tight seals to prevent condensation from fogging the viewing glass.

D. Hydrostatic Tank Gauge System
1. System shall be the dial type calibrated in Liters gallons.
2. Gauge shall be manually actuated using a built-in hand pump.
3. The transmission line from the gauge to the tank shall be seamless copper tubing run in Schedule 80 PVC carrier pipe.
4. The tank assembly (fittings, air bells, and tubing) shall be installed according to the gauge manufacturer's recommendations.

E. Digital Tank Gauge System
1. Gauge system shall be the mechanically or electronically actuated type that can continuously monitor a tank's usable liquid level storage capacity.
2. The system shall provide a digital readout of a tank's liquid level in terms of inches and gallons.
3. The system shall be accurate to plus or minus 1/16 inch.
4. The system shall measure water accumulation in mm inches from 3/4 to 5 inches off the bottom of a storage tank.
5. Construct system components to be chemically compatible with the fuel to be handled.
6. For each tank monitored, provide a sending unit that transmits the digital readout from a tank to [the electronic monitoring/alarm panel defined in Section 33 58 00 LEAK DETECTION FOR FUELING SYSTEMS, an electronic display panel (provided by manufacturer).
7. Panel shall be a NEMA 4 enclosure as defined by NEMA 250, standard industrial enclosure.
8. Panel doors shall swing left or right.
9. The panel shall display the digital readout of each monitored tank on an LCD mounted exterior to the panel.
10. The panel shall also have external controls to allow operators to toggle between information on the LCD without having to open the panel.

2.10 MANWAY CONTAINMENT SUMP

A. Sump shall be the factory-fabricated, direct-buried type that provides a watertight connection either directly to the exterior of the tank or to a flanged manway opening.

B. Sump shall be constructed of either fiberglass reinforced plastic or molded polyethylene.

C. Sump construction shall be chemically compatible with the type of products being handled within the connecting tank.

D. Sump shall allow access to a tank manway cover without disturbing surrounding backfill.

E. Sump shall be larger in diameter than the connecting tank manway.

F. Sump shall be designed to withstand the underground burial loads.

G. Sump assembly shall prevent the influx of rainfall, drainage, and ground water.

H. Piping Penetrations
   1. Sump sides shall allow the penetration of carrier pipes, exterior containment pipes, conduits, and vapor pipes as required.
   2. Sump penetrations shall be booted or sealed to ensure that liquid will not escape from the sump in the event that the liquid level within the sump rises above the pipe penetration.
   3. Boots and seals used shall be compatible with the fuel to be handled.
   4. Boots and seals shall be water resistant to the influx of water from outside the sump.
   5. Boots and seals shall be designed and installed to accommodate the anticipated amount of thermal expansion and contraction in the piping system.

I. Access Cover
   1. Where indicated, the entire top of a containment sump shall be capped with a bolted down, watertight access cover.
   2. Cover shall be constructed of the same material as the sump.
   3. Cover shall have a larger diameter than the tank manway cover below.

2.11 TANK MOUNTED FUEL DISPENSING UNIT

A. Provide fuel dispensing unit with integral UL labeled suction pump as supplied by the tank manufacturer.

B. Unit shall include all necessary appurtenances for operation.

C. Unit shall include a visible register to indicate individual deliveries up to 99.9 gallons with a reset meter.

D. Pump shall have a delivery capacity of 15 gpm.

E. Hose shall be a minimum 3/4 inch inside diameter and fuel resistant.

F. The dispensing nozzle shall be of the automatic shutoff type with graduated notches for various delivery speeds.

G. Dispensing unit shall provide a means for locking of the nozzle to the pump when the pump is shutoff.
   1. Diesel fuel dispensing unit cabinet shall be painted yellow from the manufacturer.
   2. Gasoline dispensing unit shall be painted red from the manufacturer.

H. Units shall be clearly marked for the fuel they are dispensing.

2.13 INSPECTION WELL

A. Inspection well shall be constructed of Schedule 40 PVC pipe that is six (6) inches in diameter.

B. Pipe shall be factory slotted from the bottom to within 12 inches of grade.

C. With the pipe installed vertically, slots shall be horizontal and have a width of 0.02 inch with not less than 30 slots per foot.

D. Slots shall encompass at least 80 percent of the pipe's 360 degree perimeter with the pipe maintaining its structural integrity.

E. Slots shall allow fluid within the soil to infiltrate into the pipe without allowing sediment to fill the pipe.

F. Each well shall extend down two (2) ft below the deepest buried storage tank. Well shall have a permanently fixed bottom cap.

G. Well shall have a removable top cap that is protected from traffic with a watertight street manway and cover as indicated.

H. Well shall have a 3/8 inch vent hole located directly below the top cap to vent the well.

I. The top cap of each well shall be accessible from the surface through a 12 inch diameter manhole.

J. The manhole ring shall be constructed of steel, cast iron, or fiberglass, have a cast iron cover, be a minimum of 12 inches deep, and withstand H-20 highway loading as defined by AASHTO HB-17.

K. Each manhole cover shall have the words "DO NOT FILL - INSPECTION WELL" cast permanently into the top.
   1. The letters shall be a minimum of 1/2 inch in size.

L. Each manhole cover shall have a white circle with a black triangle painted on the surface.

2.14 ACCESSORIES

A. Concrete Anchor Bolts

B. Concrete anchors shall conform to ASTM A307, Grade C, hot-dipped galvanized.

C. Bolts and Studs
   1. Carbon steel bolts and studs shall conform to ASTM A307, Grade B, hot-dipped galvanized.
   2. Stainless steel bolts and studs that conform to ASTM A193/A193M, Grade 8.
      Nuts
   3. Carbon steel nuts shall conform to ASTM A563, Grade A, hex style, hot-dipped galvanized.
   4. Stainless steel nuts shall conform to ASTM A194/A194M, Grade 8.

D. Washers
   1. Provide flat circular washers under each bolt head and each nut.
   2. Washer materials shall be the same as the connecting bolt and nut.
   3. Carbon steel washers shall conform to ASTM F844, hot-dipped galvanized.
   4. Stainless steel washers shall conform to ASTM A194/A194M, Grade 8.

E. Polytetrafluoroethylene (PTFE) Tape
   1. Tape shall conform to ASTM D3308.

F. Street Manway Assembly
   1. Round street manhole frames and covers shall be the straight traffic type.
   2. Frames and covers shall be in accordance with the City of Rockland standards.
   3. Covers shall form a watertight seal with the manhole frame to prevent surface water inflow.
   4. Frame and cover assembly shall be rated to withstand H-20 highway loading as defined by AASHTO HB-17.

2.15 FINISHES

A. Factory Coating
   1. Unless otherwise specified or approved of by the City of Rockland, provide all equipment and components with the manufacturer's standard factory finishes for the intended use.

PART 3 - EXECUTION

3.1 INSTALLATION

A. Install work so that parts requiring periodic inspection, operation, maintenance, and repair are readily accessible.

B. Handle storage tanks with extreme care to prevent damage during placement and install in accordance with the manufacturer's installation instructions and NFPA 30 or NFPA 30A, as applicable.

C. Inspect the exterior surface of each tank for obvious visual damage prior to and during the placement of each storage tank.

D. Repair surface damage to a storage tank according to manufacturer's requirements before proceeding with the system installation.

E. Provide the termination of fill lines within a tank with an antisplash deflector.

F. Provide nylon dielectric bushings on pipe connections to a steel tank.

G. Underground Storage Tank
   1. Install underground storage tanks in accordance with API RP 1615 except as modified herein.
   2. Place tank on a 1/8 inch per foot slope with the fill point at the low end and the vent connection at the high end.
   3. Locate tank so that the fuel discharge pipes slope up uniformly toward the fuel outlet.
   4. Install containment sumps prior to any backfill being added above the storage tanks.

H. Steel Tank Handling
   1. Store, handle, and place externally coated steel tanks with care and in a manner that will minimize damage to the coating and will not reduce its protective value.
   2. Place coated tanks in position carefully and with a minimum of handling.
   3. Prior to backfilling a tank, visually inspect the tank exterior protective coating for damage.
   4. Repair any damaged tank coating in accordance with the appropriate UL or STI standard (UL 1746, STI 020-50-1000, or STI 010-50-1000).

I. Steel Tank Installation Procedures
   1. Set tank on a minimum of 6 inches of backfill material.
   2. Anchor tank to a reinforced concrete anchor pad as indicated using manufacturer's supplied holddown straps.
   3. Separate tank from an anchor pad by a minimum of 12 inches of backfill material.
   4. Coat metal straps, turnbuckles, anchors, and accessories to resist corrosion.
   5. Uniformly place backfill material around the entire tank and extend to grade level.
   6. Inspect tank cathodic protection anodes, if applicable, to ensure integrity during backfill operations.

J. FRP Tank Handling
   1. Handle tank with extreme care to prevent damage during installation and transportation to the site.
   2. Any damaged tank shall be replaced or repaired and tested under direct supervision and advice of the tank manufacturer, using the manufacturer's written procedures.

K. FRP Tank Installation Procedures
   1. Set tank on a minimum of six (6) inches of backfill material.

2. Anchor tank to a reinforced concrete anchor pad as indicated through the use of manufacturer's supplied holddown straps.
3. Separate tank from an anchor pad by a minimum of 12 inches of backfill material.

L. Equipment
1. Properly level, align, and secure equipment in place and in accordance with manufacturers' instructions.
2. Provide supports for equipment, appurtenances, and pipe as required.
3. Install anchors, bolts, nuts, washers, and screws where required for securing the work in place.
4. Sizes, types, and spacings of anchors and bolts not indicated or specified shall be as required for proper installation.

3.2 FIELD QUALITY CONTROL

A. Underground Storage Tank Tightness Tests
1. Perform a tightness test on each underground storage tank on-site just prior to their placement into the ground.
2. Pneumatically pressurize each storage tank's primary chamber to 35 kPa - 5 psig and monitor for a drop in pressure over a two (2) hour period during which there shall be no drop in pressure in the tank greater than that allowed for thermal expansion and contraction.
3. Following the successful completion of the primary chamber test, bleed the pressure from the primary chamber into the interstitial space.
4. Maintain this pressure while applying soapsuds or equivalent material over the exterior of the tank.
   a. While applying the soapsuds, visually inspect the entire tank, including the bottom surfaces, for leaks (bubble formations).
   b. Inspection of the bottom surfaces of a tank may be performed by rotating the tank; however a tank shall only be rotated in strict accordance with the manufacturer's recommendations.
      i. Do not rotate a tank more than 90 degrees from the upright position.
5. During testing, install a pressure relief device that relieves at the tank manufacturer's suggested pneumatic pressure limit.
6. Gauges used in pneumatic tests shall have a scale with a maximum limit of 69 kPa 10 psig.

B. Repairs
1. Repairs are not allowed.
2. If tank does not pass the Tank Tightness Test, then it shall be replaced in-kind at no cost to the owner.

C. Tank Manufacturer's Tests
1. In addition to the tests required herein, perform any additional tests (i.e., leak tests, cathodic protection verification tests, etc.) on each storage test that is required by the tank manufacturer's written test procedures.
2. Manufacturer's tests that are redundant to tests already required by this specification will only be performed once per tank.
3. Repair all leaks discovered during the tests in accordance with manufacturer's instructions.
4. Following tank repairs, re-test the tank until the tank successfully passes the manufacturer's testing requirements.

D. System Commissioning
1. System commissioning shall conform to Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS (provided by manufacturer).

3.3 DEMONSTRATIONS

A. Tank Fill Tests

1. Tank fill tests shall not be performed until after the flushing, cleaning, and adjusting requirements defined in Section 33 08 55 COMMISSIONING OF FUEL FACILITY SYSTEMS (provided by Manufacturer).
2. For the tank fill tests, initially fill each storage tank with fuel in order to verify the tank level alarm system operates properly and the tank overfill protection device functions as designed.
3. Stop filling each tank immediately once the overfill devices operate.
4. Do not overfill any storage tank more than the 98 percent level.
5. Drain the system below the low liquid level setpoint to verify operation of the low level alarm.
6. Correct and retest any problems with the level alarm system or the overfill device until each operate as specified herein.
7. During the tests, verify that all tank gauges are calibrated and operating appropriately.

3.4 FIELD PAINTING

A. Painting required for surfaces not otherwise specified shall be field painted as specified by the manufacturer.

B. Do not paint stainless steel and aluminum surfaces.

C. Do not coat equipment or components provided with a complete factory coating.

D. Prior to any field painting, obtain approval from the Manufacturer and City of Rockland.
   1. Clean surfaces to remove dust, dirt, rust, oil, and grease.

End of Section 33 56 10

APPENDIX “A”

The key to success starts with a solid foundation.
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Geotechnical Report



Mid-Coast School of Technology

1 Main Street Rockland, Maine

2/10/2017

SUMMIT GEOENGINEERING SERVICES

PIN 16274

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February 10, 2017
Summit #16274

Elizabeth Fisher, Director
Mid-Coast School of Technology
1 Main Street
Rockland, Maine 041841

Reference: Geotechnical Engineering Services
Mid-Coast School of Technology – 1 Main Street Rockland, Maine

Dear Ms. Fisher;

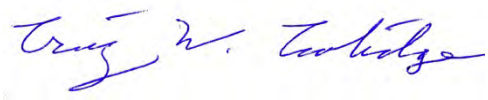
We have completed our geotechnical investigation for the proposed Mid-Coast School of Technology (MCST) located at 1 Main Street in Rockland, Maine. Our scope of services included performing subsurface explorations at the site and preparing this report summarizing our findings and geotechnical recommendations. The geotechnical considerations identified for development at this site include:

- The presence of marine deposits and its potential for settlement
- The raising of site by import fill, its potential for settlement, and ability to support loads
- The raising of site by import fill with side slopes of 2H:1V and its slope stability
- The potential for perched groundwater beneath footings and pavement sections
- The presence of building/sheds, pavement, and topsoil within the new school footprint
- The presence of existing school (to be demolished) within new pavement areas

Discussion and geotechnical recommendations for the identified considerations are included in this report for the new school foundations and pavement areas.

We appreciate the opportunity to serve you during this phase of your project. If there are any questions or additional information is required, please do not hesitate to call.

Sincerely yours,
Summit Geoengineering Services





Craig W. Coolidge, P.E.
Vice President
Principal Engineer

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1.0 Project and Site Description

Summit Geoengineering Services (SGS) was asked to conduct a geotechnical investigation for the new Mid-Coast School of Technology building to replace the existing school located at 1 Main Street in Rockland, Maine. The new school is proposed as a 2-story steel framed structure with a footprint of approximately 90,000 square feet. We understand the new school will be constructed adjacent to the existing school, which will remain operational during construction and be demolished after the new school is occupied. New access drives and pavement areas are planned as part of site development.

The site slopes at 3 to 4 percent grade from Main Street (west) towards Rockland Harbor (east) from elevations 50 to 20 feet. The site is bordered by steep bluffs, approximately 10 to 15 feet in height, adjacent to Rockland Harbor. The new school footprint is planned east of the existing school with current grades ranging from elevations 36 to 23 feet. The anticipated finish floor for the new school is elevation 33.5 feet requiring 3 feet of cut and up to 10 feet of fill.

2.0 Explorations and Laboratory Testing

Summit Geoengineering Services (SGS) observed the subsurface conditions with the drilling of 9 test borings. Borings were performed by East Coast Explorations under contract to SGS using a tire mounted CME 550 ATV. Borings were advanced to depths of 20 to 32 feet using 2.25-inch hollow stem augers or 3-inch casing with rotary wash. Soil was sampled with SPT split spoon per ASTM D1586 and rock sampled by ASTM D2113. Borings were backfilled upon completion.



SPT Sampling with Auto-Drop Hammer by East Coast Explorations

Exploration locations are shown on the Exploration Location Plan in Appendix A. Logs of the explorations are provided in Appendix B. The explorations were approximately located by SGS by taping from existing site features prior to drilling. Dig Smart of Maine was subcontracted by SGS to verify exploration locations were free from underground utilities prior to drilling.

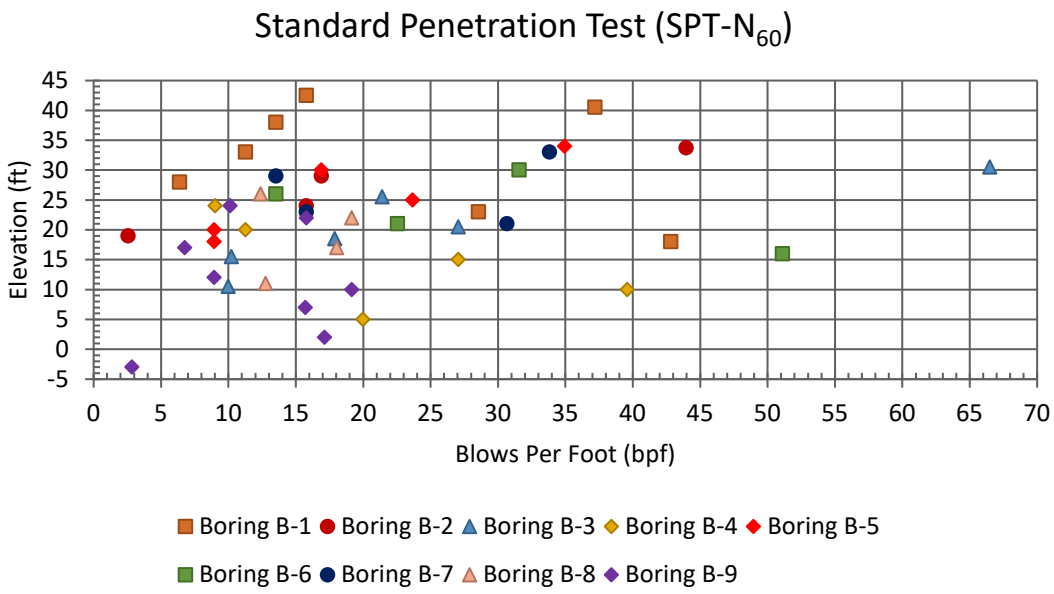
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Thirty-six samples of the marine deposit were tested for moisture content in accordance with ASTM D2216 with moisture ranging from 10.6% to 29.7%. Two samples were tested for Atterberg Limits in accordance with ASTM D4318 and three samples were tested for grain size analysis in accordance with ASTM D6913. Reports of the laboratory tests can be found in Appendix C. Summary of the laboratory test results are as follows:

LABORATORY TEST SUMMARY								
Boring	Depth	Moist. Content	Gradation Analysis			Atterberg		Notes
			Gravel	Sand	Fines	LL	PI	
B-1	0.5'-2.5'	15.9%	8%	81%	11%	--	--	Granular Fill
B-6	0'-2'	14.8%	22%	67%	11%	--	--	Granular Fill
B-2	10'-12'	21.9%	--	--	--	33	12	Marine (Clay)
B-9	19'-21'	11.1%	22%	31%	47%	19	3	Marine (Sand-Silt)

3.0 Subsurface Conditions

The subsurface conditions consist of 1 to 6 feet of ***fill*** overlying ***marine deposit***. Bituminous ***pavement***, granular ***fill***, and/or ***topsoil*** was present at the surface of the test borings. ***Bedrock*** was encountered at depths of 14 to 32 feet. ***Groundwater*** was present at a depth of 12 to 15 feet during our exploration. Graphic presentation of corrected SPT-N_{60} values obtained from split spoon samples are presented below:



The subsurface conditions are further described as follows:

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3.1 Soil Layers

Topsoil is described as dark brown silt with rootlets and is classified as ML in accordance with the Unified Soil Classification System (USCS). The topsoil is frozen or moist.

Fill is described as brown sand with some to little gravel and little silt and is classified as SP-SM in accordance with the USCS. Standard penetration tests (SPT-N_{60}) for the fill indicate compact to dense conditions. The fill is frozen or damp to wet.

Marine deposit is described as an upper and lower subunit. The upper subunit consist of olive brown and mottled silty clay and is classifed as CL in accordance with USCS. Pocket penetrometer tests (unconfined compression strength) and standard penetration tests (SPT-N_{60}) for the upper subunit indicate a range of stiff to soft conditions. Moisture content ranges from 18.2% to 29.7% with liquid limit of 33 and plasticity index of 12 suggesting the clay is partially to mostly saturated (moist to wet).

The lower subunit consist of gray sand-silt mixture with some to little gravel and clay and is classified as SM-ML in accordance with the USCS. Standard penetration tests (SPT-N_{60}) for the lower subunit indicate compact conditions. Moisture content ranges from 10.6% to 16.4% with liquid limit of 19 and plasticity index of 3 suggesting the sand-silt is mostly saturated (wet).

3.2 Bedrock

Weathered rock was encountered 6 to 18 inches above the bedrock surface at borings B-2, B-6, and B-7. The weathered rock consists of dark gray rock fragments with rusty mottled seams.

Bedrock was encountered at depths of 15 to 32 feet for borings B-2 through B-9. Bedrock outcrops are widely present along the shoreline of the site towards Rockland Harbor.



Bedrock Outcrops Along Shoreline (Rockland Harbor)

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Summary of the bedrock depths and elevations are presented below:

BEDROCK SUMMARY TABLE			
Boring	**Depth (feet)**	**Elevation (feet)**	**Notes**
B-1	> 27.0'	> 17.0'	No Bedrock Refusal to Depth of 27.0'
B-2	20.5'	14.5'	Weathered Rock at 19' to 20.5'
B-3	23.0'	8.5'	Auger Refusal
B-4	24.0'	1.0'	Roller Cone 0.5' Into Bedrock
B-5	19.5'	15.5'	Rock Core 20' to 25'
B-6	15.5'	15.5'	Rock Core 16' to 21' / Weathered Rock at 15'
B-7	15.0'	19.5'	Rock Core 15' to 20' / Weathered Rock at 14'
B-8	19.5'	7.5'	Roller Cone 0.5' Into bedrock
B-9	32.0'	-7.0'	Roller Cone Refusal / SPT Refusal

Bedrock Depths & Elevations Are Rounded to Nearest 0.5 Feet +/-

Mapping by the Maine Geological Survey indicates bedrock at the site is part of the Ogier Formation consisting of mudstone. Rock core samples obtained in borings were slight to moderately weathered, slightly fractured, fine-grained gray schist (mudstone).



Rock Cores (N, 5-ft) by East Coast Explorations

The rock is estimated as having a hardness value of 4 using the Mohs hardness scale. The joints within the bedrock were horizontal to moderately dipping (0 to 55 degrees), planar to undulated, and close. The percent recovery of the core, referred to as the ratio of total recovered sample length divided by the total coring length, ranged from 97 to 100 percent. The Rock Quality Designation (RQD) of the rock core is expressed as the sum of rock pieces 4 inches or greater in length compared to the length of the core sample. The RQD of the cored rock ranged from 53 to 90 percent. Detailed information of the rock cores is provided on the borings logs in Appendix B.

3.3 Groundwater

Groundwater was observed at a depth range of 12 to 19 feet in the test borings during our exploration. Groundwater appears present near the interface of marine deposit olive silty clay and gray sand-silt. Summary of the groundwater depths and elevations are presented below:

GROUNDWATER SUMMARY TABLE			
Boring	**Depth (feet)**	**Elevation (feet)**	**Notes**
B-1	19.0’	25.0’	Perched Water at 3’
B-2	14.0’	21.0’	--
B-3	15.0’	16.5’	--
B-4	12.0’	13.0’	--
B-5	14.0’	21.0’	--
B-6	14.0’	17.0’	Perched Water at 3’
B-7	12.0’	22.0’	Perched Water at 4.5’
B-8	14.0’	21.0’	--
B-9	14.0’	11.0’	--

Bedrock Depths & Elevations Are Rounded to Nearest 0.5 Feet +/-

Groundwater appears to flow west to east towards Rockland Harbor. Perched groundwater from seasonal rain or snow-melt is present near the interface of granular fill and upper marine deposit. High tide for the adjacent Rockland Harbor is elevation 5 feet. Based on this, and the relatively low permeability of the marine deposits, tidal influence upon groundwater elevation beneath the site is considered minor.

4.0 Geotechnical Evaluation

The geotechnical engineering properties used for our analysis were estimated from results of the subsurface investigation. We recommend a maximum column load of 250 kips to minimize post construction settlement to approximately ¼ to ½ inch for conventional spread footing foundations. This settlement is based on an allowable bearing pressure of 4,000 psf. Differential settlement is recommended to be limited at a deflection of 1/300 or less. To evaluate potential effects of differential settlement, we recommend Summit Geoengineering Services (SGS) be made available to review structural foundation plans, column spacing, and design loads.

The anticipated finish floor for the new school is elevation 33.5 feet requiring 3 feet of cut and up to 10 feet of fill. We estimate settlement generated by the weight of the fill imposed on the underlying marine deposits to be approximately ¼ to ½ inch. This settlement is expected to occur immediately during placement of fill or within 7 days following completion of fill placement as pore pressure dissipates from the underlying marine deposits. To minimize the effects of settlement generated by the weight of fill upon new foundations, a recommended construction sequence is provided in Section 5.6 Granular Borrow.

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5.0 Geotechnical Recommendations

With proper site preparation and load limitations, the new school can be supported using conventional spread footings. The following are geotechnical recommendations for design and construction of the building foundations:

- Column loads for new foundations are limited to 250 kips
- Foundation consists of slab on grade with spread footings at or near elevation 33 feet
- Foundation footings on granular fill are prepared as outlined in Section 5.6
- Foundation footings on marine (clay) are stabilized, if necessary, with crushed stone
- Topsoil, pavement, and building/sheds are removed from beneath new foundations
- Subgrade beneath footings are inspected by the geotechnical engineer

5.1 Foundation Bearing Pressure

We recommend the foundation elements be proportioned using an allowable bearing pressure of 4,000 psf. Settlement for the allowable bearing pressure is estimated at ¼ to ½ inch imposed by the foundation loads. Settlement is estimated on a maximum column load of 250 kips. Differential settlement is recommended at less than a deflection of 1/300 (δ/L deflection divided by span length) between column footings.

5.2 Frost Protection

Exterior footings should be constructed at a minimum depth of 4 feet below finished grade for frost protection based on a design air-freezing index of 1,100 F-degree days for the Rockland area. We recommend exterior and interior portions of foundation walls and footings are backfilled with Foundation Backfill. The Foundation Backfill should be compacted to 95 percent of its maximum dry density in accordance with ASTM D1557. The maximum particle size should be limited to 6 inches and portion passing a 3-inch sieve should meet the following gradation:

FOUNDATION BACKFILL	
Sieve Size	**Percent Passing**
½ inch	35 to 80
¼ inch	25 to 65
No. 40	0 to 30
No. 200	0 to 7

Reference: MDOT Specification 703.06, Type D (2014)

For compacted Foundation Backfill meeting the above specification, the following soil parameters can be used for foundation design of lateral loads:

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Foundation Backfill Design Parameters

- Active Earth Pressure Coefficient (K_A): 0.28
- At Rest Earth Pressure Coefficient (K_o): 0.44
- Passive Earth Pressure Coefficient (K_p): 3.54
- Total Unit Weight (γ_t): 130 pcf
- Effective Friction Angle (φ'): 34°

5.3 Building Slabs

We recommend the slabs be constructed on a minimum 12-inch thick layer of Foundation Backfill. The Foundation Backfill should be compacted to 95 percent of its maximum dry density in accordance with ASTM D1557.

The coefficient of subgrade reaction, k (per 12-inch plate) applies to the design of reinforced concrete foundations over soil. The slabs can be designed using a coefficient of subgrade reaction of 200 tons/ft^3.

Due to the potential for capillary rise from perched groundwater, we recommend a vapor barrier be used beneath the building slab. The vapor barrier should be installed in accordance with the latest American Concrete Institute specifications (ACI 302).

5.4 Groundwater Control

Groundwater was encountered at a depth range of 12 to 14 feet, elevations 22 to 11 feet, within the new school footprint. Based on this, foundation footings are expected above anticipated groundwater. Perched groundwater from rain or snowmelt is anticipated where footings are constructed upon the upper marine deposits (clay). To provide drainage of seasonal groundwater, we recommend foundation underdrains be installed along the base of the exterior footings on the upslope (west wall) of the building. Additionally, we recommend exterior grades slope away from the building footprint to reduce runoff water from infiltrating the foundation backfill soils.

Foundation underdrains should consist of 4 inch rigid perforated PVC placed adjacent to the exterior footings and surrounded by a minimum of 6 inches of Crushed Stone. Crushed Stone should be wrapped in filter fabric (Mirafi 140N or similar) to prevent clogging from the migration of the fine soil particles in the marine deposits.

5.5 Seismic Design

The seismic profile was evaluated using data from the test borings. Based on the results for undrained shear strength and standard penetration resistance, a Site Class D condition is recommended in accordance with ASCE 7-10.

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The lower marine deposit (sand-silt) was evaluated for liquefaction during earthquake based on penetration resistance obtained from SPT-N_{60} values from test borings, results of the gradation analysis, and peak ground acceleration (PGA) mapping by the United States Geological Survey (USGS). The deterministic peak ground acceleration PGA_M (ASCE 7-10) for the site is 0.14g. The lower marine deposit (sand-silt) is considered resistance to widespread liquefaction with a factor of safety estimated at 3 where earthquake magnitude is 7.5. Settlement by earthquake induced deformation (volumetric strain) is estimated at ¼ inch for earthquake magnitude 7.5.

5.6 Granular Borrow

To prepare the site grade for construction of the new school at elevation 33 feet, approximately 3 feet of cut and 10 feet of fill will be necessary. Fill required to meet grade beneath the new school should consist of compacted Granular Borrow. Granular Borrow should consist of sand or gravel of hard durable particles, free from vegetable matter, lumps or balls of clay, frozen material and other deleterious substances. The portion passing a 3-inch sieve should meet the following gradation specification:

GRANULAR BORROW	
Sieve Size	**Percent Passing**
No. 40	0 to 70
No. 200	0 to 20

Reference: MDOT Specification 703.19, Granular Borrow (2014)

Granular Borrow should be placed in 6 to 12 inch lifts and compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557.



Photograph of Site Requiring Granular Borrow to Raise Grade

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Settlement generated by the weight of the Granular Borrow imposed on the underlying marine deposit is estimated at ¼ to ½ inch. This settlement is expected to occur immediately during placement of Granular Borrow or within 7 days following placement as pore pressure dissipates from the underlying marine deposits. To minimize the effects of settlement generated by the Granular Borrow, we suggest the following earthwork sequence:

- Remove topsoil, pavement, and building/sheds to prepare subgrade
- Place Granular Borrow, in compacted lifts, up to top of grade (Elevation 32 feet +/-)
- Excavate foundation footings upon completion of Granular Borrow placement
- Backfill foundation footings with compacted Foundation Backfill
- Backfill grade beneath slab with 12 inches of Foundation Backfill (Elevation 33 feet +/-)
- Install vapor barrier and fine grade for construction of slab (Elevation 33.5 feet +/-)

Utilization of this construction sequence will reduce the amount of post construction settlement imposed on the building foundations. Reduction of post construction settlement will reduce the effects of differential settlement between the building portion constructed on marine deposit (west side) with portion constructed on Granular Borrow (east side).

We recommend Granular Borrow be placed beneath the access drive extending along the south and east foundations in conjunction with fill placed beneath the building footprint. Preliminary site grading indicates an approximate side slope of 2 horizontal to 1 vertical. We recommend slopes be faced with suitable protection such as vegetation, slope reinforcement, and/or riprap.

Global stability for the fill slope was evaluated with the following parameters:

- Maximum fill height of 10 feet consisting of compacted Granular Borrow
- Side slopes of 2 horizontal to 1 vertical with suitable surface protection for erosion
- Fill bearing on firm marine deposit (clay) as encountered in borings B-4 and B-9

Global stability for the fill slope is estimated as having a static factor of safety of 9.

5.7 Shoreline Bluff

This geotechnical investigation does not include evaluation for global slope stability of the shoreline bluff located east of the new school footprint. The new school is located beyond a setback distance of 75 feet. The bluff is approximately 15 feet in height with slopes of 1 to 1.5 horizontal to 1 vertical. Bedrock outcrops are widespread along the toe of the bluff. Localized scour from an adjacent stream is present near the base of the southern bluff. Available geological mapping provided by the Maine Geological Survey provides the following findings:

- Coastal Bluffs Mapping – Unstable to Stable (Ledge) “Yellow and Green”
- Coastal Landslide Hazards Mapping – Low Coastal Bluff “Green”

6.0 Pavement Recommendations

We understand the project includes new bituminous pavement sections. The subgrade will consist of existing fill (sand) and upper marine deposits (clay). The mean annual freezing index for the Rockland area is estimated at 750 F-degree days. Based on the subgrade and mean annual freezing index, the mean annual frost penetration depth is 36 inches.

We recommend a minimum total bituminous pavement section thickness of 50% of the mean annual frost penetration or 18 inches for light duty sections and 60% of the mean annual frost penetration depth or 22 inches for sections subjected to moderate to heavy truckloads. We further recommend that the bituminous pavement sections consist of the following materials.

MATERIAL	THICKNESS (in) Light Duty	THICKNESS (in) Heavy Duty	SPECIFICATION
Asphalt Surface Course	1	1.5	MDOT 703.09 Type 9.5 mm or Type 12.5 mm
Asphalt Binder Course	2	2.5	MDOT 703.09 Type 19 mm
Base Soil	3	3	MDOT 703.06 Type A
Subbase Soil	12	15	MDOT 703.06 Type D
Geotextile Fabric	--	--	Mirafi 500X or Similar

For portions of the bituminous pavement subjected to light traffic loads of cars and light trucks we recommend MDOT Type 9.5mm surface course. Where heavy duty sections are needed for trucks we suggest MDOT 703.09 Type 12.5mm for improved strength and durability of the asphalt surface.

Base and Subbase (MDOT Type A and Type D) should be free from organic matter, balls of clay, and other deleterious substances. The portion of soil passing a 3-inch sieve shall meet the following gradation specification:

Sieve Designation	Percent Passing a 3-inch Sieve	
	MDOT Type A (Base)	MDOT Type D (Subbase)
2 Inch	100	--
½ Inch	45 – 70	35 – 80
¼ Inch	30 – 55	25 – 65
No. 40	0 – 20	0 – 30
No. 200	0 – 6	0 – 7

Reference: MDOT Specification 703.06, Aggregate for Base and Subbase (2014)

Additional fill required beneath pavement sections should consist of compacted Granular Borrow, as specified in Section 5.6 Granular Borrow. Granular Borrow should be placed in 6 to 12 inch lifts and compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557.

We recommend geotextile be placed between Subbase and Granular Borrow or subgrade (existing fill or marine deposit). Geotextile should consist of Mirafi 500X or equivalent. Geotextile should have a minimum soil cover of 8 inches and overlap of 18 inches. Sewn seams are not required as part geotextile installation provided the subgrade is stiff during placement.

Pavement sections are planned within the current building footprint. We recommend any existing pavement, building structures, and abandoned utilities located immediate below new pavement sections be removed. Areas of over-excavation should be replaced with compacted Granular Borrow. We recommend a minimum separation of 12 inches between the bottom of pavement Subbase and any foundation elements left in-place such as concrete footings which cannot efficiently be removed. We recommend topsoil, building debris such as wood, or deleterious material be removed in its entirety from beneath new pavement sections.

7.0 Earthwork Considerations

We recommend the geotechnical engineer be retained to observe excavation and subgrade preparation to confirm that soil conditions and construction methods are consistent with this report. We further recommend that a qualified geotechnical consultant be retained to monitor and test soil materials used during construction to ensure proper material type and placement. Soil materials testing reports should be made available to the geotechnical engineer for review.

Based on preliminary gradation results, the existing site fill is considered suitable for reuse as Granular Borrow. Due to variability in gravel content for existing fill, we recommend prior to reuse, excavated fill should be stockpiled and properly mixed for materials testing. Stockpile should have a minimum of 2 samples collected and tested for grain size analysis (ASTM D6913) and maximum dry density (ASTM D1557) to evaluate its variability and suitability for reuse.

Existing pavement, topsoil, and materials such as foundations for existing buildings are removed from beneath the new building footprint and pavement areas prior to placing Foundation Backfill, Granular Borrow, or Subbase. We recommend subgrade beneath existing foundations (buildings) which are removed should be inspected by the geotechnical engineer to evaluate its suitability to support new foundations and pavement areas.

Foundation Backfill, Granular Borrow, Base, and Subbase should be compacted to 95 percent of its maximum dry density determined in accordance with ASTM D1557.

We recommend granular subgrade be proof-rolled prior to placement of Foundation Backfill, Granular Borrow, or Subbase. Proof rolling should consist of a minimum of five passes in a north-south direction and then five passes in an east-west direction using a vibratory roller or plate compactor, where access is permitted. Proof rolling of marine deposit (clay) subgrade is not required where subgrade is firm and intact or where stabilized using crushed stone.

We recommend the subgrade of marine deposit (clay) that becomes softened or disturbed during construction, be over-excavated and replaced with 6 to 12 inches of Crushed Stone. Crushed Stone should be should be tamped to lock the stone structure together. Additionally, we recommend the geotechnical engineer be made available to inspect subgrade prior to placement of crushed stone to evaluate proper stabilization.

Dewatering may be required for seasonal (perched) groundwater or runoff within excavations. We recommend that dewatering consist of shallow sumps installed sufficiently deep to keep the base of the excavation free from standing water. Additionally, diversion and control of runoff should be performed to prevent rain or snowmelt from entering the excavations.

General excavations and utility trenching below 4 feet should be sloped as follows:

- 1H to 1V (OSHA type B) for firm clay marine deposit
- 1.5H to 1V (OSHA type C) for sand-silt marine deposit
- 1.5H to 1V (OSHA type C) for granular fill
- 1.5H to 1V below groundwater

These slopes are based on the current OSHA Excavation Guidelines.

We recommend that all winter concrete construction be performed in accordance with the American Concrete Institute (ACI 306) for cold weather concreting. The following recommendations apply to earthwork construction during freezing conditions. In general, these recommendations are intended to minimize the penetration of frost into soil beneath foundations and slabs.

- Footing excavations should be protected from frost overnight by the use of insulated blankets or by tenting and heating.

- Footings should not be cast on frozen soil. The frozen zone should be removed and replaced as specified with the appropriate material.

- Fill areas should be sealed with a 12 inch loose layer of soil (or otherwise insulated) at the end of the day to protect the compacted soil from freezing. The frozen layers should be removed in the morning prior to placing and compacting the next lift.

- Due to the difficulty of thawing previously frozen soils (even within a heated shell), we recommend that the subgrade soil be protected from frost penetration where practical, especially if foundations or slabs are planned to be placed during periods of freezing.

- Frozen foundation and slab subgrade soils will become soft during thaw in the spring. We recommend that heavy traffic be avoided during thawing. Once the soil thaws and the accumulated water in the soil has drained, the subgrade should return to a firm condition. If placement of the footings or slabs occurs during thaw, we recommend that soft areas be removed and replaced with the use of geotextile fabric and crushed stone to stabilize soft areas.

8.0 Closure

Our recommendations are based on professional judgment and generally accepted principles of geotechnical engineering and project information provided by others. Some changes in subsurface conditions from those presented in this report may occur. Should these conditions differ materially from those described in this report, SGS should be notified so that we can re-evaluate our recommendations.

It is recommended that this report be made available in its entirety to contractors for informational purposes and be incorporated in the construction Contract Documents. We recommend that SGS be retained to review final construction documents relevant to the recommendations in this report.

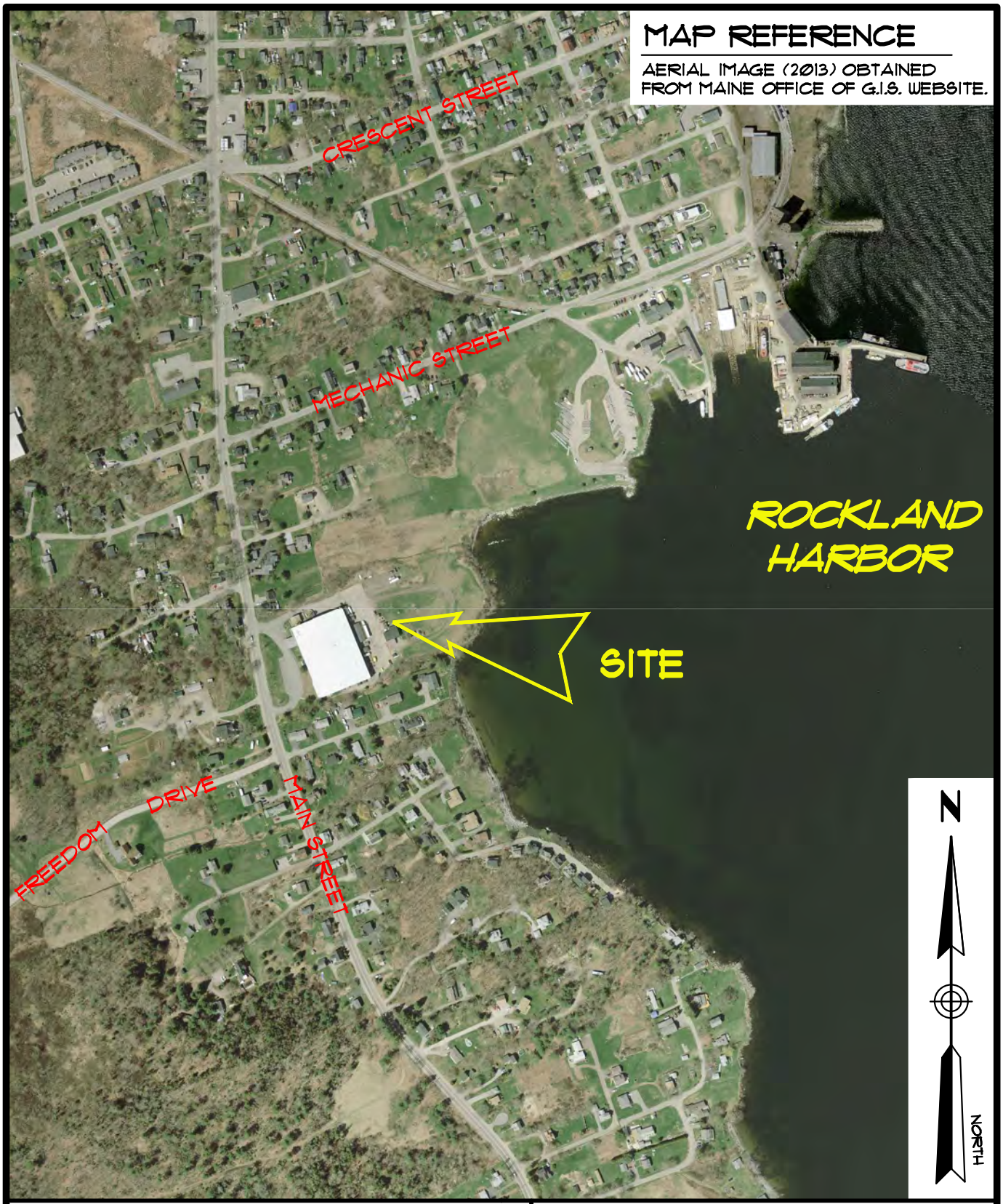
We appreciate the opportunity to serve you during this phase of your project. If there are any questions or additional information is required, please do not hesitate to call.

APPENDIX A

SITE LOCATION MAP

TEST BORING LOCATION PLAN

GEOLOGICAL MAPPING



SITE LOCATION MAP
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

DATE: 1-26-2017	DRAWN BY: KRF	CHECKED BY: CC
JOB: 16274	SCALE: 1"= 500'	FILE: 16274 MAPS

145 LISBON ST. - SUITE 601
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B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
1 DEMO PHASE 1
DEMO PHASE 2
250' SHORELINE ZONE LINE
12' SET-BACK
25' SETBACK
ORIGINAL BUILDING FOOTPRINT
DUCTILE IRON 1972
SIGHT DISTANCES (SPEED LIMIT 35 MPH)
391'
617'
INV.=45.7'
INV.=16.8'
INV.=27.1'
INV.=22.5'
INV.=22.4'
INV.=29.8'
INV.=33.2'
INV.=34.5'
INV.=35.9'
INV.=40.1'
INV.=42.9'
INV.=43.3'
INV.=47.3'
RIM=35.89'
31.38
33.98
33.22
32.8
32.92
31.35
51.56
51.45
R70'
R95'
R59'
R10'
R55'
R18' (TYP)
R5
24'
19'
9' (TYP)
6.5'
26'
6'
12'
SCALE: 1"= 100'

LEGEND

B-2 SUMMIT TEST BORING (JAN. 20, 23 & 25, 2017)

MAP REFERENCE

"OVERALL SITE PLAN, LAVALLEE BRENSINGER ARCHITECTS, MID-COAST SCHOOL OF TECHNOLOGY", DATED JANUARY 25, 2017, PREPARED BY GARTLEY & DORSKY.

SCALE: 1" = 60'

0 30 60 120 180

NORTH

PROJECT: NEW SCHOOL
1 MAIN STREET - ROCKLAND, MAINE

CLIENT: MID-COAST SCHOOL OF TECHNOLOGY

TITLE: TEST BORING LOCATION PLAN

SCALE: 1" = 60'

DRAWN BY: KRF

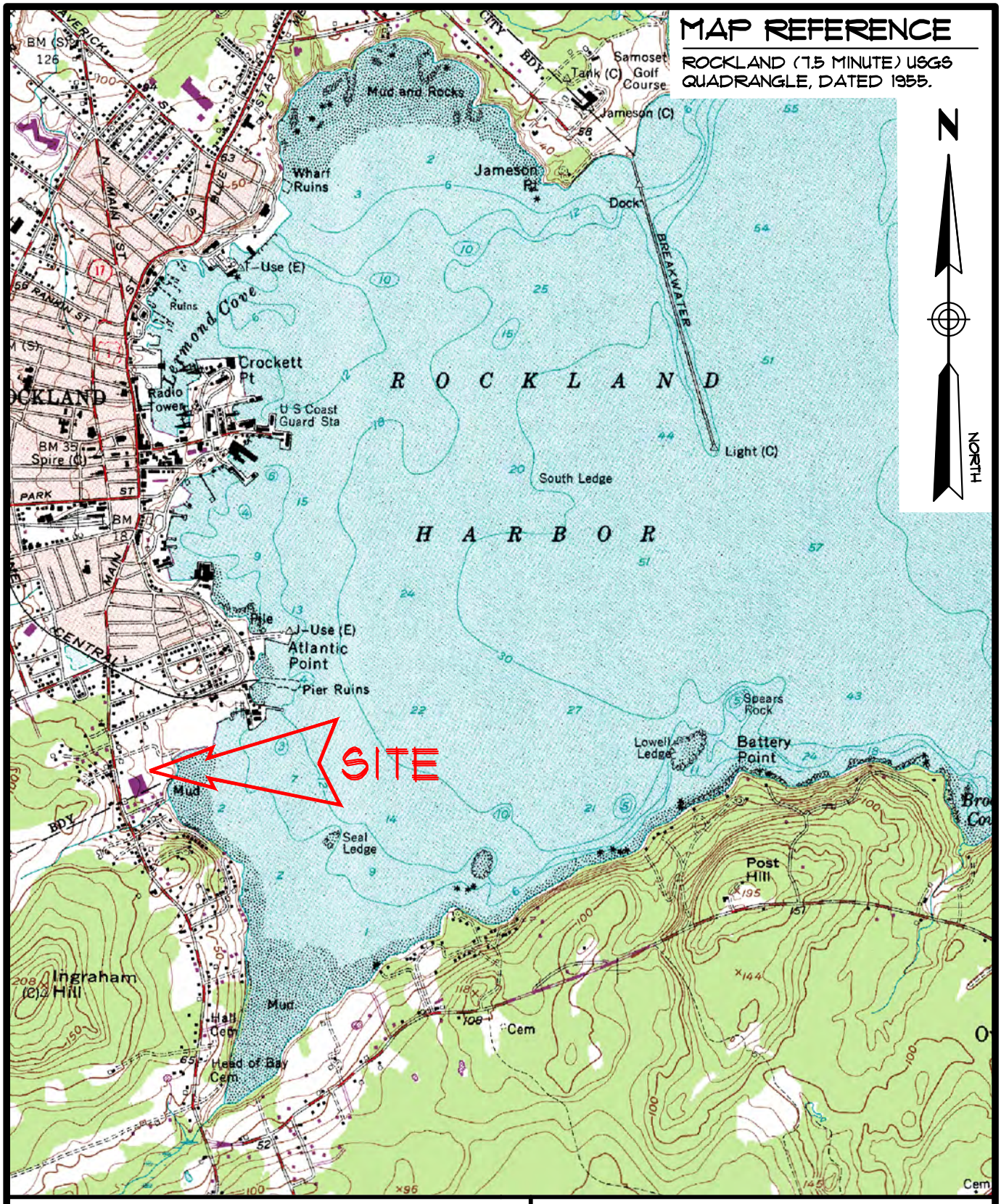
DATE: JANUARY 26, 2017

APPR. BY: WMP

PROJ.#: 16274

FIGURE: 1

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U.S.G.S. TOPOGRAPHIC MAP
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

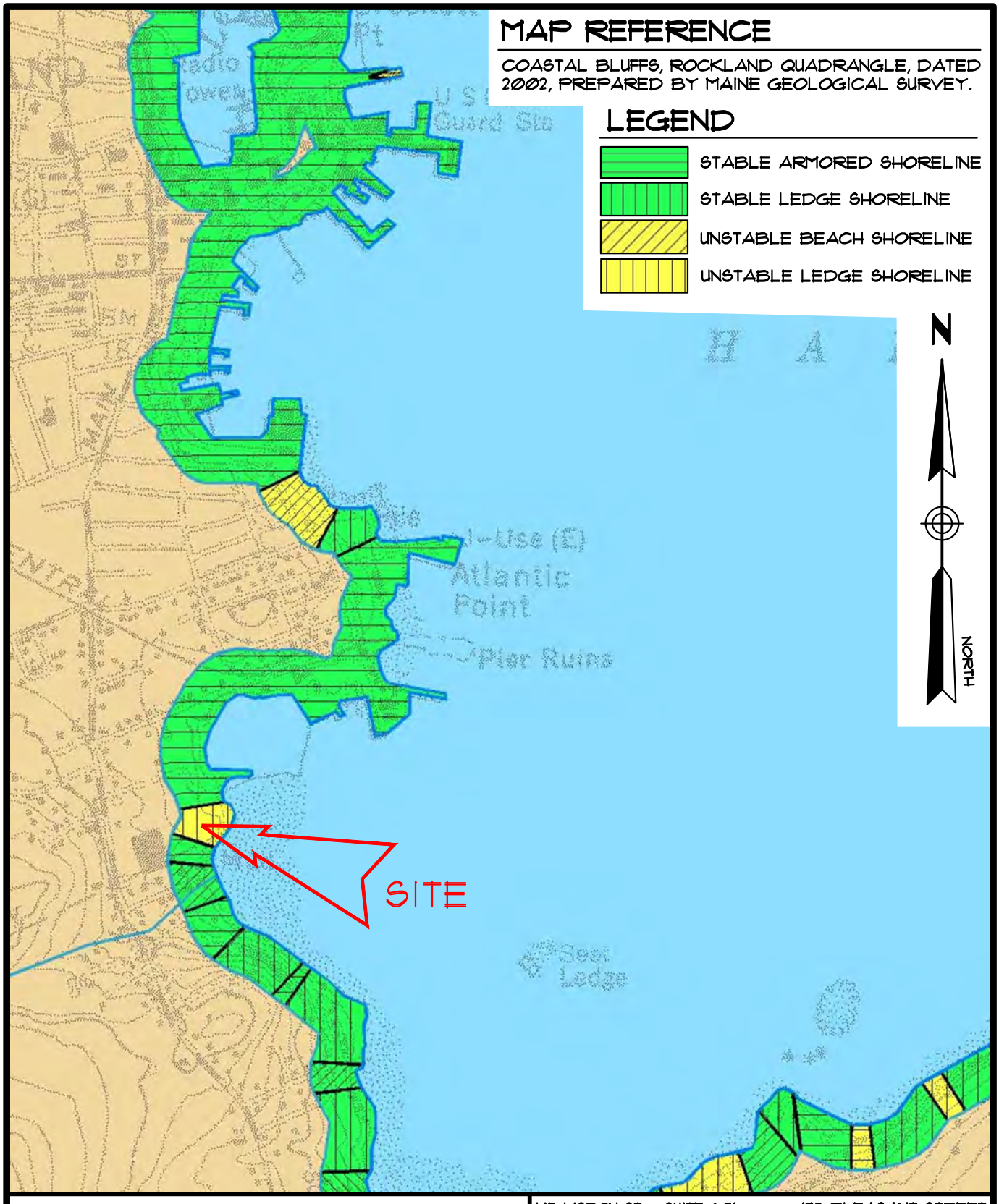
MID-COAST SCHOOL OF TECHNOLOGY

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COASTAL BLUFFS
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

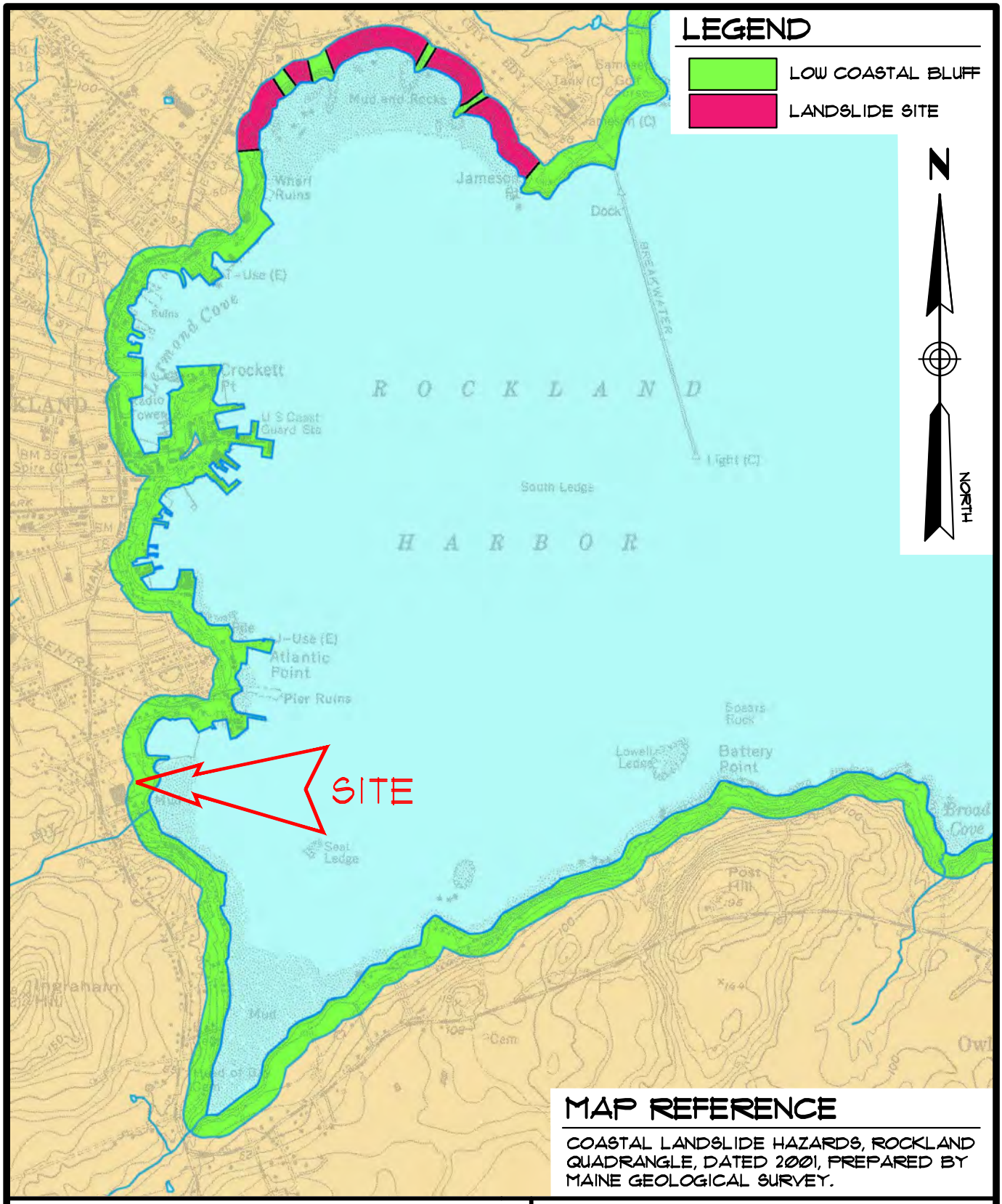
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MAP REFERENCE

COASTAL LANDSLIDE HAZARDS, ROCKLAND QUADRANGLE, DATED 2001, PREPARED BY MAINE GEOLOGICAL SURVEY.

COASTAL LANDSLIDE HAZARDS
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

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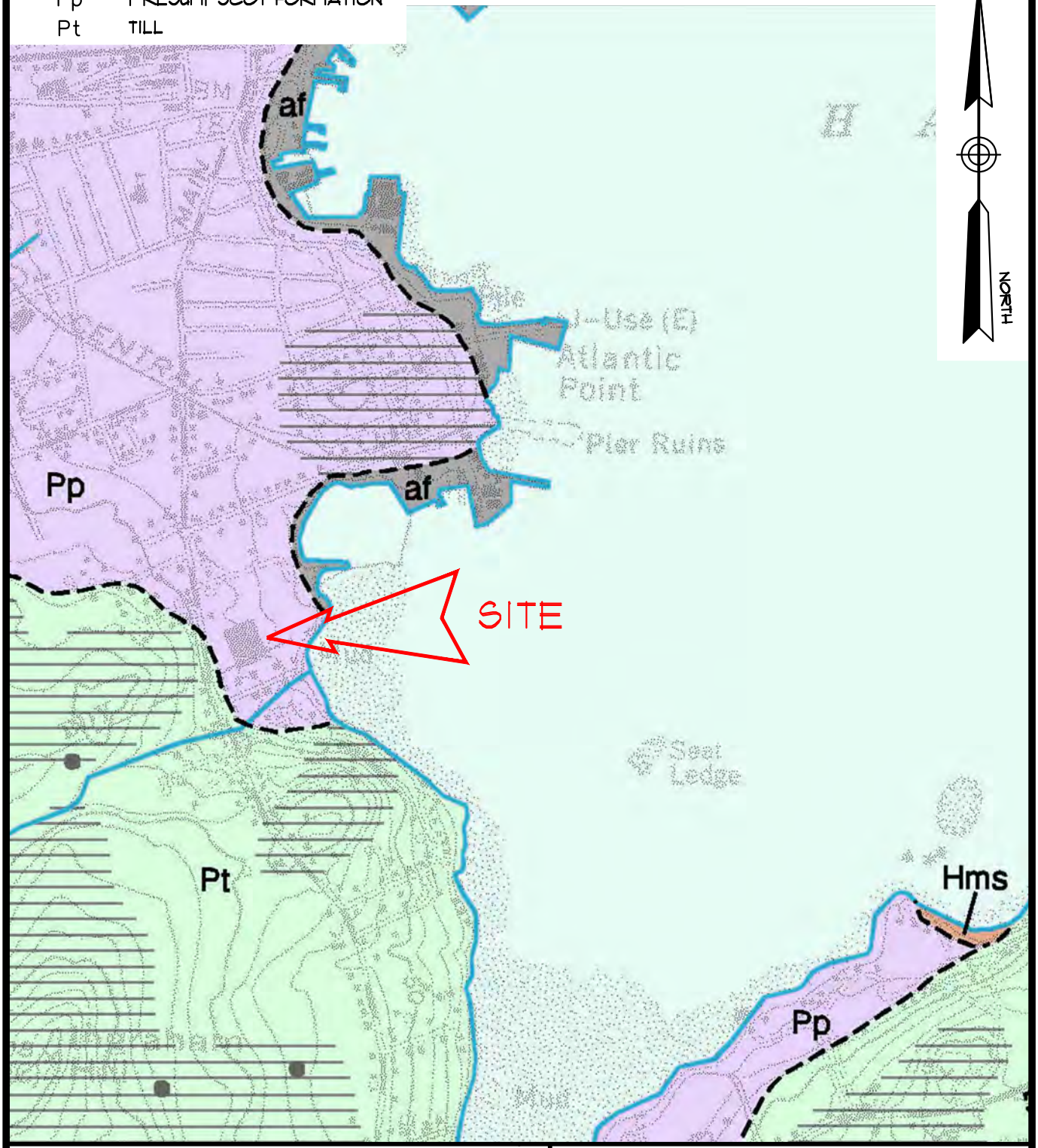
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LEGEND

af	ARTIFICIAL FILL
Pp	PRESUMPSCOT FORMATION
Pt	TILL

MAP REFERENCE

MAINE GEOLOGICAL SURVEY, SURFICIAL GEOLOGY, ROCKLAND QUADRANGLE, DATED 2010.



SURFICIAL GEOLOGY
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

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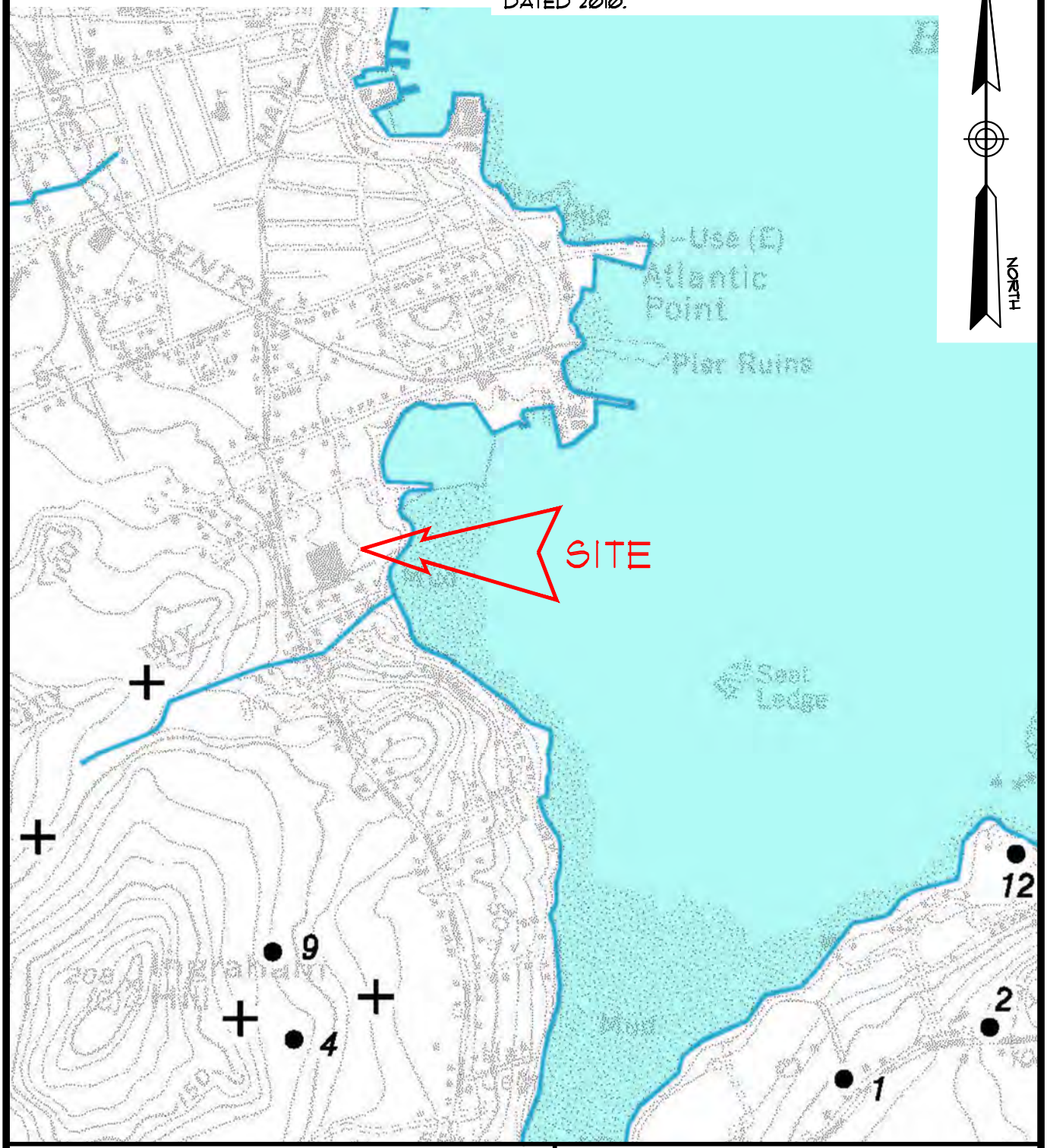
LEGEND

+ BEDROCK OUTCROP

19● BEDROCK WELL WITH DEPTH TO BEDROCK

MAP REFERENCE

MAINE GEOLOGICAL SURVEY, SURFICIAL MATERIALS, ROCKLAND QUADRANGLE, DATED 2010.



SURFICIAL MATERIALS
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

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JOB: 16274	SCALE: 1"= 1000'	FILE: 16274 MAPS

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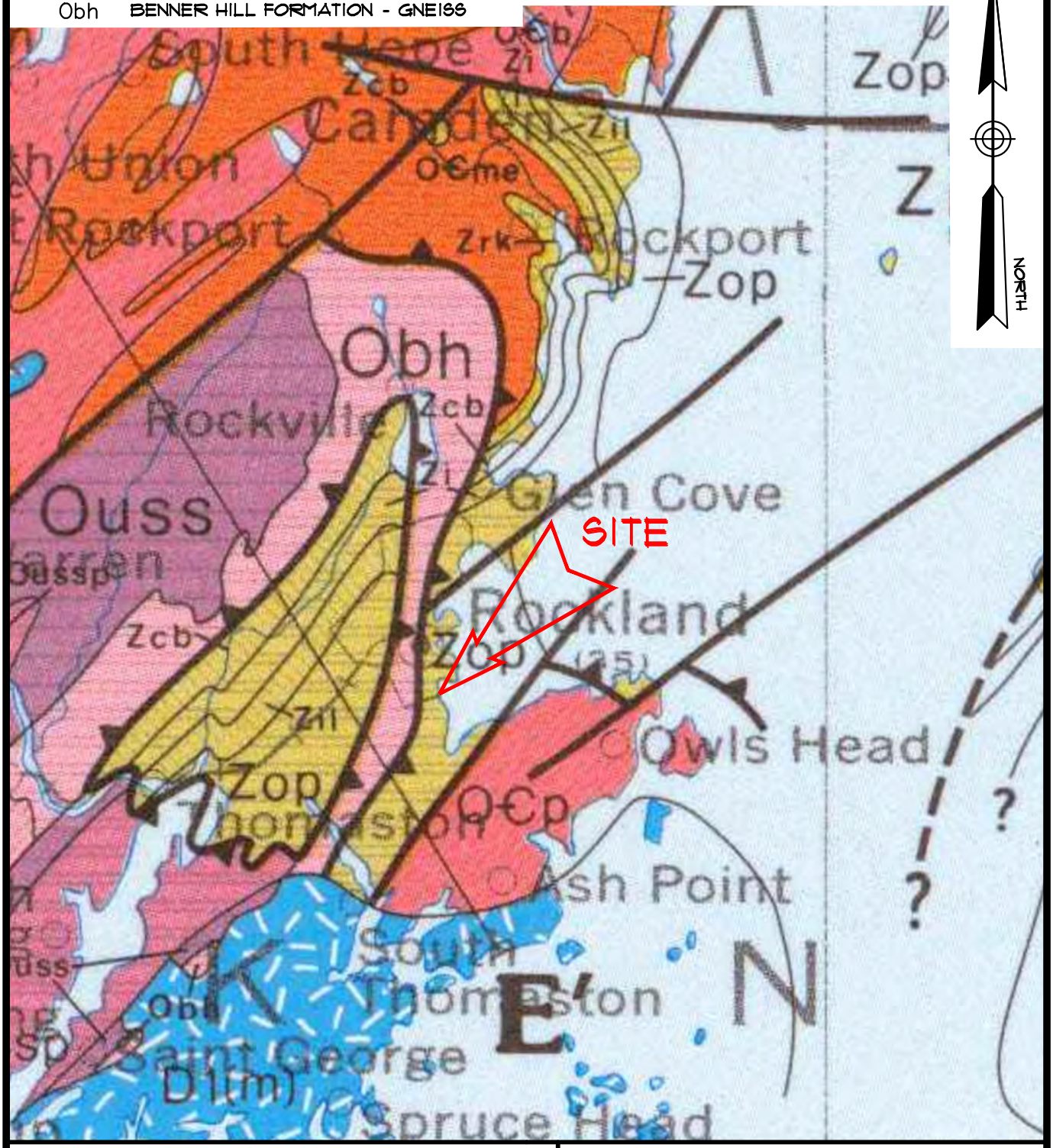
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LEGEND

Zop	OGIER FORMATION - MUDSTONE
OCp	PENOBSCOT FORMATION - SLATE
Obh	BENNER HILL FORMATION - GNEISS

MAP REFERENCE

BEDROCK GEOLOGY MAP OF MAINE, DATED 1985, PREPARED BY MAINE GEOLOGICAL SURVEY.



BEDROCK GEOLOGY
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

DATE: 1-26-2017	DRAWN BY: KRF	CHECKED BY: CC
JOB: 16274	SCALE: 1"=2 MILES	FILE: 16274 MAPS

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APPENDIX B

TEST BORING LOGS

EXPLORATION COVER SHEET

The exploration logs are prepared by the geotechnical engineer from both field and laboratory data. Soil descriptions are based upon the Unified Soil Classification System (USCS) per ASTM D2487 and/or ASTM D2488 as applicable. Supplemental descriptive terms for estimated particle percentage, color, density, moisture condition, and bedrock may also be included to further describe conditions.

Drilling and Sampling Symbols:

SS = Split Spoon Sample
UT = Thin Wall Shelby Tube
SSA = Solid Stem Auger
HSA = Hollow Stem Auger
RW = Rotary Wash
SV = Shear Vane
PP = Pocket Penetrometer
RC = Rock Core Sample
FV = Field Vane Shear Test
PS = Concrete Punch Sample
Hyd = Hydraulic Advancement of Drilling Rods
Push = Direct Push of Drilling Rods
WOH = Weight of Hammer
WOR = Weight of Rod
PI = Plasticity Index
LL = Liquid Limit
W = Natural Water Content
USCS = Unified Soil Classification System
Su = Undrained Shear Strength
Su(r) = Remolded Shear Strength

Water Level Measurements:

Water levels indicated on the boring logs are the levels measured in the boring at the times indicated. In pervious soils, the indicated elevations are considered reliable groundwater levels. In impervious soils, the accurate determination of groundwater elevations may not be possible, even after several days of observations. Groundwater monitoring wells may be required to record accurate depths and fluctuation.

Gradation Description and Terminology:

Boulders:	Over 12 inches	Trace:	Less than 5%
Cobbles:	12 inches to 3 inches	Little:	5% to 15%
Gravel:	3 inches to No.4 sieve	Some:	15% to 30%
Sand:	No.4 to No. 200 sieve	Silty, Sandy, etc.:	Greater than 30%
Silt:	No. 200 sieve to 0.005 mm		
Clay:	less than 0.005 mm		

Density of Granular Soils and Consistency of Cohesive Soils:

CONSISTENCY OF COHESIVE SOILS		DENSITY OF GRANULAR SOILS	
SPT N-value blows/ft	**Consistency**	**SPT N-value blows/ft**	**Relative Density**
0 to 2	Very Soft	0 to 4	Very Loose
2 to 4	Soft	5 to 10	Loose
5 to 8	Firm	11 to 30	Compact
9 to 15	Stiff	31 to 50	Dense
16 to 30	Very Stiff	>50	Very Dense
>30	Hard		

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-1**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	44 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/20/2017	Date Completed: 1/20/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	2-¼" HSA	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/20/2017	3.2 ft	40.8 ft	Measured in open borehole (perched)
1/20/2017	19 ft +/-	25 ft +/-	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
						4.5" Bituminous Pavement		PAVEMENT
1	S-1	24/24	0.5 - 2.5	11		Brown Gravelly SAND, little Silt, compact, frozen,		0.4'
				8		SP-SM		FILL
2				6		Brown medium-fine SAND, little Silt & Gravel,	Gravel = 8%	1.5'+/-
				7		compact, damp to wet w/ depth, SP-SM	Sand = 81%	
3	S-2	24/8	2.5 - 4.5	8			Fines = 11%	
				15			MC = 15.9%	
4				18		Gray to olive brown gravelly SAND, some to little	(Perched Water	3'+/-
				14		Silt, occasional cobbles, compact to dense, wet,	at 3.2 ft)	
5						SM		
	S-3	24/18	5 - 7	4	39	Olive brown to gray and mottled Silty CLAY,	PP = 5,000 to	5'+/-
6				5		stiff, moist, CL	7,000 psf	GLACIAL MARINE
				7			MC = 22.1%	DEPOSIT
7				13				(Presumpscot
								Formation)
8								
9								
10								
	S-4	24/24	10 - 12	3		Olive brown to gray Silty CLAY, stiff, moist, CL	PP = 2,000 to	
11				5			4,000 psf	
				5			MC = 23.7%	
12				9				
13								
14								
15								
	S-5	24/24	15 - 17	1		Gray Silty CLAY, firm, moist, CL	PP = 1,000 to	
16				3			2,000 psf	
				2			MC = 22.3%	
17				3				
18								
19								
					25			19'+/-
20								
	S-6	24/18	20 - 22	7		Gray medium-coarse SAND, little to trace Silt,		
21				8		compact, wet, SP-SM		
				12				
22				25				

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-1**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	2 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	44 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/20/2017	Date Completed: 1/20/2017

DRILLING METHOD		SAMPLER	
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Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/20/2017	3.2 ft	40.8 ft	Measured in open borehole
1/20/2017	19 ft +/-	25 ft +/-	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
23								GLACIAL MARINE DEPOSIT (Presumpscot Formation)
24								
25								
	S-7	24/12	25 - 27	9		Gray Gravelly SILT, some Sand, little Clay,		
26				11		occasional cobbles, dense, wet, ML		
				19				
27				21				
					17	End of Exploration at 27', No Refusal		27'
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Boring #: **B-2**

Project:	Mid-Coast School of Technology	Project #:	16274
Location:	1 Main Street	Sheet:	1 of 1
City, State:	Rockland, Maine	Chkd by:	CWC
Drilling Co:	East Coast Explorations	Boring Elevation:	35 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/20/2017	Date Completed: 1/20/2017

DRILLING METHOD		SAMPLER		ESTIMATED GROUND WATER DEPTH			
Vehicle:	ATV	Length:	24" SS	Date	Depth	Elevation	Reference
Model:	CME-550	Diameter:	2"OD/1.5"ID	1/20/2017	14 ft	21 ft	Measured in open borehole
Method:	2-¼" HSA	Hammer:	140 lb				
Hammer Style:	Auto Drop	Method:	ASTM D1586				

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
						2" Bituminous Pavement		PAVEMENT
1	S-1	24/12	0.3 - 2.3	27		Brown SAND, some Gravel, little Silt, compact to		0.1'
				22		dense, frozen to damp, SP-SM		FILL
2				17				
				12				
3								
					32			3'+/-
4								GLACIAL MARINE
								DEPOSIT
5								(Presumpscot
	S-2	24/24	5 - 7	3		Olive brown and slightly mottled Silty CLAY, stiff	PP = 4,000 to	Formation)
6				5		damp, CL	6,000 psf	
				10			MC = 23.2%	
7				14				
8								
9								
10								
	S-3	24/24	10 - 12	3		Olive brown and slightly mottled Silty CLAY, stiff,	PP = 5,000 psf	
11				6		damp to moist, CL	LL = 33	
				8			PI = 12	
12				9			MC = 21.9%	
13								
14							Water at 14'	
					21			14'+/-
15								
	S-4	24/24	15 - 17	1		Gray Silty CLAY, little Sand and Gravel, soft,	PP = 500 to	
16				1		wet, CL	1,000 psf	
				1			MC = 28.1%	
17				2				
18								
19								
					16	Dense drilling through weathered rock		19'+/-
20								WEATHERED ROCK
21					14.5	End of Exploration at 20.5', Auger refusal on Bedrock		20.5'
								BEDROCK
22								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Boring #: **B-3**

Project:	Mid-Coast School of Technology	Project #:	16274
Location:	1 Main Street	Sheet:	1 of 1
City, State:	Rockland, Maine	Chkd by:	CWC
Drilling Co:	East Coast Explorations	Boring Elevation:	31.5 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/20/2017	Date Completed: 1/20/2017

DRILLING METHOD		SAMPLER		ESTIMATED GROUND WATER DEPTH			
Vehicle:	ATV	Length:	24" SS	Date	Depth	Elevation	Reference
Model:	CME-550	Diameter:	2"OD/1.5"ID	1/20/2017	15 ft	16.5 ft	Observed moisture content
Method:	2-¼" HSA	Hammer:	140 lb				
Hammer Style:	Auto Drop	Method:	ASTM D1586				

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/18	0 - 2	19		Brown Gravelly SAND, some to little Silt, occasional		
1				38		cobbles, compact to dense, frozen to damp, SM to		FILL
				21		SP-SM		
2				15				
3								
4								
5								
	S-2	24/4	5 - 7	5		Same as above, compact, damp, SM to SP-SM		
6				8		Pushed cobble, low sample recovery.		
				11	25.5	Olive brown Silty CLAY, very stiff, damp, CL	PP = 4,000 to	6'+/-
7				12			6,000 psf	GLACIAL MARINE
								DEPOSIT
8								(Presumpscot
								Formation)
9								
10								
	S-3	24/24	10 - 12	8		Olive brown and mottled Silty CLAY, stiff, damp	PP = 4,000 to	
11				12		to moist, CL	2,000 psf	
				12		(Blow counts high due to pushing cobble)	w/ depth	
12				11			MC = 23.9%	
	S-4	24/24	12 - 14	8		Same as above, occasional Sand lenses, stiff, moist,		
13				7		CL	PP = 2,000 to	
				7			3,000 psf	
14				6			MC = 26.8%	
15								
	S-5	24/18	15 - 17	4	16.5	Olive brown to gray Sandy SILT, some Gravel, little	MC = 16.4%	15'+/-
16				4		Clay, firm to stiff, wet, ML		
				4				
17				8				
18								
19								
20								
	S-6	24/18	20 - 22	2		Gray Silty SAND, some to little Gravel, little Clay,	MC = 15.5%	
21				3		firm, wet, SM-ML		
				4				
22				6				
					8.5	End of Exploration at 23', Auger Refusal on Bedrock		23' BEDROCK

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-4**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	25 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/25/2017	Date Completed: 1/25/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/25/2017	12 ft	13 ft	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/18	0 - 2	4		Dark brown Clayey SILT, rootlets, firm, frozen to		TOPSOIL
1				3		damp, ML		
				5	24.3	Olive brown and mottled Silty CLAY, trace Sand,	PP = 3,000 to	0.7'
2				6		stiff, moist, CL	4,000 psf	GLACIAL MARINE
						Olive brown SAND, some to little Silt and Gravel,		1.5' DEPOSIT
3						loose to compact, moist, SM		(Presumpscot
								3'+/- Formation)
4								
	S-2	24/24	4 - 6	4		Olive brown and slightly mottled Silty CLAY, stiff,	PP = 6,000 to	
5				4		moist, CL	7,000 psf	
				6			MC = 23.6%	
6				8				
7								
					18	Cobble at 7'		7'+/-
8								
9								
	S-3	24/12	9 - 11	7		Olive brown SILT-CLAY, some Gravel and Sand,	PP = 8,000 psf	
10				12		very stiff, wet, ML-CL	MC = 12.9%	
				12				
11				11				
12								
						Softer drilling (wet) at 12'+/-		
13								
14								
	S-4	24/12	14 - 16	3		Gray Sandy SILT, some Gravel, little Clay, firm to	PP = 5,000 psf	
15				4		stiff, wet, ML	MC = 10.6%	
				27		(Blow counts high, pushed cobble)		
16				15				
17								
18								
19								
	S-5	24/12	19 - 21	5		Gray SILT-CLAY, some Sand and Gravel, stiff,	PP = 1,500 to	
20				7		wet, ML-CL	3,000 psf	
				7			MC = 12.5%	
21				12				
22								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-4**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	2 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	25 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/25/2017	Date Completed: 1/25/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/25/2017	12 ft	13 ft	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
23						Roller cone advancement to 24'		GLACIAL MARINE DEPOSIT
24								
	S-6	0/0	24	50/0"	1	Attempted spoon at 24', refusal on bedrock		24'
25						Roller cone advancement 6 inches into bedrock.		BEDROCK
					0.5	End of Exploration at 24.5', Bedrock Refusal		24.5'
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-5**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	35 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/23/2017	Date Completed: 1/23/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH			
Date	Depth	Elevation	Reference
1/23/2017	14 ft	21 ft	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/20	0 - 2	14		2" Bituminous Pavement		PAVEMENT
1				21		Brown SAND, some Gravel, little Silt, compact,		0.1'
				10		frozen, SP-SM		FILL
2				5		Olive brown SILT, some Sand and Gravel, little Clay,		1.1'
						stiff, frozen to damp, ML		
3								
					32			3'+/-
4								GLACIAL MARINE
	S-2	24/24	4 - 6	5		Olive brown and mottled Silty CLAY, stiff to very	PP = 6,000 to	DEPOSIT
5				6		stiff, moist, CL	8,000 psf	(Presumpscot
				9			MC = 23.0%	Formation)
6				12				
7								
8								
9								
	S-3	24/24	9 - 11	6		Olive brown and mottled Silty CLAY, stiff to very	PP = 6,000 to	
10				9		stiff, moist, CL	8,000 psf	
				12			MC = 20.5%	
11				14				
12								
13								
14								
	S-4	24/24	14 - 16	3		Olive brown Silty CLAY, firm, wet, CL	PP = 2,000 to	
15				3			3,000 psf	
				4			MC = 27.9%	
16				4				
	S-5	24/24	16 - 18	3		Same as above, firm, wet, CL		
17				4			PP = 1,000 to	
				3	17	Gray Silty CLAY, soft to firm, wet, CL	500 psf	17'
18				4			MC = 27.5%	
19						Same as above, stiff, wet, CL	PP = 500 psf	
	S-6	7/7	19 - 19.6	4		(Spoon refusal on bedrock, rock fragments in tip)	MC = 28.0%	
20				50/1"	15.4	Roller cone advancement into rock 2 inches		19.6'
	ROCK CORE DATA							BEDROCK
21	RUN	RECOVERY	DEPTH	RQD		Moderately hard, slighlty to moderately weathered,		
	C-1	97%	19.8' - 24.8'	90%		slightly fractured to sound, fine-grained, gray SCHIST		
22						(mudstone). Mohs hardness = 4.		
						See next page		

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-5**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	2 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	35 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/23/2017	Date Completed: 1/23/2017

DRILLING METHOD		SAMPLER		ESTIMATED GROUND WATER DEPTH			
Vehicle:	ATV	Length:	24" SS	Date	Depth	Elevation	Reference
Model:	CME-550	Diameter:	2"OD/1.5"ID	1/23/2017	12 ft	13 ft	Observed moisture content
Method:	3" Casing w/ wash	Hammer:	140 lb				
Hammer Style:	Auto Drop	Method:	ASTM D1586				

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	ROCK CORE DATA							
23	RUN	RECOVERY	DEPTH	RQD		Joints are close, horizontal to moderately dipping (0° to 55°), planar, undulated, and tight.		BEDROCK
	C-1	97%	19.8' - 24.8'	90%				
24								
25								
					10.2	End of Exploration at 24.8'		24.8'
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-6**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 1
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	31 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/25/2017	Date Completed: 1/25/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/25/2017	14 ft	17 ft	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/20	0 - 2	18		Brown SAND, some Gravel, little Silt, compact to	Gravel = 22%	
1				19		dense, frozen to wet, SP-SM	Sand = 67%	FILL
				9			Fines = 11%	
2				9			MC = 14.8%	
3								
					28			3'+/-
4								GLACIAL MARINE
	S-2	24/24	4 - 6	4		Olive brown and mottled Silty CLAY, stiff, damp	PP = 4,000 to	DEPOSIT
5				5		to moist, CL	6,000 psf	(Presumpscot
				7			MC = 24.6%	Formation)
6				10				
7								
8								
9								
	S-3	24/24	9 - 11	7		Olive brown and mottled Silty CLAY, very stiff,	PP = 4,000 to	
10				9		moist, CL	6,000 psf	
				11			MC = 18.2%	
11				13				
12								
13								
14								
	S-4	20/12	14 - 15.7	4		Same as above, firm to stiff, wet, CL		
15				7		Gray SILT-CLAY, little Sand and Gravel, wet, ML-CL	MC = 21.5%	14.5'
				33	16	Spoon refusal on bedrock at 15.7'		15' WEATHERED ROCK
16				50/2"	15.3	Roller cone 6 inches into rock, 15.7' to 16.2'		15.7'
								BEDROCK
17	ROCK CORE DATA							
	RUN	RECOVERY	DEPTH	RQD		Moderately hard, slighlty to moderately weathered,		
18	C-1	97%	16.2' - 21.2'	90%		slightly fractured to sound, fine-grained, gray SCHIST		
						(mudstone). Rock from 16.7 ft to 18.7 ft is pitted.		
19						Mohs hardness = 4.		
20						Joints are close, shallow to moderately dipping		
						(5° to 55°), planar, undulated, and tight.		
21								
22					9.8	End of Exploration at 21.2'		21.2'

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-7**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 1
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	34 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/20/2017	Date Completed: 1/23/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	2-¼" HSA	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/20/2017	12 ft	22 ft	Observed moisture content
1/23/2017	4.5 ft	29.5 ft	Measured in open borehole (perched)

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/24	0 - 2	17		Brown SAND, some Gravel, little Silt, compact,		
1				18		frozen to damp, SP-SM		FILL
				12				
2				10				
						Cobble at 2'+/-		
3								
					31			3'+/-
4							Water at 4.5'	GLACIAL MARINE DEPOSIT
								(Presumpscot
5								
	S-2	24/24	5 - 7	1		Olive brown and mottled Silty CLAY, stiff, damp	PP = 6,000 to	Formation)
6				5		to moist, CL	7,000 psf	
				7			MC = 22.4%	
7				11				
8								
9								
10								
	S-3	24/24	10 - 12	3		Olive brown and mottled Silty CLAY, stiff, damp	PP = 6,000 psf	
11				6		to moist, CL	MC = 21.0%	
				8				
12				9				
	S-4	21/21	12 - 13.8	10		Same as above, stiff, moist, CL		
13				11	21	Olive brown Gravelly SILT-CLAY, some Sand, very	MC = 18.4%	13'+/-
				13		stiff, wet, ML-CL		
14				50/3"	20.2	Spoon refusal on weathered rock at 13.8'		13.8'
						Auger advancement to 15' through weathered rock		WEATHERED ROCK
15								
	S-5	3/3	15 - 15.3	50/3"		Attempted spoon at 15', refusal on bedrock		
16	ROCK CORE DATA				18.7	(Switched to 3" casing w/ wash and performed		15.3'
	RUN	RECOVERY	DEPTH	RQD		rock core on 1/23/17.)		BEDROCK
17	C-1	100%	15.3' - 20.3'	53%				
						Moderately hard, moderately weathered, moderately		
18						fractured to slightly fractured, fine-grained, gray		
						SCHIST (mudstone). Fractured rock becoming		
19						more sound at 18'. Mohs Hardness = 4.		
20						Joints are very close, horizontal to moderately dipping		
						(0° to 55°), planar, undulated, and loose to open.		
21					13.7	End of Exploration at 20.3'		20.3'
22								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-8**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 1
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	27 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/25/2017	Date Completed: 1/25/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/25/2017	14 ft	21 ft	Measured in open borehole

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/24	0 - 2	10		Brown SAND, some Gravel, little Silt, compact to		FILL
1				7		dense, frozen to damp, SP-SM		
				4	26	Dark brown SILT, some Clay & rootlets, firm, ML		1' FORMER TOPSOIL
2				7	25.5	Olive brown and mottled Silty CLAY, stiff, damp		1.5'
						to moist, CL		GLACIAL MARINE
3								DEPOSIT
								(Presumpscot
4								Formation)
	S-2	24/24	4 - 6	5		Olive brown and mottled Silty CLAY, stiff, damp	PP = 5,000 to	
5				7		to moist, CL	8,000 psf	
				10			MC = 23.3%	
6				14				
7								
8								
					19	Cobble at 8'		8'+/-
9								
	S-3	24/12	9 - 11	9		Olive brown Silty CLAY, some Sand and Gravel,	PP = 8,000 psf	
10				8		very stiff, moist, CL	MC = 12.2%	
				8				
11				11				
12								
13								
					14	Softer drilling at 13' (wet)		13'+/-
14								
15								
	S-4	24/18	15 - 17	4		Gray Sandy SILT, some to little Gravel, little Clay,	PP = 2,000 to	
16				4		compact to stiff, wet, ML	4,000 psf	
				6			MC = 13.1%	
17				9				
18								
19								
	S-5	8/8	19 - 19.7	5		Same as above, stiff, wet, ML-CL	MC = 12.6%	
20				50/2"	7.3	Spoon refusal on bedrock at 19.7', roller cone to 20'		19.7' BEDROCK
					7	End of Exploration at 20', Refusal on Bedrock		20'
21								
22								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-9**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	1 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	25 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/23/2017	Date Completed: 1/23/2017

DRILLING METHOD		SAMPLER	
Vehicle:	ATV	Length:	24" SS
Model:	CME-550	Diameter:	2"OD/1.5"ID
Method:	3" Casing w/ wash	Hammer:	140 lb
Hammer Style:	Auto Drop	Method:	ASTM D1586

ESTIMATED GROUND WATER DEPTH

Date	Depth	Elevation	Reference
1/23/2017	14 ft	11 ft	Observed moisture content

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	SAMPLE DESCRIPTION	Geological/ Test Data	Geological Stratum
	S-1	24/10	0 - 2	5		Dark brown SILT, rootlets, firm, moist, ML		TOPSOIL
1				5	24.7	Brown SAND, little Gravel and Silt, loose, frozen		0.3'
				4		to damp, SP-SM	PP = 3,000 to	FILL
2				2	23.5	Olive brown and mottled Silty CLAY, firm, damp to		1.5'
						moist, CL		GLACIAL MARINE
3								DEPOSIT
								(Presumpscot
4								Formation)
	S-2	24/24	4 - 6	5		Olive brown and mottled Silty CLAY, stiff, damp	PP = 6,000 to	
5				6		to moist, CL	8,000 psf	
				8			MC = 24.0%	
6				8				
7								
8								
9								
	S-3	24/24	9 - 11	1		Olive brown Silty CLAY, firm, moist, CL	PP = 2,000 to	
10				3			3,000 psf	
				3			MC = 29.7%	
11				7				
						Gravel / cobble at spoon tip		
12								
13								
14								
	S-4	24/24	14 - 16	2		Same as above, firm, wet, CL		
15				3		Gray Silty CLAY, fine Sand seams and lenses, firm,	PP = 1,000 to	14.5'
				4		wet, CL	2,000 psf	
16				5			MC = 18.7%	
	S-5	24/24	16 - 18	7		Gray SILT-CLAY, some fine Sand and seams, stiff,		
17				8		wet, ML-CL	MC = 19.1%	
				7				
18				8				
					7			18'+/-
19								
	S-6	24/24	19 - 21	4		Gray Silty SAND, some Gravel, little Clay, compact to	LL = 19	
20				5		stiff, wet, SM-ML	PI = 3	
				6			MC = 11.1%	
21				8				
22								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

SUMMIT GEOENGINEERING SERVICES

SOIL BORING LOG

Project:	Mid-Coast School of Technology	Boring #:	**B-9**
Location:	1 Main Street	Project #:	16274
City, State:	Rockland, Maine	Sheet:	2 of 2
		Chkd by:	CWC

Drilling Co:	East Coast Explorations	Boring Elevation:	25 feet
Driller:	Chris Palmer	Reference:	Existing Conditions & Topographic Survey Plan SV-1 by Gartley & Dorsky
Summit Staff:	Erika Stewart, E.I.	Date started: 1/23/2017	Date Completed: 1/23/2017

DRILLING METHOD		SAMPLER		ESTIMATED GROUND WATER DEPTH			
Vehicle:	ATV	Length:	24" SS	Date	Depth	Elevation	Reference
Model:	CME-550	Diameter:	2"OD/1.5"ID	1/23/2017	14 ft	11 ft	Observed moisture content
Method:	3" Casing w/ wash	Hammer:	140 lb				
Hammer Style:	Auto Drop	Method:	ASTM D1586				

Depth (ft.)	No.	Pen/Rec (in)	Depth (ft)	blows/6"	Elev. (ft.)	**SAMPLE DESCRIPTION**	Geological/ Test Data	Geological Stratum
23								GLACIAL MARINE DEPOSIT
24	S-7	24/12	24 - 26	6		Gray Silty SAND, some Gravel, little Clay, compact to	MC = 11.4%	
25				7		stiff, wet, SM-ML		
				5				
26				6				
27								
28								
29	S-8	24/12	29 - 31	WOH		Gray SILT-CLAY, some Sand and Gravel,	MC = 15.4%	
30				WOH		very soft, wet, ML-CL		
				2				
31				2				
						Attempted shelby tube sample, tube refusal		
32						Attempted spoon sample at 32', refusal on bedrock		
					-7	End of Exploration at 32', Refusal on Bedrock		32' BEDROCK
33								
34								
35								
36								
37								
38								
39								
40								
41								
42								
43								
44								

Granular Soils		Cohesive Soils		% Composition
Blows/ft.	Density	Blows/ft.	Consistency	ASTM D2487
0-4	V. Loose	<2	V. soft	
5-10	Loose	2-4	Soft	< 5% Trace
11-30	Compact	5-8	Firm	5-15% Little
31-50	Dense	9-15	Stiff	15-30% Some
>50	V. Dense	16-30	V. Stiff	> 30% With
		>30	Hard	

NOTES: PP = Pocket Penetrometer, MC = Moisture Content
LL = Liquid Limit, PI = Plastic Index, FV = Field Vane Test
$(S_u)_{fv}$ = Peak / Remolded Undrained Shear Strength

Boulders = diameter > 12 inches, Cobbles = diameter < 12 inches and > 3 inches
Gravel = < 3 inch and > No 4, Sand = < No 4 and >No 200, Silt/Clay = < No 200

Soil Moisture Condition
Dry: S = 0%
Humid: S = 1 to 25%
Damp: S = 26 to 50%
Moist: S = 51 to 75%
Wet: S = 76 to 99%
Saturated: S = 100%

APPENDIX C

LABORATORY TEST RESULTS

SUMMIT
GEOENGINEERING SERVICES

Laboratory Determination of Water (Moisture) Content of Soil ASTM D2216

PROJECT NAME:	New School	PROJECT #:	16274
PROJECT LOCATION:	1 Main Street, Rockland, Maine	DRYING METHOD:	Oven Dried
CLIENT:	Mid-Coast School of Technology	DESCRIPTION:	Glacial Marine
SOURCE:	Test Borings	TECHNICIAN:	Erika Stewart, E.I.
COLLECTION DATE:	1/20/17, 1/23/17, & 1/25/17	TESTING DATE:	01/26/17

Location	Sample No.	Depth	Moisture Content	Remarks
B-1	S-3	5' - 7'	22.1%	
B-1	S-4	10' - 12'	23.7%	
B-1	S-5	15' - 17'	22.3%	
B-2	S-2	5' - 7'	23.2%	
B-2	S-3	10' - 12'	21.9%	
B-2	S-4	15' - 17'	28.1%	
B-3	S-3	10' - 12'	23.9%	
B-3	S-4	12' - 14'	26.8%	
B-3	S-5	15' - 17'	16.4%	Contains Sand & Gravel
B-3	S-6	20' - 22'	15.5%	Contains Sand & Gravel
B-4	S-2	4' - 6'	23.6%	
B-4	S-3	9' - 11'	12.9%	Contains Sand & Gravel
B-4	S-4	14' - 16'	10.6%	Contains Sand & Gravel
B-4	S-5	19' - 21'	12.5%	Contains Sand & Gravel
B-5	S-2	4' - 6'	23.0%	
B-5	S-3	9' - 11'	20.5%	
B-5	S-4	14' - 16'	27.9%	
B-5	S-5	16' - 18'	27.5%	
B-5	S-6	19' - 19.6'	28.0%	

REMARKS:

145 Lisbon Street (PO Box 7216), Lewiston, Maine 04243, (207) 576-3313
173 Pleasant Street, Rockland, Maine 04841, (207) 318-7761

SUMMIT
GEOENGINEERING SERVICES

Laboratory Determination of Water (Moisture) Content of Soil ASTM D2216

PROJECT NAME:	New School	PROJECT #:	16274
PROJECT LOCATION:	1 Main Street, Rockland, Maine	DRYING METHOD:	Oven Dried
CLIENT:	Mid-Coast School of Technology	DESCRIPTION:	Glacial Marine
SOURCE:	Test Borings	TECHNICIAN:	Erika Stewart, E.I.
COLLECTION DATE:	1/20/17, 1/23/17, & 1/25/17	TESTING DATE:	01/26/17

Location	Sample No.	Depth	Moisture Content	Remarks
B-6	S-2	4' - 6'	24.6%	
B-6	S-3	9' - 11'	18.2%	
B-6	S-4	14' - 16'	21.5%	Trace Sand & Gravel
B-7	S-2	5' - 7'	22.4%	
B-7	S-3	10' - 12'	21.0%	
B-7	S-4	12' - 13.8'	18.4%	Contains Sand & Gravel
B-8	S-2	4' - 6'	23.3%	
B-8	S-3	9' - 11'	12.2%	Contains Sand & Gravel
B-8	S-4	15' - 17'	13.1%	Contains Sand & Gravel
B-8	S-5	19' - 19.7'	12.6%	Contains Sand & Gravel
B-9	S-2	4' - 6'	24.0%	
B-9	S-3	9' - 11'	29.7%	
B-9	S-4	14' - 16'	18.7%	Contains Sand
B-9	S-5	16' - 18'	19.1%	Contains Sand & Gravel
B-9	S-6	19' - 21'	11.1%	Contains Sand & Gravel
B-9	S-7	24' - 26'	11.4%	Contains Sand & Gravel
B-9	S-8	29' - 31'	15.4%	Contains Sand & Gravel

REMARKS: Page 2 of 2

SUMMIT
GEOENGINEERING SERVICES

GRAIN SIZE ANALYSIS - ASTM D6913

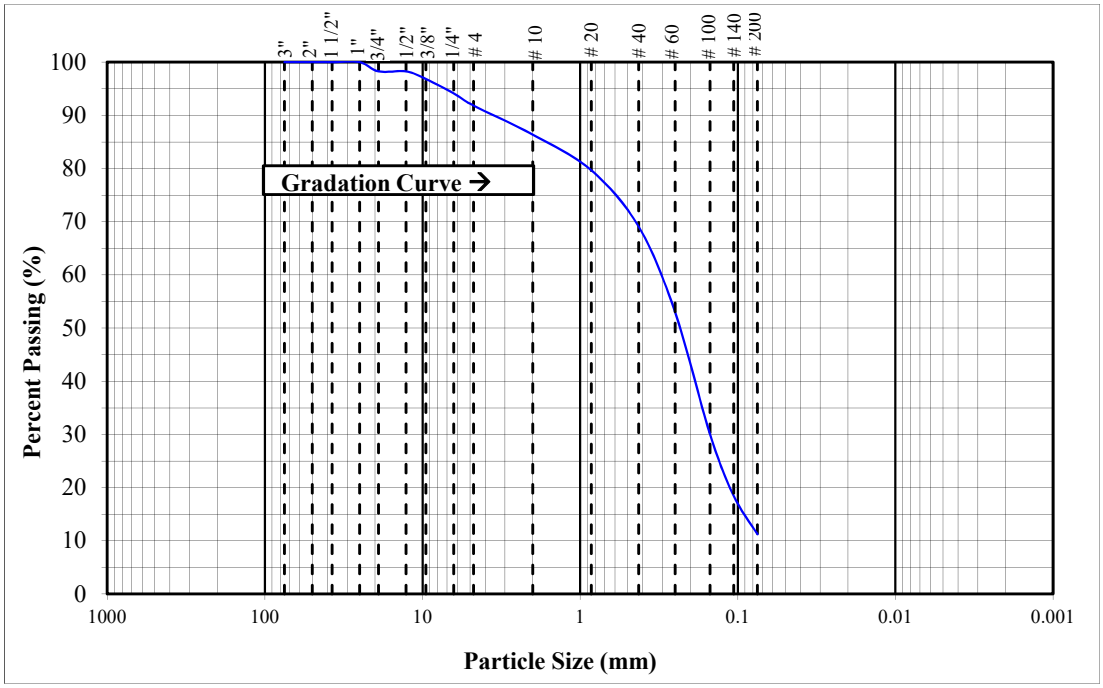
PROJECT NAME:	New School	PROJECT #:	16274
PROJECT LOCATION:	1 Main Street, Rockland, Maine	EXPLORATION #:	B-1
CLIENT:	Mid-Coast School of Technology	SAMPLE #:	S-1
TECHNICIAN:	Erika Stewart, E.I.	SAMPLE DEPTH:	0.5' - 2.5'
SOIL DESCRIPTION:	Med-fine SAND, little Silt & Gravel, SP-SM	TEST DATE:	1/30/2017

TEST PROCEDURE

Sample Source: Split Spoon	**Sieve Stack:** Composite	**Specimen Procedure:** Air Dry
Test Method: Method A	**Separating Sieve(s):** 3/8 Inch	**Dispersion Type:** Tap Water

DATA

STANDARD SIEVE DESIGNATION (mm)	ALTERNATIVE SIEVE DESIGNATION (in)	PERCENT PASSING (%)
75	(3 in)	100
50	(2 in)	100
37.5	(1-1/2 in)	100
25.0	(1 in)	100
19.0	(3/4 in)	98
12.7	(1/2 in)	98
9.5	(3/8 in)	97
6.35	(1/4 in)	94
4.75	(No. 4)	92
2.00	(No. 10)	86
0.850	(No. 20)	80
0.425	(No. 40)	69
0.250	(No. 60)	53
0.150	(No. 100)	30
0.106	(No. 140)	18
0.075	(No. 200)	11



REMARKS: Moisture Content = 15.9%.

SUMMIT
GEOENGINEERING SERVICES

GRAIN SIZE ANALYSIS - ASTM D6913

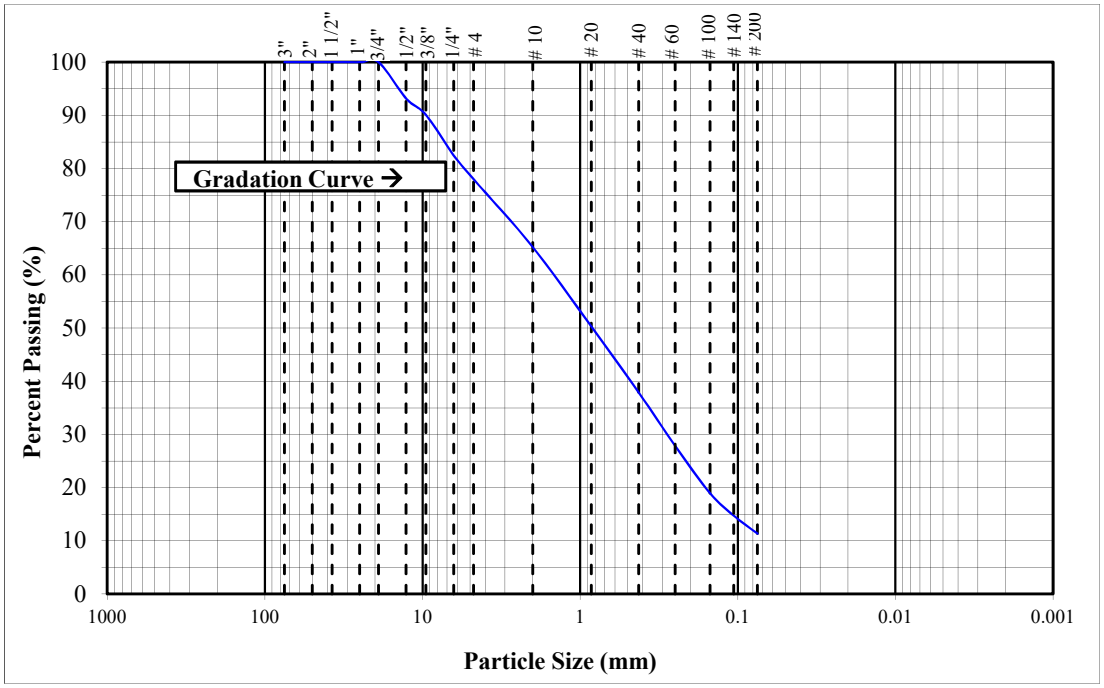
PROJECT NAME:	New School	PROJECT #:	16274
PROJECT LOCATION:	1 Main Street, Rockland, Maine	EXPLORATION #:	B-6
CLIENT:	Mid-Coast School of Technology	SAMPLE #:	S-1
TECHNICIAN:	Erika Stewart, E.I.	SAMPLE DEPTH:	0' - 2'
SOIL DESCRIPTION:	SAND, some Gravel, little Silt, SP-SM	TEST DATE:	1/30/2017

TEST PROCEDURE

Sample Source: Split Spoon	**Sieve Stack:** Composite	**Specimen Procedure:** Air Dry
Test Method: Method A	**Separating Sieve(s):** 3/8 Inch	**Dispersion Type:** Tap Water

DATA

STANDARD SIEVE DESIGNATION (mm)	ALTERNATIVE SIEVE DESIGNATION (in)	PERCENT PASSING (%)
75	(3 in)	100
50	(2 in)	100
37.5	(1-1/2 in)	100
25.0	(1 in)	100
19.0	(3/4 in)	100
12.7	(1/2 in)	93
9.5	(3/8 in)	90
6.35	(1/4 in)	83
4.75	(No. 4)	78
2.00	(No. 10)	65
0.850	(No. 20)	50
0.425	(No. 40)	38
0.250	(No. 60)	28
0.150	(No. 100)	19
0.106	(No. 140)	15
0.075	(No. 200)	11



REMARKS: Moisture Content = 14.8%.

SUMMIT
GEOENGINEERING SERVICES

GRAIN SIZE ANALYSIS - ASTM D6913

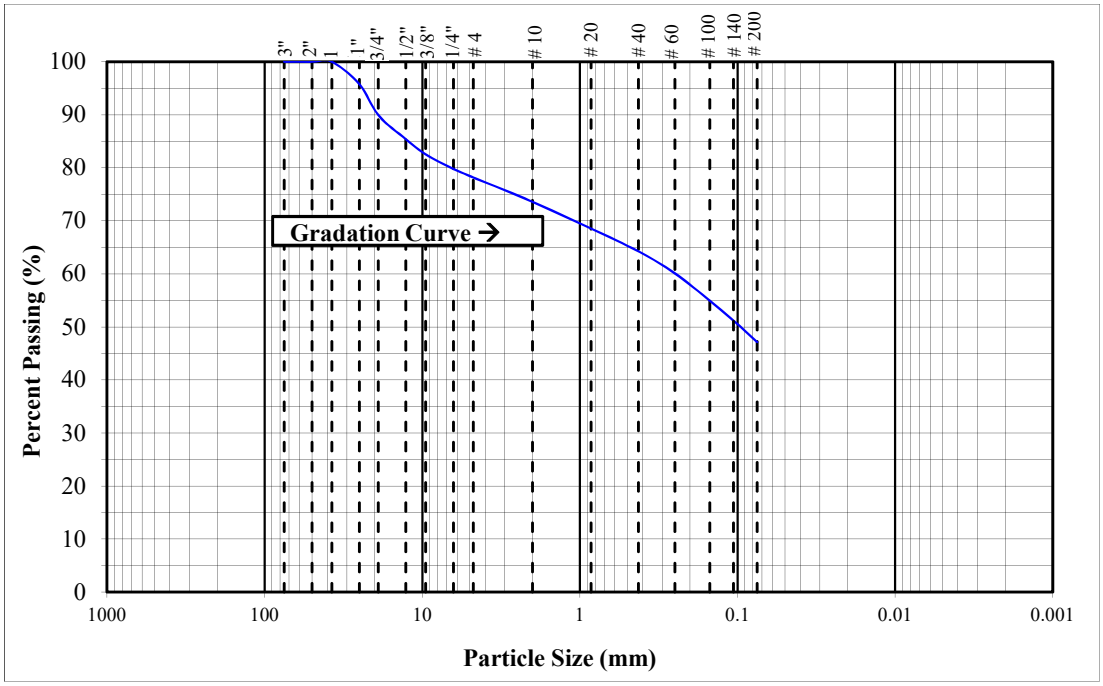
PROJECT NAME:	New School	PROJECT #:	16274
PROJECT LOCATION:	1 Main Street, Rockland, Maine	EXPLORATION #:	B-9
CLIENT:	Mid-Coast School of Technology	SAMPLE #:	S-6
TECHNICIAN:	Erika Stewart, E.I.	SAMPLE DEPTH:	19' - 21'
SOIL DESCRIPTION:	Silty SAND, some Gravel, little Clay, SM-ML	TEST DATE:	1/30/2017

TEST PROCEDURE

Sample Source: Split Spoon	**Sieve Stack:** Composite	**Specimen Procedure:** Air Dry
Test Method: Method A	**Separating Sieve(s):** 3/8 Inch	**Dispersion Type:** $(NaPO_3)_6$ Solution

DATA

STANDARD SIEVE DESIGNATION (mm)	ALTERNATIVE SIEVE DESIGNATION (in)	PERCENT PASSING (%)
75	(3 in)	100
50	(2 in)	100
37.5	(1-1/2 in)	100
25.0	(1 in)	96
19.0	(3/4 in)	90
12.7	(1/2 in)	85
9.5	(3/8 in)	83
6.35	(1/4 in)	80
4.75	(No. 4)	78
2.00	(No. 10)	74
0.850	(No. 20)	69
0.425	(No. 40)	64
0.250	(No. 60)	60
0.150	(No. 100)	55
0.106	(No. 140)	51
0.075	(No. 200)	47



REMARKS: Moisture Content = 10.5%.

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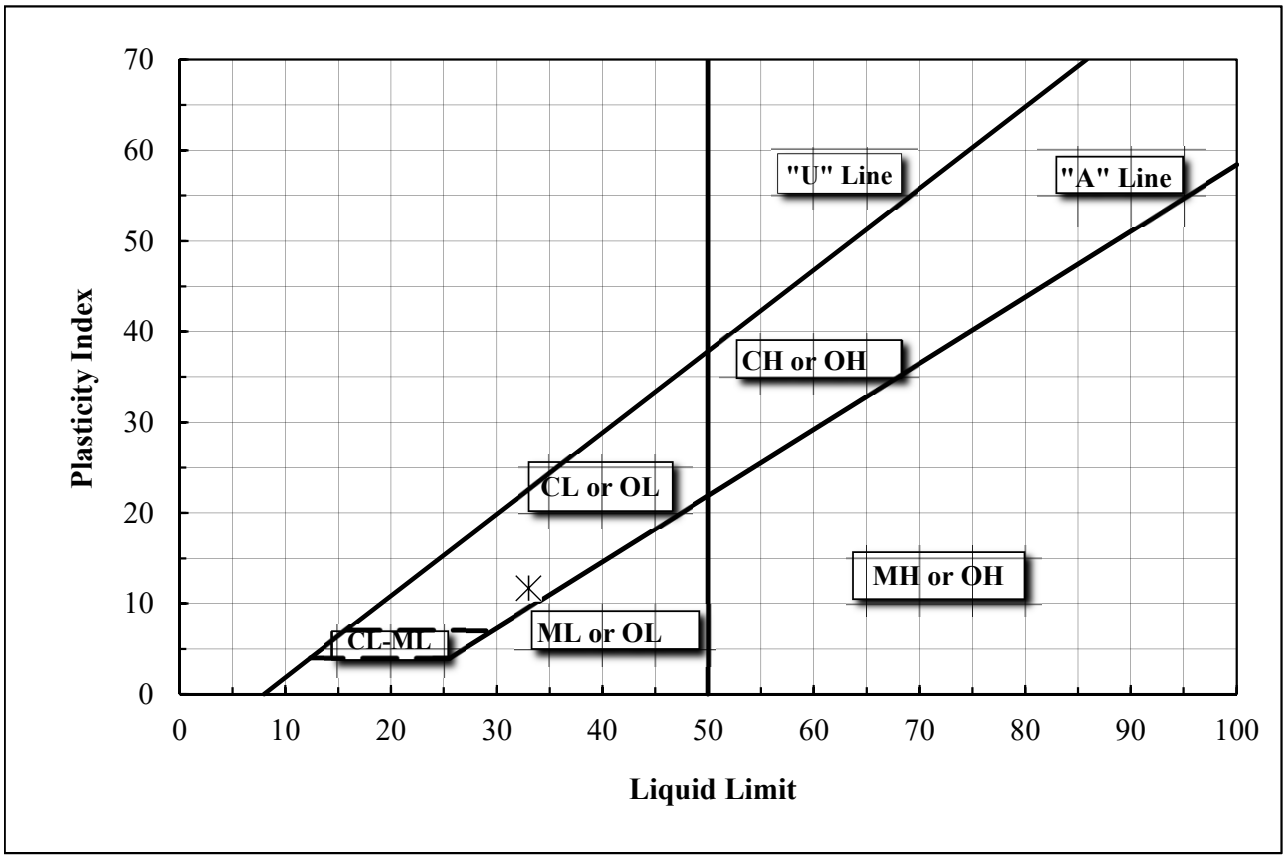
ATTERBERG LIMIT TEST - ASTM D4318

Method "A" (Multi-point)

PROJECT NAME:	New School	PROJECT NUMBER:	16274
CLIENT:	Mid-Coast School of Technology	SAMPLE NUMBER:	S-3
SOURCE:	Boring B-2	DEPTH:	10' - 12'
TEST DATE:	2/3/2017	TECHNICIAN:	Erika Stewart, E.I.

DATA

Source	Depth	LL	PL	PI	Classification
B-2	10' - 12'	33	21	12	Olive brown Silty CLAY, CL



Notes: Moisture Content = 21.9%

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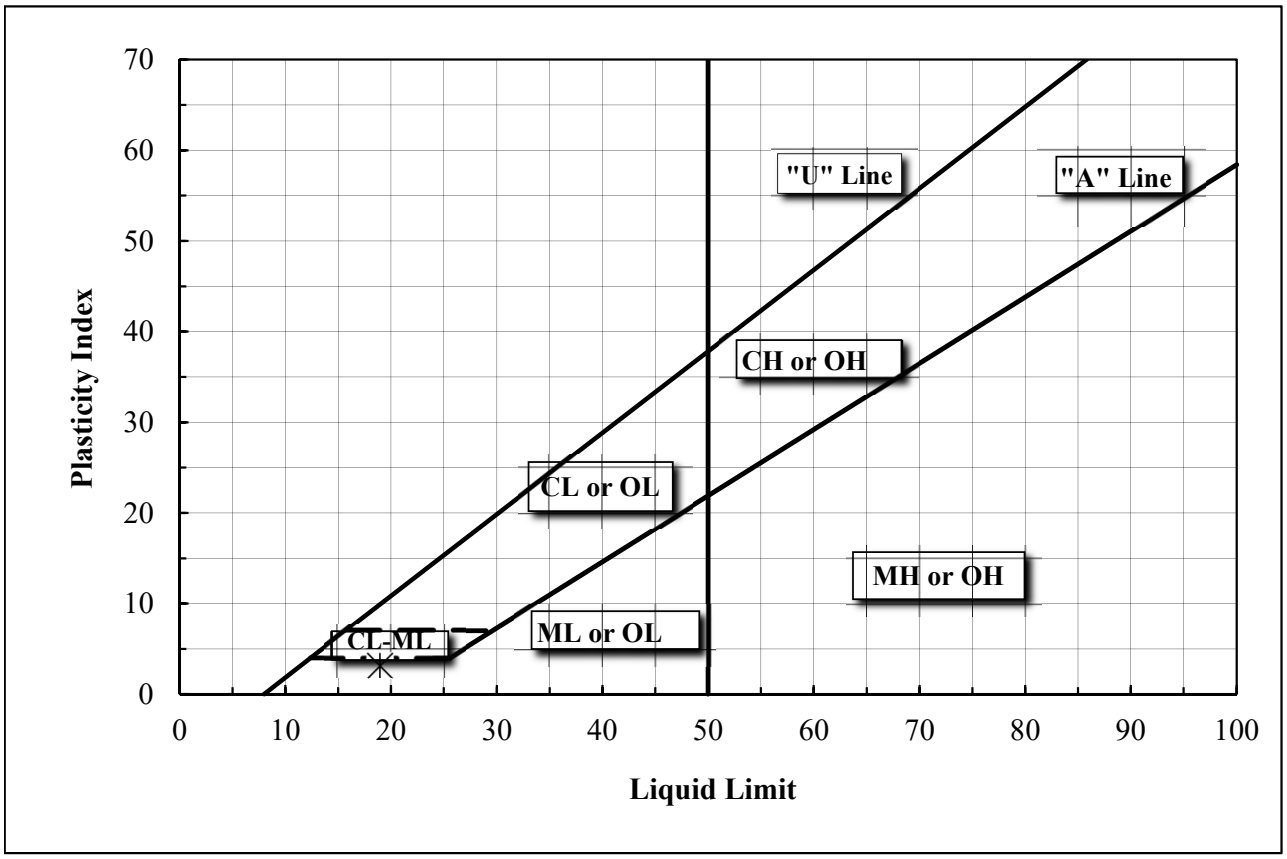
ATTERBERG LIMIT TEST - ASTM D4318

Method "A" (Multi-point)

PROJECT NAME:	New School	PROJECT NUMBER:	16274
CLIENT:	Mid-Coast School of Technology	SAMPLE NUMBER:	S-6
SOURCE:	Boring B-9	DEPTH:	19' - 21'
TEST DATE:	2/6/2017	TECHNICIAN:	Erika Stewart, E.I.

DATA

Source	Depth	LL	PL	PI	Classification
B-9	19' - 21'	19	16	3	Gray Silty SAND, some Gravel, little Clay SM-ML



Notes: Moisture Content = 11.1%

The key to success starts with a solid foundation.
ENGINEERING | EXPLORATION | EXPERIENCE

Geothermal Test Report



Mid-Coast School of Technology

1 Main Street Rockland, Maine

5/1/2017

SUMMIT GEOENGINEERING SERVICES

PIN 16274

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May 1, 2017
Summit #16274

Elizabeth Fisher, Director
Mid-Coast School of Technology
1 Main Street
Rockland, Maine 041841

Reference: Geotechnical Engineering Services – Geothermal Testing
Mid-Coast School of Technology – 1 Main Street Rockland, Maine

Dear Ms. Fisher;

We have completed our geothermal testing for the proposed Mid-Coast School of Technology (MCST) located at 1 Main Street in Rockland, Maine. Our scope of services included the drilling of 1 test well, performing field thermal conductivity testing, and preparing this report summarizing our findings and recommendations. The considerations identified for geothermal well construction and design at this site include:

- The presence of fractured bedrock layers to 100 feet below ground surface
- The presence of high groundwater yield (100 gal/min) from fractured bedrock layers
- The presence of elevated chloride content from water tested onsite at 300 ppm
- Results of the thermal conductivity and possible influence of high groundwater yield

Discussion and recommendations for the identified considerations are included in this report for the design and construction of a closed loop geothermal system for the new school building.

We appreciate the opportunity to serve you during this phase of your project. If there are any questions or additional information is required, please do not hesitate to call.

Sincerely yours,
Summit Geoengineering Services

Craig W. Coolidge, P.E.
Vice President
Principal Engineer



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Well Drillers Log.....Appendix B
Thermal Conductivity Test Results.....Appendix C

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1.0 Project and Site Description

Summit Geoengineering Services (SGS) was asked to conduct geothermal testing for the new Mid-Coast School of Technology building to replace the existing school located at 1 Main Street in Rockland, Maine. The new school is proposed as a 2-story steel framed structure with a footprint of approximately 90,000 square feet. We understand the new school will be constructed adjacent to the existing school, which will remain operational during construction and be demolished after the new school is occupied.

The geothermal system is proposed as a closed loop having wells drilled to an approximately depth of 400 feet below grade. The well field is planned within the existing parking lot near Main Street, located west of the existing school. Number of wells has not yet been determined.

2.0 Test Well Installation

Summit Geoengineering Services (SGS) observed the drilling of 1 test well performed by Goodwin Well and Water, Inc. under contract to SGS. Test well was drilled on April 17, 2017 to a depth of 420 feet using 6-inch diameter drill tooling. Casing was set to a depth of 32 feet. Due to fracture bedrock caving at a depth of 95 feet, re-drilling and fracture grouting was required to obtain sidewall stability.



Drilling of Test Well by Goodwin Well and Water Inc.

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Location of the test well is shown on the Well Location Plan in Appendix A. A drillers log prepared by Goodwin Well and Water, Inc. is provided in Appendix B. Dig Smart of Maine was subcontracted by SGS to verify exploration well location was free from underground utilities prior to drilling.

Upon completion of the well drilling, the polyethylene piping loop (1.25" in diameter) was installed to a depth of 400 linear feet below grade and backfilled with 48 bags (50 lbs each) of GeoPro TG Lite grout mixed with PowerTEC additive resulting in a thermal conductivity of 1.0 Btu/hr-ft-°F. Grouting of the test well was completed on April 19, 2017.



Loop Installation by Goodwin Well and Water, Inc.

3.0 Subsurface Conditions

The subsurface conditions consist of overburden soil (clay) overlying bedrock encountered at a depth of 26 feet below ground surface. Bedrock drilled between to depths of 26 to 106 feet below ground surface exhibited localized fractures. Recorded fractures with estimated groundwater yields during the test well installation are as follows:

Depth (Feet, Below Ground Surface)	Groundwater Yield (Gallons Per Minute)
46 ft bgs	1 gpm
53 ft bgs	10 gpm
56 ft bgs	1 gpm
85 ft bgs	60 gpm
95 ft bgs	30 gpm

Bedrock was considered more competent with less fracturing from a depth of 106 feet to 420 feet.

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Mapping by the Maine Geological Survey indicates bedrock at the site is part of the Ogier Formation consisting of mudstone (schist). Rock core samples obtained in shallow test borings during our geotechnical investigation (SGS Report #16274, dated February 2, 2017) consisted of fine-grained gray schist. The rock was estimated as having a hardness value of 4 using the Mohs hardness scale. Visual inspection of the rock cuttings and drilling resistance (rock hardness) was consistent during advancement of the test well to a depth of 420 feet suggesting formation consistency (Schist).

Static groundwater was present at a depth of 7 feet during installation of the test well. The estimated total groundwater yield from the test well is 100 gallons per minute or greater. The predominate water bearing layer was encountered from 86 to 106 feet below ground surface.

Chloride content was tested during installation of the test well as an indicator for possible salt water intrusion. The threshold suggested for portable water is 250 ppm or less. The threshold for using salt water resistant (neat) grout is 500 ppm and above for a closed loop system. These limits are published by the State of Maine Department of Health and Human Services. Test results during drilling of the test well are as follows:

- Water Sampled for Drilled Depth of 140 feet, Chloride Content = 300 ppm
- Water Sampled for Drilled Depth of 420 feet, Chloride Content = 300 ppm

Based on the test results, the groundwater sampled from the bedrock is slightly elevated above portable water, but below the threshold for requiring neat grout for closed loop installation. Due to close proximity of the site to Rockland Harbor supporting saltwater, we recommend the chloride content be monitored during installation of the wells for the possibility of elevated chloride content.

4.0 Thermal Conductivity Testing

Formation thermal conductivity testing was performed as outlined by ASHRAE 1118-TRP. Thermal testing equipment and technical report was provided by Geothermal Resource Technologies, Inc. Copy of the thermal conductivity report is provided in Appendix C.

Summit Geoengineering Services, Inc. (SGS) conducted the onsite testing for formation thermal conductivity testing on April 22 through April 24, 2017 for a duration of 48 hours. Electrical power for the testing was supplied using a portable diesel powered 50kW generator.

Results of the formation thermal conductivity testing are as follows:

- Formation Thermal Conductivity (From Testing) = 2.15 Btu/hr-ft-°F
- Formation Thermal Diffusivity = 1.37 ft^2/day
- Undisturbed Formation Temperature = 49.8° to 50.4° F

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Thermal Conductivity Testing by Summit Geoengineering Services, Inc.

Due to the presence of significant groundwater yield and its potential for locally increasing the formation thermal conductivity test results, a reduced value is recommended for overall system design. This is to account for potential groundwater yield variability between multiply wells and based on values typical to similar formations which are slightly lower than observed test results. Based on this, the suggested design values for the closed loop system are as follows:

- Formation Thermal Conductivity (Design Recommendation) = 1.80 Btu/hr-ft-°F
- Formation Thermal Diffusivity (Design Recommendation) = 1.15 ft^2/day

5.0 Installation Considerations

The following are considerations for installation of the geothermal well field for a closed loop system based on the findings and observation of the test well:

- Water management plan for high water yield during installation of wells
- Presence of fracture rock and its susceptibility to caving within open borehole
- Elevated chloride content, tested at 300 ppm, and need for neat grout if above 500 ppm

To provide borehole stability and to reduce the amount of groundwater yield within upper rock fractures, we recommend drill casing be installed to an approximately depth of 100 feet below ground surface, as deemed appropriate by the well drilling contractor. Use of drill casing will increase material cost but reduce amount of water needed to be handled onsite. Drill casing will improve drilling productivity by reducing caving potential of boreholes. Additionally, caving could damage loop systems upon completion of installation. The use of drill casing will also help reduce the amount of groundwater being circulated throughout the fracture zones during the well field installation helping to reduce the corresponding risk of saltwater intrusion.

6.0 Closure

Our recommendations are based on professional judgment and generally accepted principles of geotechnical engineering and project information provided by others. Some changes in subsurface conditions from those presented in this report may occur. Should these conditions differ materially from those described in this report, SGS should be notified so that we can re-evaluate our recommendations.

We appreciate the opportunity to serve you during this phase of your project. If there are any questions or additional information is required, please do not hesitate to call.

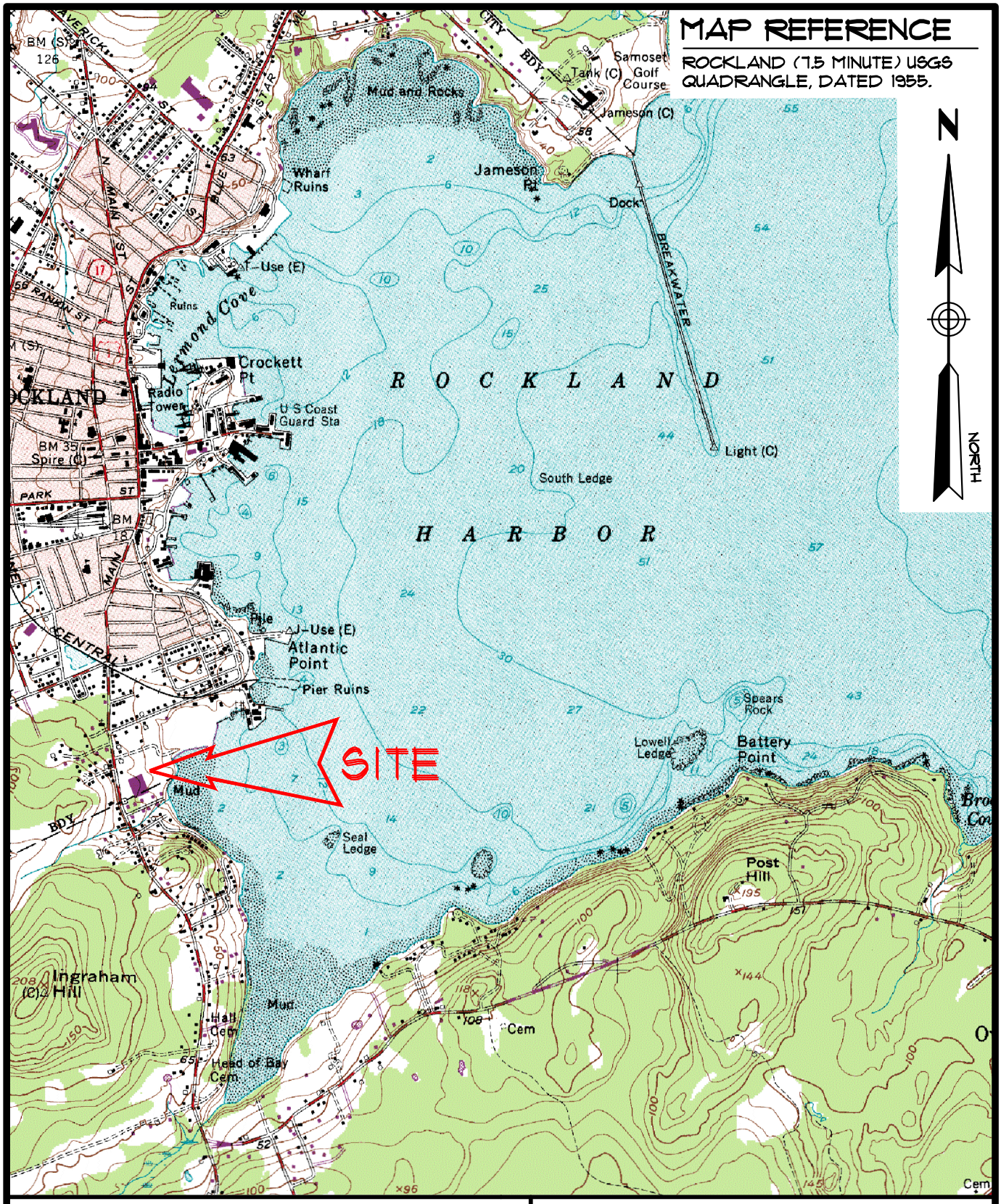
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APPENDIX A

SITE LOCATION MAP

TEST WELL LOCATION PLAN

GEOLOGICAL MAPPING



U.S.G.S. TOPOGRAPHIC MAP
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

DATE: 1-26-2017	DRAWN BY: KRF	CHECKED BY: CC
JOB: 16274	SCALE: 1" = 2000'	FILE: 16274 MAPS

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BLUE SHADED AREA
= GEOTHERMAL FIELD

GEOTHERMAL TEST WELL

LILIAS MacBEAN HART
BOOK 2335, PAGE 175
TAX MAP 9, LOT A-10-1

CITY OF ROCKLAND
SNOW MARINE PARK
BOOK 745, PAGE 322
TAX MAP 9, LOT A-11

REGION 8 COOPERATIVE BOARD FOR VOCATIONAL EDUCATION
BOOK 626, PAGE 275
TAX MAP 9, LOT A-11-1
6.70 ACRES

MID-COAST SCHOOL OF TECHNOLOGY

MICHAEL ROSS
BOOK 4292, PAGE 229
TAX MAP 16, LOT 33

WALTER B. WOTTON
PATRICIA A. WOTTC
TAX MAP 16, LOT

MAIN STREET a/k/a ROUTE 73

5/8" REBAR FLUSH WITH THE SURFACE OF THE GROUND.

5/8" REBAR FLUSH WITH THE SURFACE OF THE GROUND. "BEAL 01486/2286"

BASE OF BENT 3/4" IRON ROD 1.5' LONG FROM BEND. (HELD)

DRAINAGE DITCH

BRUSHY WOODLANDS

LAWN

GRAVEL

PAVEMENT

12' SET-BACK

250' SHORELINE ZONE LINE

HIGH WATER LINE

WATER LINE AS PAINT LOCATED BY MAINE WATER IN JANUARY OF 2017, AND SURVEY LOCATED JANUARY 10, 2017. SEE NOTE 8.

DETERIORATED PAVEMENT

CONCRETE RETAINING WALL LOADING RAMP

4" PVC PERFORATED

SALT & SAND SHED

FLAGPOLE

PATH

DRAINAGE SWALE

CONCRETE RETAINING WALL

CONCRETE PAD WITH TRANSFORMER

CONCRETE VAULT WITH MANHOLES & VENT PIPES

CONCRETE VAULT
STEEL DOOR ACCESS
SEWER PUMP STATION
UTILITY CABINET
DUMPSTERS

SPRINKLER CONNECTION
DRY HYDRANT

ABOVE GROUND PROPANE PIPES BUILDING TO VAULT.

METAL GRATED STEPS AND LANDING.

8" HIGH ASPHALT CURB NOTHING BEHIND IT.

COVERED ENTRY

PORTABLE CLASSROOMS BUILDING

OLD TRUCK BODY (STORAGE)

OLD BOX TRAILER CONTAINER (STORAGE)

CONCRETE ENTRANCE APRON

METAL VENT DUCTWORK

CONCRETE PADS

CRUSHED STONE (TYPICAL)

CONCRETE SLAB OR PAD (TYPICAL)

ASPHALT CURBING

WOODEN BRIDGE

HYDRANT VALVE WITH RAILROAD TRACK POSTS

10" DIA. WOODEN POST

CONCRETE VAULT WITH DRY HYDRANT

WOODEN TIE RETAINING WALL FOR PLANTER AT SCHOOL SIGN

4" WIDE YELLOW LINES (TYPICAL)

4"- 6" WIDE WHITE LINES (TYPICAL)

1" DECIDUOUS

10" DECIDUOUS

(2) 14" ASH

(4) 8" ELMS

OAK TREE
3/4" IRON ROD 0.5' ABOVE GROUND WITH YELLOW SURVEY CAP "J.H. MATHIESON PLS 2310"
S07°59'52"E 1.78' FROM HELD 1-1/2" IRON PIPE.

N72°50'19"E 510.20'

N72°50'19"E 23'+/-

S68°09'45"W 26'+/-

S68°09'45"W 644.26'

506'± ALONG

TIE LINE S04°20'26"W 363.18'

SIGHT DISTANCES (SPEED LIMIT 35 MPH)

MAP REFERENCE

"BOUNDARY SURVEY & EXISTING CONDITIONS & TOPOGRAPHIC SURVEY", REVISION DATED JANUARY 26, 2017, PREPARED BY GARTLEY & DORSKY ENGINEERING & SURVEYING.

SCALE: 1" = 60'

0 30 60 120 180

SCALE: 1" = 100'

NORTH

PROJECT: NEW SCHOOL
1 MAIN STREET - ROCKLAND, MAINE

CLIENT: MID-COAST SCHOOL OF TECHNOLOGY

TITLE: GEOTHERMAL LOCATION PLAN

SCALE: 1" = 60'

DRAWN BY: KRF

APPR BY: CWC

DATE: MAY 1, 2017

PROJ.#: 16274

FIGURE: 1

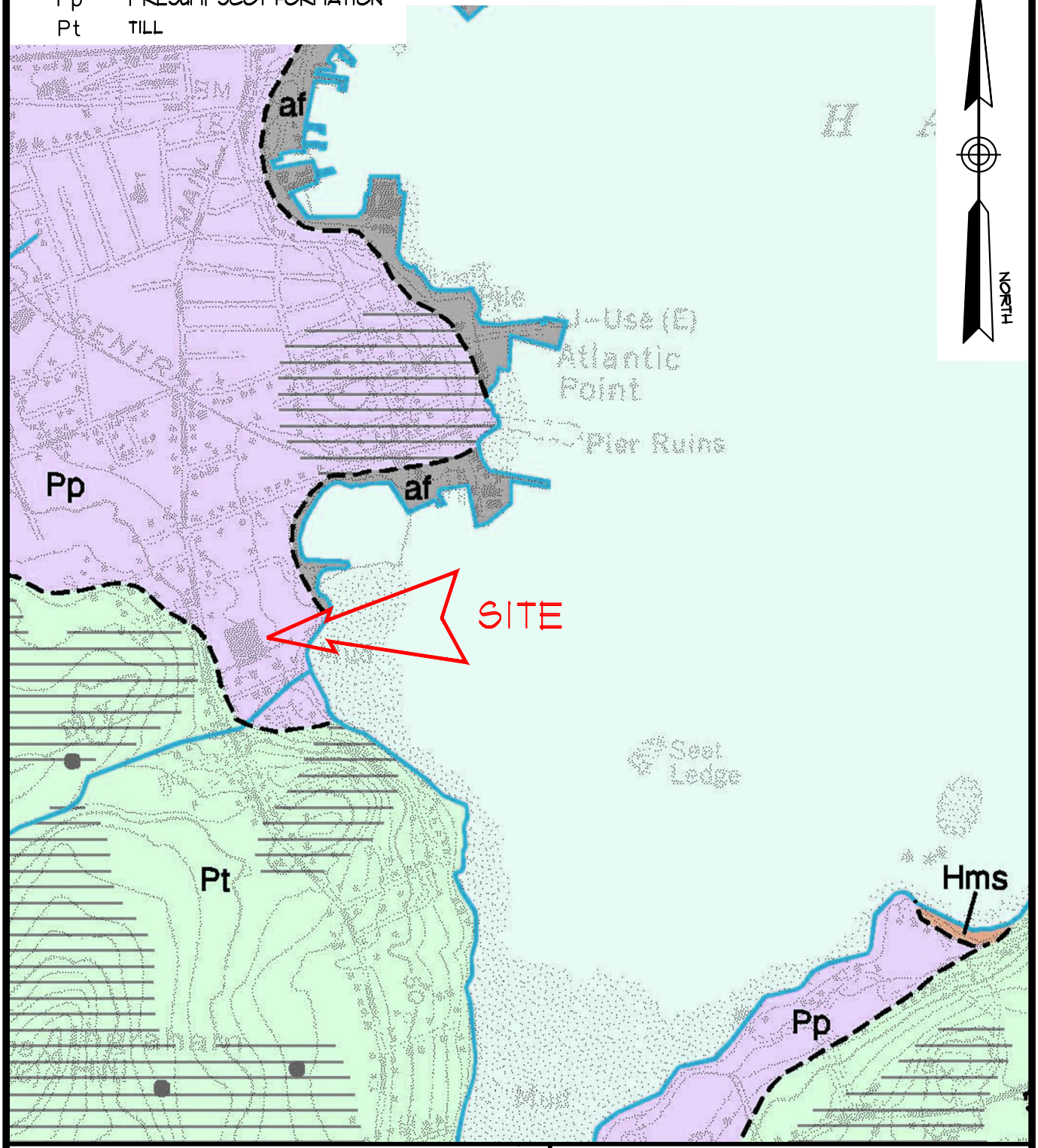
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Tel.: (207) 576-3313

LEGEND

af	ARTIFICIAL FILL
Pp	PRESUMPSCOT FORMATION
Pt	TILL

MAP REFERENCE

MAINE GEOLOGICAL SURVEY, SURFICIAL GEOLOGY, ROCKLAND QUADRANGLE, DATED 2010.



SURFICIAL GEOLOGY
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

DATE: 1-26-2017	DRAWN BY: KRF	CHECKED BY: CC
JOB: 16274	SCALE: 1"= 1000'	FILE: 16274 MAPS

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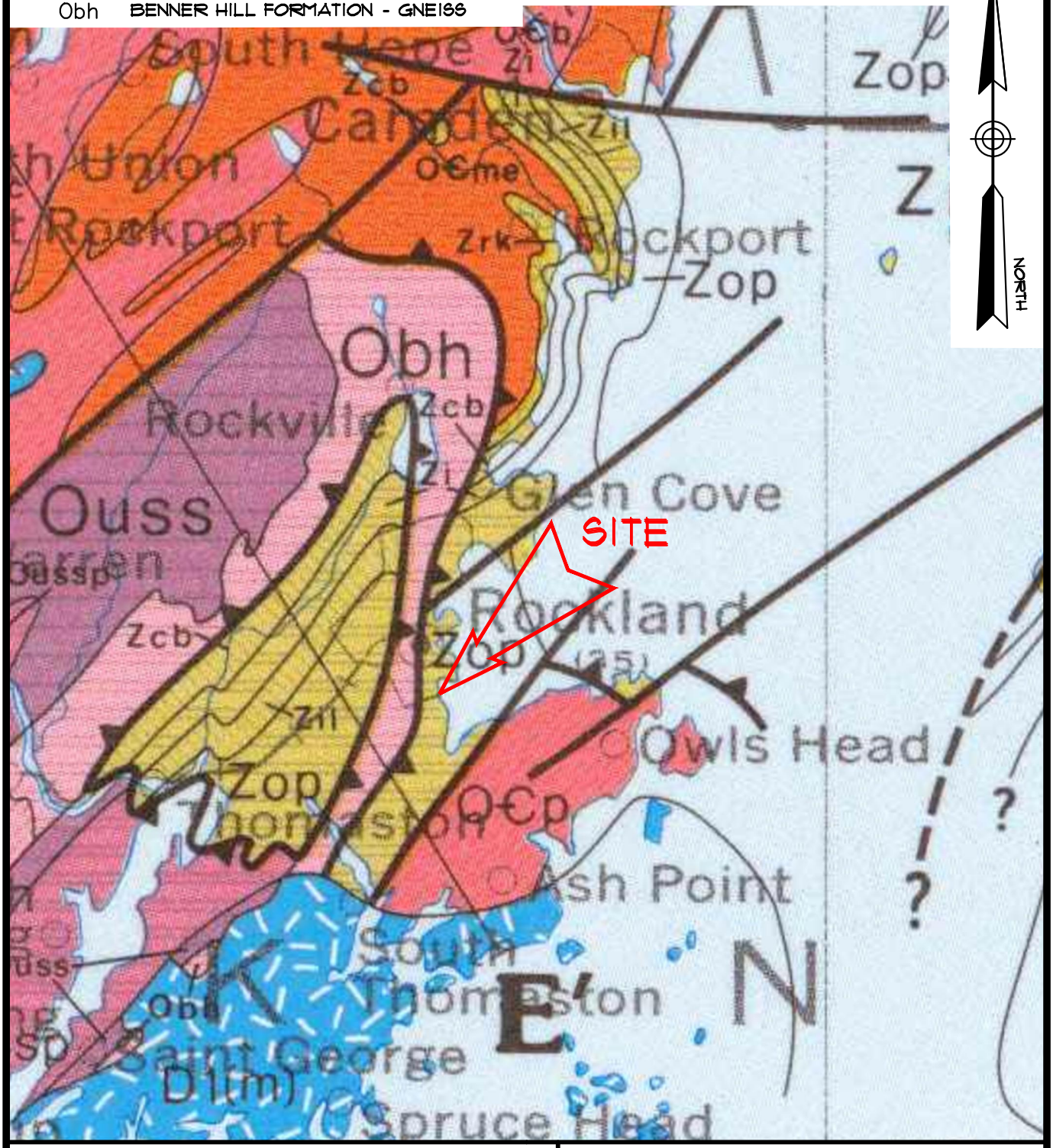
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LEGEND

Zop	OGIER FORMATION - MUDSTONE
OCp	PENOBSCOT FORMATION - SLATE
Obh	BENNER HILL FORMATION - GNEISS

MAP REFERENCE

BEDROCK GEOLOGY MAP OF MAINE, DATED 1985, PREPARED BY MAINE GEOLOGICAL SURVEY.



BEDROCK GEOLOGY
NEW SCHOOL

1 MAIN STREET - ROCKLAND, MAINE

PREPARED FOR

MID-COAST SCHOOL OF TECHNOLOGY

DATE: 1-26-2017	DRAWN BY: KRF	CHECKED BY: CC
JOB: 16274	SCALE: 1"=2 MILES	FILE: 16274 MAPS

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APPENDIX B

WELL DRILLERS LOG

WO# 340978

DRILLER'S LOG CLOSED LOOP GEOTHERMAL WELL

CUSTOMER: SUMMIT ENVIRONMENTAL OWNER: MID COAST SCHOOL OF TECH

SALES PERSON: SCOTT JOB #: 2017072 TOWN: ROCKLAND

Loop field layout (show each well location with last three digits of job # for each):

Directions

IN AUGUSTA TURN (L) ONTO RT 17 TOWARDS ROCKLAND. CONTINUE ON RT 17 FOR 40 MILES. AT BLINKING YELLOW LIGHT ACROSS FROM GOLF COURSE BEAR RIGHT ONTO N. MAIN ST. GO .3 MILES TURN (R) ONTO BROADWAY. GO 1.6 MILES AND TURN (L) ONTO THOMASTON ST. GO .2 AND TURN (R) ONTO

LATITUDE: LONGITUDE: MAIN ST/RT. 1. GO .3 SCHOOL ON LEFT

WELL: Ovhd wires ___ Plank ___ Pump off water ___ Cover side of house ___ Chainsaw ___

Remove cuttings ___ Dig safe (1) Min. amt. casing ___ Required yield 0

Remarks: (1) DIG SAFE # 20171201964

DRILL 400 @ CLOSED LOOP GEOTHERMAL BOREHOLE. LOOP & GROUT TO A 1.0 THERMAL CONDUCTIVITY ENGINEER WILL BE ON SITE. WILL NEED TO DRIVE OVER SMALL CURB. INSTALL HAYBALES IN DRAINAGE DITCH. CREATE 2 HAYBALE CHECK DAMS TO FILTER OUT SEDIMENT IN THE DRAINAGE DITCH.

APRIL 1ST

DATE ON: 4-17-17 DATE OFF: 4-19-17 DRILLER/HELPERS: Bob, Jeff, Mikely

OVERBURDEN MATERIALS ENCOUNTERED:

FROM 0 TO 5 FT.	___CLAY	___SILT	___SAND	___GRAVEL	✓ BOULDERS	___HARDPAN
FROM 5 TO 15 FT.	___CLAY	___SILT	___SAND	✓ GRAVEL	___BOULDERS	___HARDPAN
FROM 15 TO 26 FT.	✓ CLAY	___SILT	___SAND	___GRAVEL	___BOULDERS	___HARDPAN
FROM ___ TO ___ FT.	___CLAY	___SILT	___SAND	___GRAVEL	___BOULDERS	___HARDPAN

DEPTH TO BEDROCK: 26 FT. BAGS OF MUD USED: ___

CASING SIZE: 6 CASING LENGTH: 32 LEFT IN PLACE: ✓ YES ___ NO

DEPTH & EST. YIELD OF WATER PRODUCING ZONES:

DEPTH 46 FT. YIELD 1 GPM		DEPTH 75 FT. YIELD 60 GPM	
DEPTH 53 FT. YIELD 10 GPM		DEPTH 95 FT. YIELD 30 GPM	
DEPTH 56 FT. YIELD 1 GPM		DEPTH ___ FT. YIELD ___ GPM	

TOTAL DEPTH: 420 FT. TOTAL EST. YIELD: 100+ GPM STATIC WATER LEVEL: 7 FT.

TOTAL LOOP LGTH (ft.): 400' LOOP DIA (in.): 1¼ LOOP MANUFACTURER: Dil Creek

TYPE OF GROUT: TG Lite w/ Powertec GROUT MANUFACTURER: GeoPro

BAGS OF GROUT USED (50#): 48 SAND USED (lbs): ___

GALLONS OF H2O PER SACK: 16 GROUT THERMAL CONDUCTIVITY: 1.0 Btu/hr ft F

TYPE / MANUFACT. OF ADDITIVE USED: PowerTec QUANTITY OF ADDITIVE USED: 24

LOOP PRESSURE TEST / PRE INSTALLATION: Pressure: 50 psi Time: 60 min Employee: Bob Murrell

LOOP PRESSURE TEST / POST INSTALLATION: Pressure: 60 psi Time: 60 min Employee: Jesse Boudwin

BOREHOLE GROUTED FROM DEPTH OF 400 feet to 0 feet.

WERE ANY INTERVALS STONED DUE TO WATER BEARING FRACTURES: ✓ yes ___ no.

From 106 feet to 86 feet, From 76 feet to 32 feet, From ___ feet to ___ feet, From ___ feet to ___ feet

37 bags of stone used

DRILLERS COMMENTS: from 26' to 100 Ledge Really Busted up with a lot of fractures. Really Bad Fracture at 95' The hole Kept Caving in. Had to Pump Grout in that Fracture to Get it to

Grouting Time Records

Date	Start	Finish	Employee

APPENDIX C

THERMAL CONDUCTIVITY TEST RESULTS

Formation Thermal Conductivity
Test & Data Analysis

Test location **Mid-Coast School of Technology**
Rockland, ME

Test Date April 22-24, 2017

Analysis For Summit Geoengineering Services
145 Lisbon Street, Suite 601
Lewiston, Maine 04240
Phone: (207) 520-4846

Test Performed By Summit Geoengineering Services

WESTERN OFFICE
PO Box 256, Elkton, SD 57026
P: 866-991-4784 F: 605-542-3941

MAIN OFFICE
PO Box 150, Bowie, TX 76230
P: 940-872-2222 F: 940-872-3678

EASTERN OFFICE
PO Box 16143, Asheville, NC 28816
P: 828-225-9166 F: 828-281-4139

EXECUTIVE SUMMARY

A formation thermal conductivity test was performed at the Mid-Coast School of Technology in Rockland, Maine. The vertical bore was drilled on April 17 and grouted on April 18-19, 2017 by Goodwin Well & Water, Inc. Geothermal Resource Technologies' (GRTI) test unit was attached to the vertical bore on the afternoon of April 22, 2017.

This report provides an overview of the test procedures and analysis process, along with plots of the loop temperature and input heat rate data. The collected data was analyzed using the "line source" method and the following average formation thermal conductivity was determined.

Formation Thermal Conductivity = 2.15 Btu/hr-ft-°F

Due to the necessity of a thermal diffusivity value in the design calculation process, an estimate of the average thermal diffusivity was made for the encountered formation.

Formation Thermal Diffusivity ≈ 1.37 ft^2/day

The calculated values are fairly high for the indicated formation, which may be due to water flow across the bore. Caution should be exercised, as water flow in the formation may be only a seasonal or annual effect. The effect of water flow on heat transfer may also be less pronounced when a large number of bores in a loop field are present. Based on the formation type, lower design values are suggested with potential increases due to water flow considered as a factor of safety. The values are not based on measured data from this test but are estimates based on data from other tests in the area and published literature for the listed formation. Additional testing may be considered to better characterize the site's thermal properties.

Suggested Formation Thermal Conductivity = 1.80 Btu/hr-ft-°F

Suggested Formation Thermal Diffusivity ≈ 1.15 ft^2/day

The undisturbed formation temperature for the tested bore was established from the initial loop temperature data collected at startup.

Undisturbed Formation Temperature ≈ 49.8-50.4°F

The formation thermal properties determined by this test do not directly translate into a loop length requirement (i.e. feet of bore per ton). These parameters, along with many others, are inputs to commercially available loop-field design software to determine the required loop length. Additional questions concerning the use of these results are discussed in the frequently asked question (FAQ) section at www.grti.com.

TEST PROCEDURES

The American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) has published recommended procedures for performing formation thermal conductivity tests in the ASHRAE HVAC Applications Handbook, Geothermal Energy Chapter. The International Ground Source Heat Pump Association (IGSHPA) also lists test procedures in their Design and Installation Standards. GRTI's test procedures meet or exceed those recommended by ASHRAE and IGSHPA, with the specific procedures described below:

Grouting Procedure for Test Loops – To ensure against bridging and voids, it is recommended that the bore annulus is uniformly grouted from the bottom to the top via tremie pipe.

Time Between Loop Installation and Testing – A minimum delay of five days between loop installation and test startup is recommended for bores that are air drilled, and a minimum waiting period of two days for mud rotary drilling.

Undisturbed Formation Temperature Measurement – The undisturbed formation temperature should be determined by recording the loop temperature as the water returns from the u-bend at test startup.

Required Test Duration – A minimum test duration of 36 hours is recommended, with a preference toward 48 hours**.**

Data Acquisition Frequency - Test data is recorded at five minute intervals.

Equipment Calibration/Accuracy – Transducers and datalogger are calibrated per manufacturer recommendations. Manufacturer stated accuracy of power transducers is less than ±2%. Temperature sensor accuracy is periodically checked via ice water bath.

Power Quality – The standard deviation of the power should be less than or equal to 1.5% of the average power, with maximum power variation of less than or equal to 10% of the average power.

Input Heat Rate – The heat flux rate should be 51 Btu/hr (15 W) to 85 Btu/hr (25 W) per foot of installed bore depth to best simulate the expected peak loads on the u-bend.

Insulation – GRTI's equipment has 1 inch of foam insulation on the FTC unit and 1/2 inch of insulation on the hose kit connection. An additional 2 inches of insulation is provided for both the FTC unit and loop connections by insulating blankets.

Retesting in the Event of Failure – In the event that a test fails prematurely, a retest may not be performed until the bore temperature is within 0.5°F of the original undisturbed formation temperature or until a period of 14 days has elapsed.

Data Analysis

Geothermal Resource Technologies, Inc. (GRTI) uses the "line source" method of data analysis to determine the thermal conductivity of the formation. The line source method assumes an infinitely thin line source of heat in a continuous medium. A plot of the late-time temperature rise of the line source temperature versus the natural log of elapsed time will follow a linear trend. The linear slope is inversely proportional to the thermal conductivity of the medium. When a u-bend grouted in a borehole is used to inject heat into the ground at a constant rate in order to determine the average formation thermal conductivity, the test must be run long enough to allow the finite dimensions of the u-bend pipes and the grout to become insignificant. Experience has shown that approximately ten hours is required to allow the error of early test times and the effects of finite borehole dimensions to become insignificant.

In order to analyze real data from a formation thermal conductivity test, the average temperature of the water entering and exiting the u-bend heat exchanger is plotted versus the natural log of elapsed testing time. Using the Method of Least Squares, linear coefficients are then calculated to produce a line that fits the data. This procedure is repeated for various time intervals to ensure that variations in the power or other effects are not producing inaccurate results.

The calculated results are based on test bore information submitted by the driller/testing agency. GRTI is not responsible for inaccuracies in the results due to erroneous bore information. All data analysis is performed by personnel that have an engineering degree from an accredited university with a background in heat transfer and experience with line source theory. The test results apply specifically to the tested bore. Additional bores at the site may have significantly different results depending upon variations in geology and hydrology.

Through the analysis process, the collected raw data is converted to spreadsheet format (Microsoft Excel®) for final analysis. If desired, please contact GRTI and a copy of the data will be made available in either a hard copy or electronic format.

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TEST BORE DETAILS
(AS PROVIDED BY SUMMIT GEOENGINEERING SERVICES)

Site Name	Mid-Coast School of Technology
Location	Rockland, ME
Driller	Goodwin Well & Water, Inc.
Installed Date	Drilled April 17, grouted April 18-19, 2017
Borehole Diameter	8 inches, 0-32 ft 6 inches, 32-420 ft
Casing	Permanent 6 inch steel casing to 32 ft
U-Bend Size	1 1/4 inch DR-11 HDPE
U-Bend Depth Below Grade	400 ft
Grout Type	GeoPro PowerTECx
Grout Mixture	50 lb TG Lite, 7.5 lb PowerTECx, 16 gal water
Grouted Portion	Entire bore except as noted below

Note: Bore was backfilled with 37 bags of stone from 37-76 ft and 86-106 ft.

DRILL LOG

FORMATION DESCRIPTION	DEPTH (FT)
Boulders	0'-5'
Gravel	5'-15'
Clay	15'-26'
Ledge-numerous fractures	26'-100'
Schist (mudstone)	100'-420'

Note: Bore produced 1 gpm water at 46 ft; 10 gpm at 53 ft; 1 gpm at 56 ft; 60 gpm at 85 ft; 30 gpm at 95 ft. Total yield of 100+ gpm.

THERMAL CONDUCTIVITY TEST DATA

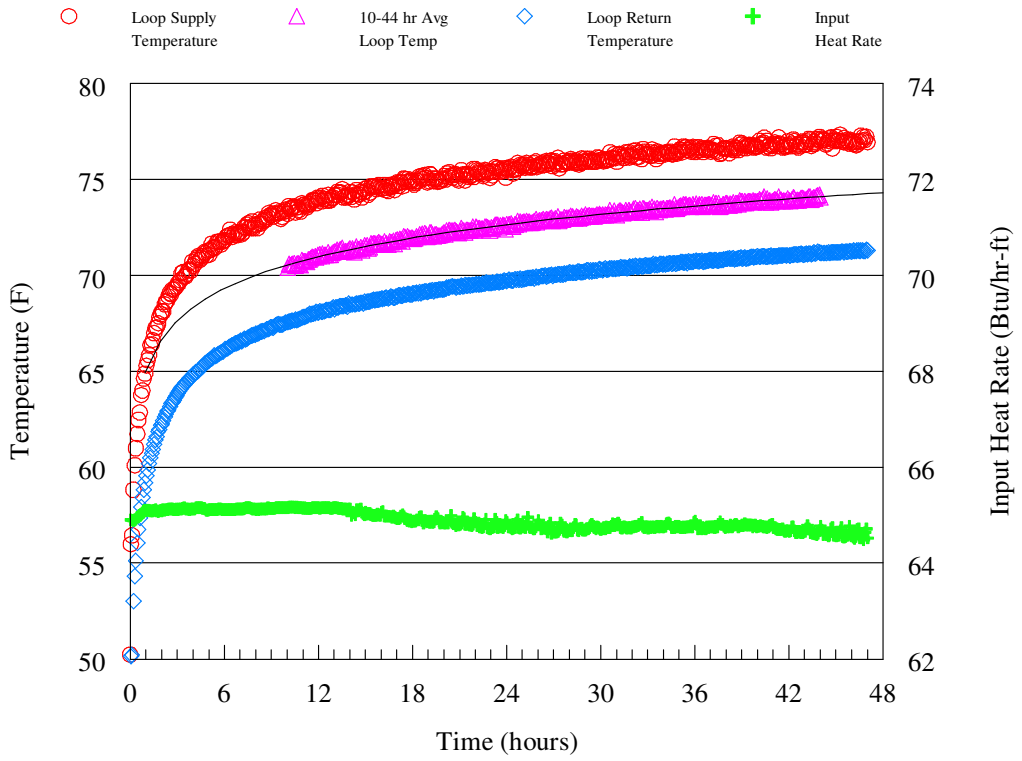


FIG. 1: TEMPERATURE & HEAT RATE DATA VS TIME

Figure 1 above shows the loop temperature and heat input rate data versus the elapsed time of the test. The temperature of the fluid supplied to and returning from the U-bend are plotted on the left axis, while the amount of heat supplied to the fluid is plotted on the right axis on a per foot of bore basis. In the test statistics below, calculations on the power data were performed over the analysis time period listed in the Line Source Data Analysis section.

SUMMARY TEST STATISTICS

Test Date	April 22-24, 2017
Undisturbed Formation Temperature	Approx. 49.8-50.4°F
Duration	47.0 hr
Average Voltage	233.7 V
Average Heat Input Rate	25,935 Btu/hr (7,599 W)
Avg Heat Input Rate per Foot of Bore	64.8 Btu/hr-ft (19.0 W/ft)
Calculated Circulator Flow Rate	8.9 gpm
Standard Deviation of Power	0.23%
Maximum Variation in Power	0.51%

LINE SOURCE DATA ANALYSIS

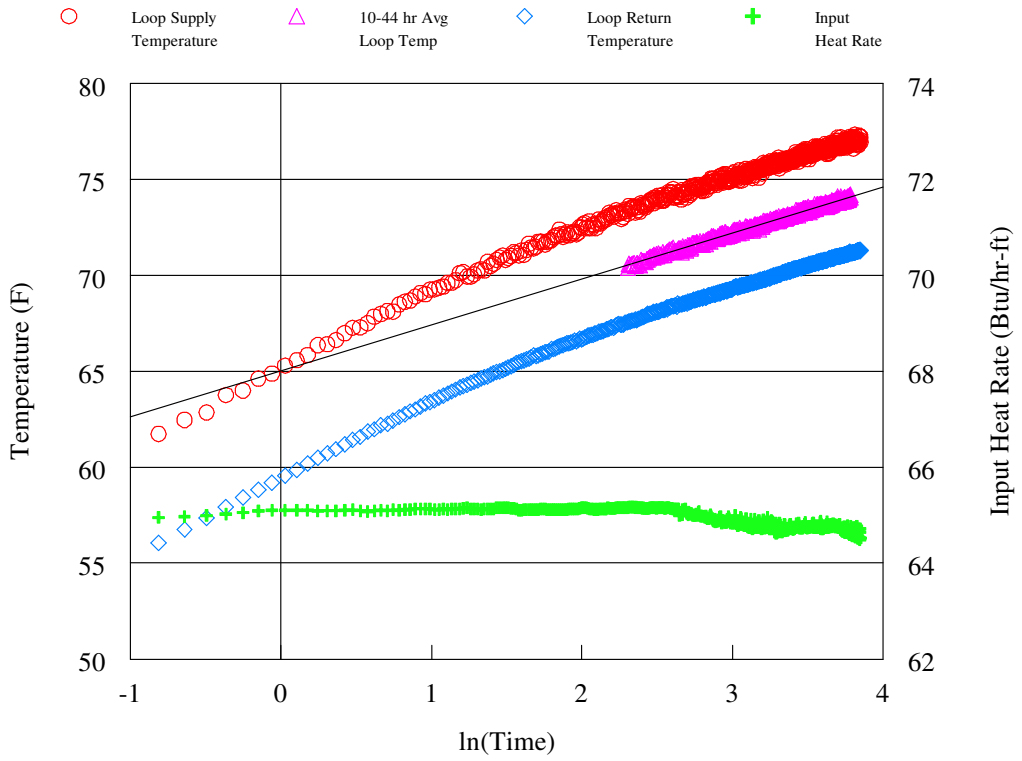


FIG. 2: TEMPERATURE & HEAT RATE VS NATURAL LOG OF TIME

The loop temperature and input heat rate data versus the natural log of elapsed time are shown above in Figure 2. The temperature versus time data was analyzed using the line source method (see page 3) in conformity with ASHRAE and IGSHPA guidelines. A linear curve fit was applied to the average of the supply and return loop temperature data between 10 and 44.0 hr. The slope of the curve fit was found to be 2.40. The resulting thermal conductivity was found to be **2.15 Btu/hr-ft-°F**. The calculated value is fairly high, possibly due to groundwater flow across the bore. When water flow is encountered, heat transfer is driven by advection to water flowing past the bore in addition to conductive heat transfer through the formation. Loop field performance may then be dependent on both hydrological conditions and the thermal properties of the formation. It is the position of GRTI in these cases to suggest a conductivity value based on assumed saturated values for the formations encountered and data from previous tests in the area. Benefits due to water flow are not considered, as the effect of multiple bores or the future behavior of the water flow is unknown. For the formation listed in the drill log, a thermal conductivity value of **1.80 Btu/hr-ft-°F** is suggested. Additional testing may be considered to better characterize the site's thermal properties.

THERMAL DIFFUSIVITY

The reported drilling log for this test borehole indicated that the formation consisted of boulders, gravel, clay, and schist/mudstone. A heat capacity value for schist was calculated from specific heat and density values listed by Kavanaugh and Rafferty (Ground-Source Heat Pumps - Design of Geothermal Systems for Commercial and Institutional Buildings, ASHRAE, 1997). A weighted average of heat capacity values based on the indicated formation was used to determine an average heat capacity of 37.6 Btu/ft^3-°F for the formation. A diffusivity value was then found using the calculated formation thermal conductivity and the estimated heat capacity. The thermal diffusivity for this formation was estimated to be **1.37 ft^2/day**. Since the calculated thermal conductivity was high, a thermal diffusivity value was also determined using the suggested conductivity value. The thermal diffusivity was estimated to be **1.15 ft^2/day** using this approach.

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CERTIFICATE OF CALIBRATION

GRTI maintains calibration of the datalogger, current transducer and voltage transducer on a regular schedule. The components are calibrated by the manufacturer using recognized national or international measurement standards such as those maintained by the National Institute of Standards and Technology (NIST).

FTC Unit 234

DA Unit 66

PRIMARY EQUIPMENT		
COMPONENT	CALIBRATION DATE	CALIBRATION DUE DATE
Datalogger	3/30/2016	3/30/2019
Current Transducer	4/22/2016	4/22/2019
Voltage Transducer	4/22/2016	4/22/2019

GRTI periodically verifies the combined temperature sensor/datalogger accuracy via an ice water bath. Temperature readings are simultaneously taken with a digital thermometer that has been calibrated using instruments traceable to NIST.

DATE	11/2/2016	4/22/2016		
THERMOCOUPLE 1 (°F)	32.0 32.0 32.0	31.9 31.9 31.9		
THERMOCOUPLE 2 (°F)	32.0 31.9 32.0	31.7 31.7 31.7		
THERMOCOUPLE 3 (°F)	32.0 32.0 32.1	31.7 31.7 31.7		
THERMOCOUPLE 4 (°F)	31.9 31.9 32.0	31.8 31.8 31.8		
DIGITAL THERMOMETER (°F)	32.0 32.0 32.0	31.9 31.9 31.9		

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